ESSAYS IN MACROECONOMICS

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Abstract

The first chapter of this dissertation focuses on the link between fiscal stimulus, asset prices, and financial frictions in a theoretical New Keynesian model with collateral requirements, housing, and distortionary taxation. My findings, based on fiscal multipliers, suggest an expansionary role for fiscal interventions that is larger on impact for changes in government expenditures compared to tax instruments (lump-sum, labor, and capital income tax). The model also predicts a drop in the price of the collateral asset (housing), induced by the increase in the real interest rate, as a result of higher government debt and the monetary response to the initial stimulus effects. The change in housing prices reduces the borrower agents' net worth and the volume of credit they can access, which in turn creates a drop in consumption at longer horizons. The existence of the financial channel, accounts for a relatively weaker role of fiscal policy in this framework compared to models where the non-Ricardian agents do not have access to the capital market. I conduct counterfactual experiments in order to assess the sensitivity of the results to financial conditions, different financing methods for government debt, and alternative calibrated values for key structural parameters.

In the second chapter, I use a regime-switching SVAR model to study the impact of government spending shocks on output, consumption and house prices under two different credit regimes (difficult and relaxed). The results show a reduced effect for expansionary fiscal policy under difficult financial conditions, as opposed to a relaxed financial regime. In this particular state, increases in government spending have a negative, short run impact, on output, private consumption, and house prices. At longer horizons, both output and asset prices start to recover. This result is compatible with the existence of a credit channel, as outlined in theoretical models of the financial accelerator, that links the government financing needs to the private terms of credit.

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Chapter 1
Fiscal Stimulus, Distortionary Taxation, and Financial Frictions

1.1 Introduction

The onset of the Financial Crisis in late 2007 that culminated in a Global Recession has forced policymakers throughout the world to critically reevaluate the toolkits at their disposal. The academic debate regarding the potential stabilizing role of fiscal policy has started picking up momentum again, especially as key interest rates were gradually cut back towards zero which limited the scope of future monetary interventions.

Empirically, the topic has received considerable attention in the past decade. The seminal contribution of Blanchard and Perotti (2002) has encouraged the development of a diverse and extensive body of related literature, often built around the SVAR framework proposed by the two authors. Nevertheless, at least until the last economic crisis, the use of theoretical DSGE models was significantly less well represented in the study of fiscal policy.

An important downside of the standard New Keynesian model based on a single type of representative agent is that it cannot replicate the positive response of private consumption after an expansionary government spending shock – a common result in the empirical studies.

The reason is that households are forward looking, so the Ricardian equivalence principle will hold in this scenario. The representative agents associate present fiscal stimulus with higher future taxes, which imposes a negative wealth effect. Thus, they will respond by increasing labor supply and reducing consumption.

Gali et al. (2007) proposed a solution to the conundrum, by introducing, so called, rule-of-thumb (RoT) consumers in a canonical DSGE model[1]. This approach, which is in line with the work of Campbell and Mankiw (1991), is able to reconcile empirical evidence and generates a crowding-in effect on consumption in response to positive fiscal shocks, if prices are sticky and the share of the liquidity constrained agents is large enough (above 25 percent in Gali et al., 2007).

The assumption, while tractable, has the notable disadvantage that it does not account at all for credit conditions or credit market imperfections. The ROT agents are by definition insensitive to changes in the real interest rates, since they do not engage in intertemporal consumption smoothing – a mechanism which makes them very responsive to transitory income. Furthermore, they do not have access to the capital market, which also insulates them from financial developments and thus leaves out a potentially meaningful policy transmission channel.

As the recent financial crisis has shown, a worsening in financial conditions can significantly reduce credit availability at the aggregate level. In particular, the reduction in the volume of credit appeared to have a particularly severe effect on the private sector, in addition to its expected negative supply side impact.

The drop in private consumption, consistent with the existence of credit constrained households, accelerated the economic decline and resulted, in many countries, in a severe economic downturn. This empirical evidence thus offers additional support to the idea of a financial amplification mechanism that ties credit conditions to movements in private con-

[1]These agents do not save and simply consume their entire (labor) income every period. Many models currently used for policy analysis incorporate this feature: SIGMA (Federal Reserve), NAWM (European Central Bank), QUEST III (European Commission), etc.

sumption and, implicitly, output. Importantly, such a channel would also hold implications regarding the conduct of fiscal policy, as the government financing needs are non-neutral with respect to the credit market.

From a theoretical point of view, the role of financial frictions as a business cycle amplification mechanism has been firmly established in the literature, starting with the seminal contributions of Kiyotaki and Moore (1997) and Bernanke, Gertler, and Gilchrist (1999). In this class of models a balance-sheet credit channel links, via asset prices, the wealth of borrowers to both private consumption and investment spending, significantly heightening their response to exogenous shocks, thus giving rise to a "financial accelerator."

The motivation for credit constraints varies, but most researchers follow either BGG (1999), who assume a moral hazard problem, or Kyiotaki and Moore (1997) who consider a limited enforceability problem[2]. The two mechanisms are qualitatively different, since the first influences the cost of credit (through an external finance premium), while the second affects directly the availability of credit (collateral requirement) which is in line with the empirical evidence mentioned above.

In this chapter I study the effects of discretionary fiscal policy in a New Keynesian framework that features housing investment and allows for credit constrained households along the lines of Kiyotaki and Moore (1997). The model is based on Iacoviello and Neri (2010), which has been shown to match well the cyclical properties and long-run behavior of housing and non-housing variables alike[3].

The assumption that a subset of the population is subject to collateral requirements is particularly relevant, as it creates an endogenous amplification mechanism that links housing wealth to non-housing consumption. Compared to a standard DSGE model, this results in

[2] An alternative approach is to introduce financial frictions by giving financial intermediaries an ability to change credit conditions without a change in borrower creditworthiness, like in Meh and Moran (2004).

[3] In particular, both housing prices and housing investment appear strongly procyclical, volatile and sensitive to monetary shocks, in line with the empirical evidence. For details see Iacoviello and Neri (2010).

an additional transmission channel for policy that reflects conditions on the demand side of the credit market.

My findings, based on present value fiscal multipliers, suggest that increases in government spending are more effective at stimulating output than reductions in taxes[4]. The existence of credit constrained households ensures a positive net response of aggregate consumption (around 0.12 on impact) which is in line with the empirical evidence[5]. The borrowers' high marginal propensity to consume plays a key role here, as it makes these agents very responsive to changes in their transitory income, in a similar manner to their RoT counterparts.

The effect is strong enough to offset, in the short run, the drop in savers' consumption, due to the negative wealth effect imposed by higher expected future taxes, and produces a Keynesian multiplier for output (1.03 on impact) under the baseline calibration. The output multipliers decline at longer horizons as a result of the crowding out of private investment and a fall in aggregate consumption. The latter is compounded by a decline in housing prices which reduces the borrowers' net worth and consumption multipliers become negative after approximatively five quarters.

Increases in government transfers and labor tax cuts have quantitatively similar effects on output, with impact multipliers of around 0.13. In both cases, fiscal stimulus generates an increase in the consumption of credit constrained agents who respond to a higher, albeit transitory, level of income. At longer horizons, multipliers become negative, as the increase in interest rates crowds out investment, depresses housing prices and raises credit costs for borrowers. In this framework, capital income tax cuts have a rather small effect on output (negative on impact -0.011, but subsequently positive) largely through the accumulation of new capital. The response of aggregate consumption is negative, due to a significant

[4]Fernandez-Villaverde (2010) comes to a similar conclusion in the context of DSGE model with financial frictions based on BGG(1999)

[5]See for example Perotti (2008), or Ramey (2011).

drop in the borrowers' consumption as the savers reallocate their financial resources towards investment.

Consistent with the findings of Gali et al.(2007), in an environment where prices are more rigid, increases in government spending result in larger output multipliers. The smaller adjustment in the expected real interest rate reduces the negative response in the savers' current consumption, while also slowing the decline of housing prices. This helps conserve the borrowers' net worth, as well as, their consumption level. The same argument can be made for a lower degree of persistence in the fiscal shock as the change in interest rates is expected to be shorter lived.

Regarding the importance of credit conditions, the loan-to-value ratio appears to play a key role in terms of the expected expansionary effect of fiscal measures. This parameter is directly tied to the borrowers' credit limit, as it determines the value of the housing stock which is allowed as collateral and thus their ability to finance consumption spending.

A worsening in the quality of credit conditions, modeled by a drop in the loan-to-value ratio (a forced deleveraging like in a credit crunch) or a reduction in the volume of private credit (modeled as a decrease in the share of borrowers) will reduce the expansionary effects of fiscal stimulus. Policy experiments have shown that a sufficiently large value of the LTV ratio (of around 0.80) is necessary in order to generate output multipliers above unity. In general, policy effects scale up with the size of credit constrained population.

The rest of the paper is organized as follows: the next two sections introduce the model and provide details on the calibration. Section four discuses the main set results and their sensitivity to alternative specifications. Finally, section five concludes.

1.2 The Model

This section presents a closed economy framework, based on Iacoviello and Neri (2010), which I extend to include a government sector that raises revenue via distortionary taxation (on capital and labor revenue) and redistributes income through transfers. The model also features two production sectors, heterogeneity in the households' discount factors and financial frictions in the form collateral constraints tied to the value of the housing stock[6].

The economy is populated by two types of households which, based on their respective discount factor, can be classified as patient (savers) and impatient (borrowers). The savers work, consume, accumulate housing and pay taxes. They own the entire capital stock, as well as, the production firms and use their savings to supply funds to the impatient households and to the government, financing the public debt.

Similarly, the borrowers work, consume, pay labor income taxes, receive transfers and accumulate housing. As opposed to savers, the impatient households only accumulate the required net worth to finance the down payment on their homes and are assumed to be up against their housing collateral constraint in the equilibrium.

On the supply side, the non-housing sector combines capital and labor to produce consumption and capital for both sectors, while the housing sector produces new homes using capital, labor and land.

Besides financial frictions and housing, the model also features price and wage stickiness, monopolistic competition and habit formation in consumption. These types of rigidities are typically considered in models used for policy analysis, such as Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007), and make the results comparable to previous findings in the literature.[7].

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[6]Differently from Andres, Bosca and Ferri (2012) the housing stock is variable in this economy, thus fluctuations in the supply of housing influence the price of housing and, implicitly, the role of colletralized debt. A model with a fixed housing supply will tend to overstate the changes in house prices, which given the financial amplification mechanism may have a large impact in the aggregate. I am also considering distortionary taxes, as opposed to lump-sum taxation. As Drautzburg and Uhlig (2011) point out the effects of fiscal policy can differ significantly at longer horizons depending on the assumed tax structure. Furthemore, Leeper et. al (2009) argue, based on a posterior odds comparison for their estimated model, that the data clearly prefers a model with a more complex fiscal sector.

[7]Iacoviello and Neri (2010) employ this framework to explore quantitatively the nature of the shocks hitting the housing market, as well as, the size of spillovers from this market to the rest of the economy. They find that the model explains well the cyclical properties and the long-run behavior of both housing and

Finally, the model economy includes a monetary authority and a government sector. The central bank controls the supply of currency and conducts monetary policy using the (short term) nominal interest rate as an instrument, while the government finances its spending through taxation and borrowing.

1.2.1 Households

The economy is populated by two types of households, patient and impatient, each of mass 1, that derive utility from consumption, leisure, and housing services. The economic size of each group is given by their corresponding wage share. This is fixed across groups, due to the assumed production function, with a constant elasticity of substitution, and it is α for borrowers and $1-\alpha$ for lenders, respectively.

The household $z \in [0,1]$, of type i, maximizes the following expected utility:

$$E_0 \sum_{t=0}^{\infty} (\beta_i)^t \left(\ln(c_{i,t} - \epsilon_i c_{i,t-1}) + j_t \ln h_{i,t} - \frac{1}{1+\eta_i} \left((n_{i,c,t})^{1+\xi_i} + (n_{i,h,t})^{1+\xi_i} \right)^{\frac{1+\eta_i}{1+\xi_i}} \right), \qquad (1.1)$$

where $i = 1, 2$ denotes the type of the household (patient or impatient) differentiated by its time-discount factor β_1 and β_2, respectively. The other factors, c, h, n_c, and n_h represent (composite) consumption, housing, hours worked in the consumption sector and housing sector, respectively.

The positive parameters ξ_i represent the inverse elasticity of substitution across hours in the two sectors and allow for less than perfect labor mobility across sectors as in Horvath (2000). The inverse Frish elasticity of labor supply is given by η_i, while $\epsilon \in [0,1]$ is the habit parameter.

The term j_t describes a housing preference shock intended to capture, in a reduced form,

nonhousing variables. Moreover, housing prices and housing investment appear to be strongly procyclical, volatile, and very sensitive to monetary shocks.

cyclical variations due to resource availability for housing purchases (relative to the other goods), as well as, institutional changes that may impact preferences.

The composite consumption is defined as a Dixit-Stiglitz aggregator of the final good varieties:

$$c_t = \left(\int_0^1 c_t(\tau)^{\frac{\epsilon_p - 1}{\epsilon_p}} d\tau \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} \tag{1.2}$$

where ϵ_p represents the intertemporal elasticity of substitution and τ denotes variety.

Also, the demand for each variety τ is given by:

$$c_t(\tau) = \left(\frac{P_t(\tau)}{P_t} \right)^{-\epsilon_p} c_t, \tag{1.3}$$

The corresponding consumer price index has the property that minimizes the cost of a bundle of final good varieties yielding c_t units of composite consumption and is given by:

$$P_t = \left(\int_0^1 P_t(\tau)^{1-\epsilon_p} d\tau \right)^{\frac{1}{\epsilon_p - 1}}, \tag{1.4}$$

where $P_t(\tau)$ denotes the price for variety τ.

Following Davis and Heathcote (2005), the log-log specification for consumption and housing in the period utility accounts for the stable nominal share of expenditures on housing goods, while the disutility of labor ($\epsilon \geq 0, \eta \geq 0$) suggests some sector specificity and a smaller response in relative hours as a result of wage differentials.

Patient Households (Savers)

The patient households are characterized by a higher propensity to save, so in equilibrium they will supply loans to the impatient households and the government sector. They own the retail firms (being entitled to dividends, paid as a lump-sum) and all the capital which they rent out, selling any remaining undepreciated capital. The savers also accumulate housing, from which they derive utility services. They owe taxes on their labor and capital income and receive a lump-sum transfer from the government.

The period budget constraint is given by:

$$c_{1,t} + ik_{c,t} + ik_{h,t} + q_t(h_{1,t} - (1-\delta_h)h_{1,t-1}) + b_{1,t} + b_{g,t} = (1-\tau_t^l)\left(\frac{w_{1,c,t}n_{1,c,t}}{X_{1,wc,t}} + \frac{w_{1,h,t}n_{1,h,t}}{X_{1,wh,t}}\right)$$

$$+ (1-\tau_t^k)\left(r_{c,t}k_{c,t-1} + r_{h,t}k_{h,t-1}\right) + \frac{R_{t-1}b_{1,t-1}}{\pi_t} + \frac{R_{t-1}^g b_{g,t-1}}{\pi_t} + Z_{1,t} + Div_{1,t}, \quad (1.5)$$

where $c_{1,t}$ denotes (composite) consumption at time t, $k_{c,t}$ represents consumption sector capital, $k_{h,t}$ is housing sector capital. The parameters δ_{kc}, δ_{kh}, and δ_h represent depreciation rates for the two types of capital and the housing stock, respectively. Also, $ik_{c,t}$ denotes net current capital investment in the consumption goods sector, while $ik_{h,t}$ is net investment in housing production capital. The real rental rates for the consumption and housing capital are $r_{c,t}$ and $r_{h,t}$, respectively.[8]

The term $h_{1,t}$ denotes housing holdings priced (in real terms) at q_t, real (private) loans are given by $b_{1,t}$, and $b_{g,t}$ are real holdings of government bonds. The gross inflation rate is $\pi_t = P_t/P_{t-1}$, R_t is the riskless nominal rate of return, and R_t^g represents the nominal rate of return for the one-period government bond. The terms $n_{1,c,t}$ and $n_{1,h,t}$ are hours worked in the consumption and housing sectors, respectively, $w_{1,c,t}$ and $w_{1,h,t}$ denote real wages, while $X_{1,wc,t}$ and $X_{1,wh,t}$ are wage markups due to monopolistic competition.

Finally, τ_t^l and τ_t^k are current tax rates, $Z_{1,t} = (1-\alpha)Z_t$ represents household transfers/lump-sum taxes (normalized by the economic size of the group) and $Div_{1,t}$ are lump-sum profits,

[8] That is: $ik_{c,t} = k_{c,t} - (1-\delta_{kc})k_{c,t-1}$ and $ik_{h,t} = k_{h,t} - (1-\delta_{kh})k_{h,t-1}$.

both from the ownership of firms and labor unions[9].

Impatient Households (Borrowers)

Impatient households discount the future at a higher rate than the patient households ($\beta_2 < \beta_1$) and they are subject to a borrowing constraint given as a fraction of the value of their housing stock[10]. The budget constraint for the impatient households and the borrowing limit are given bellow:

$$c_{2,t}+q_t(h_{2,t}-(1-\delta_h)h_{2,t-1}) = (1-\tau_t^l)\left(\frac{w_{2,h,t}n_{2,h,t}}{X_{2,wh,t}}+\frac{w_{2,c,t}n_{2,c,t}}{X_{2,wc,t}}\right)-\frac{R_{t-1}b_{2,t-1}}{\pi_t}+b_{2,t}+Z_{2,t}+Div_{2,t}, \tag{1.6}$$

$$b_{2,t} \leq mE_t\frac{q_{h,t+1}\pi_{t+1}h_{2,t}}{R_t} \tag{1.7}$$

where m is the loan-to-value ratio for the household which is consistent with the practice in the mortgage market to limit the amount lent to a fraction of the value of the asset. Alternatively, $(1-m)$ can be interpreted as the cost that lenders need to pay in order to repossess the asset in case of default.

1.2.2 Production Sector

The production sector in this economy consists of perfectly competitive wholesale firms that produce consumption goods and housing, and a continuum of monopolistically competitive

[9] In practice capital depreciation is a tax deductible item and therefore in the model the capital tax is not applied on that part of the capital owners' income.

[10] Under uncertainty the concavity of the objective function, in some states of the world, can induce the impatient households to self insure - borrow less than their credit limit. In particular this could happen after a sufficiently long spell of positive shocks. Such an occurrence would invalidate an approximation around the deterministic state, because the borrowing constraint does not bind. However, as Iacoviello (2005) has argued based on partial equilibrium evidence, under a reasonable parametrization, evidence from non-linear simulations suggests that uncertainty is "small enough" relative to the degree of impatience to rule out non-binding credit constraints.

final good firms activating at the retail level in the consumption sector.

Wholesale Consumption Goods Producers

The firms that manufacture the wholesale consumption goods CG are endowed with a Cobb-Douglas production technology and are assumed to be perfectly competitive. These firms use labor and capital as production inputs as follows:

$$CG_t = \left(A_{c,t}\left(n_{1,c,t}^{1-\alpha} n_{2,c,t}^{\alpha}\right)\right)^{1-\mu_c} (k_{c,t-1})^{\mu_c}, \tag{1.8}$$

where $A_{c,t}$ represents productivity in the consumption sector, α is the labor income share of the patient households, and μ_c is the share of capital in the production of consumption goods.

Housing Producers

Similarly to the wholesale firms, the housing producers are assumed to be perfectly competitive, with a Cobb-Douglas technology that combines labor and capital into new housing goods. Their production function is given bellow:

$$IH_t = \left(A_{h,t}\left(n_{1,h,t}^{1-\alpha} n_{2,h,t}^{\alpha}\right)\right)^{1-\mu_h} (k_{h,t-1})^{\mu_h}, \tag{1.9}$$

where $A_{h,t}$ is a shock to the marginal efficiency of producing housing and μ_h is the share of capital in the housing sector.

Retailers

In the consumption sector, there is a a continuum of measure one of retail firms, owned by the savers, that buy the wholesale goods CG_t at a competitive price P_t^w, differentiate it at no cost, and then sell it at a mark-up $X_t = P_t/P_t^w$ to the consumers[11]. The households then costlessly bundle these goods via the CES aggregator into homogeneous consumption $c_{i,t}$ and investment.

Each firm is subject to Calvo price rigidity and in any given period it has a probability, $1-\theta_\pi$ to optimally reset the price for its product. If a firm does not get to adjust the price, it will simply index it to the inflation rate in the previous period with elasticity ι_π.

Firms choose $\tilde{P}_t$ to maximize the expected present value of their real profits, as follows:

$$\sum_{k=0}^{\infty} \theta_p^k E_t\{\Lambda_{t+k}\left(\frac{\tilde{P}_t}{P_{t+k}} - \frac{X_t}{X_{t+k}}\right) CG_{t+k}^d(\tau)\} = 0. \tag{1.10}$$

where $\Lambda_{t+k} = \beta_1 \frac{C_{1,t}}{C_{1,t+k}}$ is a stochastic discount factor and X_t is the markup.

Since on average, a fraction θ_π of firms cannot reset their prices, and those that do, will choose the same price, the evolution of the aggregate price level is given by:

$$P_t = (\theta_\pi (P_{t-1})^{1-\epsilon_p} + (1-\theta_\pi)(\tilde{P}_t)^{1-\epsilon_p})^{\frac{1}{1-\epsilon_p}} \tag{1.11}$$

The consumption-sector Phillips curve is given by:

$$\ln \pi_t - \iota_\pi \ln \pi_{t-1} = \beta(E_t \ln \pi_{t+1} - \iota_\pi \ln \pi_t) - \epsilon_\pi \ln(X_t/X), \tag{1.12}$$

where $\epsilon_\pi = \frac{(1-\theta_\pi)(1-\beta\theta_\pi)}{\theta_\pi}$.

[11] Iacoviello and Neri (2010) argue that price rigidities in the housing sector appear as unrealistic, given that for these expensive goods there is a large incentive to negotiate the price and also because most homes are priced for the first time when they are sold.

1.2.3 Wage Rigidity

The model features wage rigidity, as in Erceg et al. (2000), for both types of households and sectors[12]. Therefore there are four labor unions in this economy, to which households supply homogeneous labor services[13]. In turn, the labor services are differentiated by these unions and the wages are set following a Calvo scheme with partial indexation to past inflation. Finally, the unions offer the labor services to wholesale labor packers who combine them, at no cost, into the homogeneous labor composites.

For a given type of household (patient or impatient) and sector (consumption or housing) each union is a monopolistically competitive supplier of differentiated labor services, which allows them to set their own wage. In any given period t a union in sector $j = c, h$ (regardless of the type of labor), has a probability θ_{wj} of not being able to optimally reset its nominal wage, in which case it indexes the wage to past inflation with elasticity ι_{wj}. Alternatively, it chooses a new wage such that the union's future expected average marginal revenue will equal the average marginal cost of supplying labor.

The four wage equations, derived in a similar fashion to the consumption sector Philips curve, are given by:

[12]Christiano et al. (2005) argue that the critical nominal friction in their model is wage rigidity. They find that a model that only includes price rigidities cannot generate persistent movements in output unless the price contracts have a very long duration, while a model with nominal wage rigidities does not have this problem. Iacoviello and Neri (2010) confirm that the presence of price and wage rigidities in their model is necessary to account for the volatility of housing investment. Without such mechanisms in place the housing investment sector is disconnected from the monetary and inflation disturbances.

[13]One for each household and sector pairing.

$$\ln\omega_{c,t} - \iota_{wc}\ln\pi_{t-1} = \beta(E_t\ln\omega_{c,t+1} - \iota_{wc}\ln\pi_t) - \epsilon_{wc}\ln(X_{wc,t}/X_{wc})$$
$$\ln\omega'_{c,t} - \iota_{wc}\ln\pi_{t-1} = \beta'(E_t\ln\omega'_{c,t+1} - \iota_{wc}\ln\pi_t) - \epsilon'_{wc}\ln(X_{wc,t}/X_{wc})$$
$$\ln\omega_{h,t} - \iota_{wh}\ln\pi_{t-1} = \beta(E_t\ln\omega_{h,t+1} - \iota_{wh}\ln\pi_t) - \epsilon_{wh}\ln(X_{wh,t}/X_{wh})$$
$$\ln\omega'_{h,t} - \iota_{wh}\ln\pi_{t-1} = \beta'(E_t\ln\omega'_{h,t+1} - \iota_{wh}\ln\pi_t) - \epsilon'_{wh}\ln(X_{wh,t}/X_{wh})$$

where $\omega_{i,t} = \frac{w_{i,t}\pi_t}{w_{i,t-1}}$ is the nominal wage inflation for each sector/household pair.

1.2.4 Monetary Authority

The monetary policy is conducted by a central bank. This monetary authority is assumed to be endowed with a commitment technology that insures time consistency of monetary policy decisions and, thus, the announced policy is fully credible for the private sector.

The monetary policy is given by a linear interest rate rule stated here in terms of log deviations from the deterministic steady-state level of the following form:[14]

$$\hat{R}_t = \alpha_\pi(1-\alpha_r)\hat{\pi}_t + \alpha_y(1-\alpha_r)\hat{Y}_t + \alpha_r\hat{R}_{t-1} + u_{r,t} \tag{1.13}$$

where α_r corresponds to the degree of interest rate smoothing, α_π measures the responsiveness of interest rate deviations of inflation from its steady state level, α_y is the output gap coefficient, and $u_{r,t}$ represents a zero-mean i.i.d monetary shock with variance σ_r^2. For any variable x_t, we have that $\hat{x}_t \equiv \ln(\frac{x_t}{\bar{x}})$, where $\bar{x}$ represents the non-stochastic steady state value of x_t.

[14]Many policy rules define the output gap in terms of deviations from its natural level, but that requires the policymaker to know, besides the deterministic steady state of the economy, the joint distribution of all shocks driving the economy and their current realizations.

1.2.5 Government Sector

The government in this economy balances expenditures (public spending and transfers) against tax revenues and net borrowing using the following budget constraint:

$$G_t + b_{g,t-1}\frac{R^g_{t-1}}{\pi_t} + Z_t = b_{g,t} + \tau^l_t\left(\frac{w_{1,c,t}n_{1,c,t}}{X_{1,wc,t}} + \frac{w_{1,h,t}n_{1,h,t}}{X_{1,wh,t}}\right)$$

$$+\tau^l_t\left(\frac{w_{2,h,t}n_{2,h,t}}{X_{2,wh,t}} + \frac{w_{2,c,t}n_{2,c,t}}{X_{2,wc,t}}\right) + \tau^k_t\left(r_{c,t}k_{c,t-1} + r_{h,t}k_{h,t-1}\right) \tag{1.14}$$

1.2.6 Aggregation

The consumption goods market includes private consumption of the households, investment in physical capital for the two production sectors, and government spending, thus:

$$CG_t = c_{1,t} + c_{2,t} + ik_{c,t} + ik_{h,t} + G_t \tag{1.15}$$

The market clearing condition for the housing market implies that:

$$IH_t = H_t - (1-\delta_h)H_{t-1}, \tag{1.16}$$

where IH_t is current period production of housing goods and $H_t = h_{1,t} + h_{2,t}$ denotes the aggregate stock of housing.

Total output in this economy is defined as:

$$Y_t = C_t + I_t + G_t, \tag{1.17}$$

where $C_t = c_{1,t} + c_{2,t}$ represents (total) private consumption, $I_t = ik_{c,t} + ik_{h,t} + \bar{q}IH_t$ is aggregate investment in capital goods and housing stock (evaluated at steady state real prices).[15]

Finally, the credit market clears when:

$$b_{1,t} + b_{2,t} + b_{g,t} = 0 \tag{1.18}$$

1.2.7 Exogenous processes

The model is perturbed by eight exogenous processes. Four of them, the housing preference shock, productivity in consumption sector, and housing, respectively, $\chi_t = \{j_t, A_{c,t}, A_{h,t}\}$ follow an AR(1) process described bellow.

$$\ln(\chi_t) = \rho_\chi \ln(\chi_{t-1}) + \varepsilon_{\chi_t}, \tag{1.19}$$

where $\varepsilon_{\chi_t} \sim N(0, \sigma^2_{\varepsilon_\chi}), 0 < \rho_\chi < 1$.

The monetary shock $u_{r,t}$ is assumed to be zero-mean i.i.d with variance σ_r^2. The remaining four refer to the government tax and expenditure processes. These feedback rules are posited to respond to the level of debt-to-output ratio and are given below in terms of log deviations from steady state:[16]

$$\hat{\tau}_t^l = \rho_{\tau^l}\hat{\tau}_{t-1}^l + (1-\rho_{\tau^l})\phi_{\tau_l}(\hat{b}_{g,t-1} - \hat{Y}_{t-1}) + v_t^{\tau^l}$$

$$\hat{\tau}_t^k = \rho_{\tau^k}\hat{\tau}_{t-1}^k + (1-\rho_{\tau^k})\phi_{\tau_k}(\hat{b}_{g,t-1} - \hat{Y}_{t-1}) + v_t^{\tau^k}$$

$$\hat{Z}_t = \rho_z \hat{Z}_{t-1} - (1-\rho_z)\phi_z(\hat{b}_{g,t-1} - \hat{Y}_{t-1}) + v_t^z$$

[15] This helps insulate output growth from short run changes in house prices.

[16] These fiscal processes are similar to those used in the literature for medium-scale DSGE models, like Leeper and Yang (2008), Iwata (2009), or Butz (2012).

$$\hat{G}_t = \rho_g \hat{G}_{t-1} - (1-\rho_g)\phi_g(\hat{b}_{g,t-1} - \hat{Y}_{t-1}) + v_t^g \tag{1.20}$$

where the positive parameters ϕ_z, ϕ_g, ϕ_{τ_k}, and ϕ_{τ_l} represent debt automatic stabilizers that control the repayment speed of public debt in order to ensure government solvency.

1.3 Calibration

The model economy is calibrated at a quarterly frequency, largely based on Iacoviello (2005) and Iacoviello and Neri (2010)[17]. It aims to match certain dimensions of the US economy for the period 1965Q1-2008Q1[18]. In Tables 1.1 and 1.2, I give the calibrated values used for the core structural parameters that govern preferences, technology, policy, price and wage stickiness, as well as, the various exogenous processes.

For the patient household, the discount factor β_1 is assumed to be 0.99, which corresponds to an approximately 4% steady state annual interest rate. The borrowers exhibit a stronger preference for present consumption and thus have a discount factor β_2 of 0.95. A high enough degree of impatience is required for these agents in order to insure that their credit limit is binding in the steady state.

The weight of housing j in the utility function is set at 0.12 which accounts for a ratio between the residential stock and GDP of approximately 1.35. Also, the consumption habit parameters ϵ_1 and ϵ_2 are 0.32 and 0.58, respectively. The larger value for the impatient

[17]Many related studies on fiscal policy, such as Gali et al. (2007), Leeper and Yang (2009), or Fernandez-Villaverde (2010) also rely on calibrated DSGE models of the U.S. economy and first order approximations. Using a similar approach, thus helps make our results directly comparable to the existing literature. Furthermore, as Iskrev (2008) and others suggested, local parameter identification in estimated models that use first order approximations can be problematic and higher order approximations should be considered. Nevertheless, this would raise a number of technical challenges in estimation, hinging on the use of the particle filter to recover the likelihood function like in Butz (2012), which I leave for future work.

[18]Because in this paper I am not accounting for the zero lower bound effect on the interest rate, I leave out the post-crisis period.

agents is required in order to match the persistence of consumption in aggregate data, since these agents cannot engage in inter-temporal consumption smoothing via savings.

The labor income share of the credit constrained households (α) is set at 20 percent which, as Iacoviello and Neri document, is large enough to generate a positive response of consumption to house prices. This value is in line with estimates from the literature such as Traum and Yang (2010) that give a value of 18 percent, or Jappelli (1990) with 20 percent for the share of constrained households.

Price stickiness (θ_π) is 0.83 which corresponds to a price reoptimization frequency of around six quarters. Regarding wage stickiness, the adjustment schedule is similar for both sectors with $\theta_{wc} = \theta_{wh} = 0.80$. Wage indexation is higher in the housing sector, with $\iota_{wh} = 0.40$, compared to consumption goods production $\iota_{wc} = 0.08$.

In production, the depreciation rate for housing $\delta_h = 0.01$ suggests a ratio of residential investment to total output of approximatively 6%. The depreciation rates for the consumption and housing sectors, respectively, ($\delta_{kc} = 0.025$ and $\delta_{kh} = 0.03$) give a ratio between non-residential and GDP of 27%, while the ratio of business capital to annual GDP is approximately 2.1. The labor supply elasticity (η) is assumed to be same for both types and is set at 2, in line with other studies such as Smets and Wouters (2007) with 1.9, or Traum and Yang (2010) with 2.1.

As baseline, the loan-to-value parameter (LTV) m is set at 0.85 to match the original model. It was chosen based on observed average values for homebuyers, using data from the Federal Housing Finance Agency's Monthly Survey of Rates on Conventional Single-Family Non-farm Mortgage Loans (Table 1.17) and Terms on Conventional Single-Family Mortgages, Newly Built Homes (Table 1.10). Over the considered sample, 75 percent of the buyers had a loan to value ratio above 0.7, with 34 percent above 0.80 and 17 percent above 0.9.

Regarding the policy parameters, the values for the Taylor Rule were chosen to insure determinacy and are based on the estimated values in Iacoviello and Neri (2010) i.e. $r_R = 0.59$, $r_\pi = 1.44$, $r_Y = 0.052$.

The fiscal stabilizers $\phi_g, \phi_{tr}, \phi_{\tau_k}$, and ϕ_{τ_l} have values between 0.065 and 0.126. These parameters play an important role in the existence and uniqueness of the model equilibrium, as they enforce the transversality condition for public debt, ruling out explosive paths. The values, subject to this provision, were chosen based on related studies: Leeper and Yang (2009), Butz (2012).

All shocks are quite persistent with autocorrelation coefficients ranging between 0.80 and 0.95. Their specific values are detailed in Table 1.2. The share of government spending to output in steady state $\frac{\bar{G}}{\bar{Y}}$ is fixed at 8.4% to match the average in the data, while the ratio of government debt to GDP is 48% (annual). Similarly the share of transfers $\frac{\bar{Z}}{\bar{Y}}$ is 10.14% and the tax rates, using the approach given in Jones (2002), are 22.3% for labor and 18.4% for capital.[19]

1.4 Results

1.4.1 Model Dynamics - Transmission of Fiscal Shocks

In this section I present the model's dynamic responses to expansionary fiscal shocks in all of the four fiscal instruments considered (government spending, transfers, labor and capital income taxes). The impulse response functions are included in the Appendix, Figures 1.1 through 1.4.[20] Regarding its cyclical properties, the model appears to replicate quite well both the variables correlations and their volatility (HP filtered) as shown in Tables 1.3 and 1.4.

[19] A description of the data and methodology for computing the tax rates is included in the Appendix

[20] Under a second order approximation, the dynamics of the model, as described by the IRFs, appear very similar. Nevertheless, there are some small differences in the marginal utility of consumption for the two types of agents - a second order approximation gives slightly lower values in both cases.

The economy is described by the baseline calibration and operates under a simple, current-looking Taylor-type rule. More precisely,

$$\hat{R}_t = 1.44\hat{\pi}_t + 0.052\hat{Y}_t + 0.59\hat{R}_{t-1} \tag{1.21}$$

Government spending - a temporary, one percent, increase in government expenditures has an expansionary effect on both output and aggregate consumption. The difficulty of the Neoclassical and New Keynesian models with a standard representative agent to generate a positive consumption response to changes in government spending is well documented in the literature[21]. In the absence of credit or liquidity constraints, the households, who are forward looking, will associate the fiscal stimulus with higher future taxes which creates a negative wealth effect. Therefore, consistent with consumption smoothing, they will respond by increasing labor effort and decreasing current consumption for additional savings in order to pay for their expected future tax obligations.

In the current framework the positive co-movement between government spending and consumption is explained by the response of the impatient households. These agents, due to their high discount rate, have a large marginal propensity to consume and already hold debt up to the value of their collateral. The increase in their transitory income, which is equivalent to additional borrowing at the prevailing interest rate, will allow them to expand consumption. The higher inflation also erodes the value of their outstanding debt (denominated in nominal terms), which has a further positive impact on the consumption response. Overall the effect is significant enough to offset the drop in the consumption of the patient for approximatively five quarters.

Because the stimulus is debt financed, rising government debt will put upward pressure on the interest rate. Also, the monetary authority's concerns about inflation due to increased

[21] See for example Hall (2009) for a more detailed review of the literature

demand will solicit another positive adjustment in the nominal rate. The real interest rate therefore increases and crowds out private investment.

The negative wealth effect associated with higher future taxes, as well as, the increase in the real interest induce the patient agents to reduce their demand for current consumption and housing goods in favor of savings. As a result house prices drop, which reduces the value of the collateral held by borrowers and tightens the credit limit. The credit constrained households will thus scale down their consumption at longer horizons, which over time, brings both aggregate consumption and output down.

The mechanism outlined above is absent in models with only liquidity constrained agents, who do not participate in the capital markets. If on impact and in the short run, the consumption response of the credit constrained households is similar, the addition of the asset channel allows for a more complex interplay between policy measures and economic effects.

Transfers - A one percent increase in lump-sum transfer payments to households results in a direct increase in their disposable transitory income. While the borrowers do not respond much to it, there is a significant jump on impact in the consumption of the constrained agents, which accounts for the overall change in aggregate consumption. This additional demand boosts output, as well as employment and labor income that help sustain the effect. As before, there is an increase in real interest, which accounts for crowding out of investment and a decline in house prices. Combined, the two effects make credit more expensive and reduce the borrowers' disposable income, leading to a decline in their consumption at longer horizons.

Labor taxes - a reduction in the labor income tax works very similarly to an increase in transfer payments. In both cases the positive response of aggregate consumption is largely borne out by the impatient households who are very sensitive to changes in transitory income.

These agents would like to access more credit for additional consumption, but cannot do so because of the collateral requirement. In terms of the output impact, the two policy actions have comparable effects. A major difference, though, is the response of real wages which will fall in the wake of a labor tax cut as labor supply goes up. At longer horizons, the drop in labor income will have a negative impact on consumption expenditures (especially for the borrowers as their only source of income). Nevertheless, due to the wealth effect induced by higher consumption, the reduction in real wages will be smaller than in a model without credit constraints. Wage rigidity also plays a role here, as it slows, in the short run, the decline in real wages and labor income, thus allowing for additional consumption.

Capital taxes - finally, a cut in the tax on capital revenues increases the (after-tax) rental rate of capital and induces savers to reallocate their financial resources from lending towards investment. Together with the increase in public debt, this reduces the volume of credit available to the impatient agents and accounts for a sharp negative adjustment in their consumption in the short run. At the same time, inflation will drop, pushing up the real interest rate and increasing the debt burden. There is also a decline, albeit modest, in house prices which further impacts borrowers. The positive wealth effect for the capital owners leads to only a negligible response in their consumption and the overall effect on aggregate consumption is negative, but small. On impact, the output response is negative, nevertheless as the new capital becomes operational, the economy picks up and output remains positive for around eleven quarters. At longer horizons, the real interest rate increases and investment declines, reducing production.

1.4.2 Present Value Multipliers

In line with the related literature on fiscal policy, I summarize the quantitative effects of fiscal shocks by calculating and reporting present-value multipliers for aggregate output, consumption, and investment[22] . The results are included in Tables 1.5 through 1.8, for various time horizons, up to twenty quarters.

The use of present value multipliers takes into account the dynamics induced by fiscal innovations, while also discounting macroeconomic effects in the future. As documented by Uhlig (2009) relying exclusively on impact multipliers can be misleading. Nevertheless, they are still a useful comparison point, given their widespread use in empirical studies like Blanchard and Perotti (2002), Forni, Monteforte, and Sessa (2009) and others.

More specifically, the present value multiplier of additional output induced by a policy innovation is given by the ratio between the discounted sum of changes in GDP over a k-period horizon (using the discount factor of the lenders which fixes the steady state level of the interest rate) and government spending calculated in the same way[23].

Therefore,

$$\text{Multiplier}(k) = \frac{\mathrm{E_t} \sum_{j=0}^{k} \left(\prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta Y_{t+j}}{\mathrm{E_t} \sum_{j=0}^{k} \left(\prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta G_{t+j}} \tag{1.22}$$

In this framework, with heterogeneous agents, the impact multiplier ($k = 1$) for government spending is greater than one, as a result of crowding in of private consumption borne out by increased demand from the impatient households (borrowers). The initial shift out in aggregate demand due to a higher level of government expenditures is followed by an increase in labor demand, which in turn raises household income and allows for additional consumption. The positive effect on aggregate consumption is large enough to offset in the short run the crowding out of private investment and account for a larger positive response in output.

As Gali et al. (2007) have showed, it is possible to have a positive response of private

[22]See for example Mountford and Uhlig (2009).

[23]For tax instruments I consider the change in tax revenue instead.

consumption and a larger than unity output multiplier in a New Keynesian model with liquidity constrained agents, elastic labor supply and price rigidities. Nevertheless, this type of agents does not have access to the financial market and cannot engage in intertemporal consumption smoothing, which overstates the effectiveness of fiscal policy. In their model, the output and consumption multipliers have values above 1.5 and 1, respectively, depending on calibration.

In contrast, the literature based on real business cycle models, like Fatas and Mihov (2001), Uhlig (2009) report uniformly smaller values of around 0.6. In the current model with credit constrained households, under the baseline calibration, the net (impact) effect of government spending on aggregate consumption appears positive, but relatively small (0.12), while the output multiplier is 1.03. These values are in range of the results from empirical (VAR) studies like Blanchard and Perotti (2002), or Ramey (2008), who also report multipliers of around 1.

At longer horizons, as the crowding out of private investment by government spending starts to take effect, output declines and the multipliers go down gradually but remain positive up to the twenty quarters mark. Aggregate consumption ends up falling as well, the multipliers becoming negative in this case after approximatively six quarters. Furthermore, the fall in consumption is accelerated by a decline in house prices, induced by fiscal stimulus.

The output multipliers associated with an increase in government transfers are small, with a value of 0.125 on impact. They stay positive for approximately twelve quarters, but at longer horizons, become negative, as the positive economic effects induced by increased consumption (mainly borrowers) disappear.[24].

Furthermore, there appears to be crowding out of private investment due to the increase in the interest rate, which further weakens the expansionary effects.[25] Still the long term

[24]The increase in the interest rate, has a negative effect on the credit conditions for the impatient agents, reducing the amount they can borrow.

[25]In general, the fiscal multipliers are sensitive to the monetary policy adopted by the Central Bank.

implications for aggregate investment are likely ambiguous. The increase in transfers payments leads to both higher public debt and taxes (through the debt stabilizing component of the fiscal processes). The lenders anticipating this negative wealth effect, will likely consider reallocating more resources into investment, to offset a drop in their consumption (habit formation also plays a role here).

Quantitatively, the short run output multipliers for a decrease in the labor tax are not very different from those observed for a positive government transfer shock. The mechanism behind these policies is similar, since they both affect household disposable income and thus consumption, resulting in positive multipliers.

The main difference appears at longer horizons, as the output multipliers remain positive in the case of the labor tax cut thanks to a less severe crowding out of private investment. Eventually, real wages start to decline, as well as prices, which tends to have a negative effect on the borrowers consumption by reevaluating their debt obligations. Together with the automatic stabilizers this will bring down consumption multipliers over time.

Finally, lower capital taxes appear to have a relatively weak expansionary effect on output. While rental income tax cuts create incentives for additional investment by savers, this comes at the expense of consumption for both types of agents as lenders reallocate their financial resources. The consumption multipliers are negative, but increases in output supported by the the additional capital stock alleviate the effect after approximatively eight quarters.

The increase in public debt induces, through the debt automatic stabilizers, cuts in government consumption and transfers which account for lower aggregate consumption. Furthermore, different from the other fiscal instruments discussed, under this scenario the number of hours worked does not increase on impact, thus limiting the consumption demand

A more relaxed monetary stance, characterized by a less aggressive response to inflation and/or cyclical fluctuations tends to amplify the expansionary effect of changes in government expenditures, as well as, labor income tax cuts. Figure 1.16 and 1.17 present a counter factual experiment for impact multipliers.

from credit constrained households.

Overall, the initial increase in investment turns out to be insufficient to offset the drop in consumption, so output falls at longer horizons. This decline in aggregate income also leads to an eventual drop in investment spending.

1.4.3 Sensitivity Analysis

Lump-sum versus Distortionary Taxation

The counter-factual experiment presented in Figure 1.5, compares the case when the government conducts exogenous fiscal policy, where deficits are financed via lump-sum taxes relative to the baseline scenario of distortionary taxation (on labor and capital income). The output effects of a government spending shock appear significantly larger, at medium and longer horizons, with lump-sum taxation, since the equilibrium is not affected by the timing of taxes.

At shorter horizons, the spending multipliers are closer due to the adjustment time in taxes. Nevertheless, these results suggest that a model with a simpler fiscal sector may overemphasize the impact of fiscal interventions. Baxter and King (1993) have shown that substitution effects in labor supply, induced by changes in tax rates, play an important role in this sense. More recent work based on estimated medium scale models, like Leeper et al. (2009), Drautzburg and Uhlig (2011), or Zubairy (2014) offers further support for distortionary taxation.

Fiscal Stimulus and Credit Conditions

This section explores in more detail the implications that financial frictions, modeled in this framework as a collateral constraint on private borrowing, have on the effectiveness of fiscal stimulus.

For this experiment, I focus on a temporary increase in government expenditures, since as the present value multipliers results have showed, this type of policy action has the largest effect on aggregate output, thus setting an upper threshold on the expected impact. Furthermore, there is also a wealth of related empirical results, coming from the VAR literature, which can offer a useful comparison point.

There are two main dimensions that describe credit conditions in the model economy. First, the loan-to-value (LTV) ratio directly determines the amount of debt a borrower can access based on the value of her collateral and, second, the (economic) size of credit constrained population which is controlled by their labor income share parameter α.

The results of the policy experiment are showcased in Figure 1.6 which gives the impact fiscal multipliers, as a function of the share of borrowers, for two relevant values of the LTV parameter: $m_1 = 0.85$, which matches the baseline model calibration, and $m_2 = 0.75$, a more conservative value.[26]

Intuitively, as the loan-to-value ratio increases, the borrowing constraint on the impatient agents is relaxed, which allows them to borrow and consume more. Also, for a larger share of credit constrained agents, the impact on aggregate consumption goes up as well. This puts upward pressure on wages, raises household income and ultimately leads to a more expansionary fiscal effect.

The LTV parameter directly affects the financial amplification mechanism in the model and a sufficiently large value is required to generate output multipliers larger than unity. In fact, in the conservative case, the output multipliers, while positive, are below unity even for a large fraction of constrained households (close to half). This is because the consumption of the impatient agents is not large enough, with the amount of credit available to them, to offset the crowding out effect in savers' consumption and private investment.

[26] According to data from the Federal Housing and Finance Agency from their Survey of Rates and Terms on Conventional Single-Family Non-farm Mortgage loans (Table 1.19),the average LTV ratio is 75.6 between 1973 and 2008.

Deficit financed fiscal expansions lead to a drop in house prices, under all scenarios, due to an increase in the real interest rate. The response of the real interest rate, crowds out private investment and creates added incentives for lenders to engage in inter-temporal consumption smoothing. In turn this depresses the housing market, reduces the borrowers' net worth, by decreasing the value of their housing stock (the credit collateral), and forces them to scale back consumption. If unaccounted for by the monetary authority, the feedback effect will limit the expansionary impact of the fiscal package on output and consumption.

In general, when borrowers want to increase their consumption, they also need to build up the collateral stock. This creates additional demand for housing goods and pushes up their price. However, the effect will be severely weakened when the constrained agents have very limited access to credit. So, in a deleveraged economy (like in the wake of a credit crunch) house prices would be lower on average.

The mechanism also explains why the drop in house prices is larger in response to the government spending shock under a low LTV ratio, compared to a larger value. Essentially, the downward pressure imposed on house prices by the patient agents is offset to a much smaller degree by the credit constrained households.

The model therefore predicts (when accounting for the asset price transmission channel) that under difficult financial conditions debt financed fiscal stimulus has a reduced response on output and, if credit frictions are significant enough, the response of aggregate consumption may be in fact negative.

Fiscal Multipliers, Nominal Rigidities, and the Persistence of Fiscal Shocks

The role of price rigidities is well established in both the business cycle literature and in the models typically used for monetary policy analysis (King and Watson, 1995, Erceg et al., 2000, Christiano et al., 2005, Smets and Wouters, 2007 to name just a few). Also, as Harms (2002), Gali et al (2007), Fernandez-Villaverde et al. (2011) among others have documented, shock persistence has important implications regarding the aggregate economic effects of fiscal packages (either expansionary or for consolidation). Therefore it is informative to also consider the role of these key structural parameters in the current framework.

In principle, a higher degree of price stickiness requires a smaller adjustment in the expected real interest rate, as the response of inflation is more sluggish. This effect, on the one hand, helps reduce the drop in current consumption for savers and, on the other hand, dampens the decline in housing prices. Since house prices directly determine the borrowers net worth, they implicitly set the amount of credit these agents can access and, thus, will prevent a sharper negative adjustment in their consumption.

Figure 1.7 shows present value output multipliers calculated up to a twenty quarters horizon. I consider three values of the price stickiness parameter, while keeping the rest of the baseline calibration unchanged. In line with the intuition outlined above, the simulation shows an increase in output multipliers at all horizon when prices become more rigid.

The effects of wage stickiness are showcased in Figure 1.8. When wages are more flexible labor income can raise faster in response to an increase in labor demand, induced by higher aggregate demand. In the short run, the extra income will provide for additional consumption from the credit constrained agents, nevertheless at longer horizons the associated increase in marginal costs will raise prices and limit economic growth. Thus, the economy spends less time operating above potential when wages adjust rapidly and the duration of the expansion and the overall impact on output will be reduced.

Consistent with the findings of Gali et al.(2007), the degree of persistence in fiscal shocks (here government spending) affects household choices mainly through its effects on the real interest rate and the relative prices in the economy. For instance, in the case of an expansionary fiscal shock, with a highly persistent government expenditure process, the households will expect higher public spending for longer.

This in turn will imply higher interest rates and lower house prices, forcing both types of agents to be more conservative in their spending decisions. The net effect will be a drop in aggregate consumption and output resulting in lower fiscal multipliers for both variables. The results are summarized in Figure 1.9.

Fiscal Multipliers, Government Debt Financing and Dynamics

In line with Leeper et. al (2009), I consider several alternative scenarios for public debt financing, as well as the effects of a stronger response in fiscal instruments to debt. The results of these policy experiments are presented in Figures 1.10 through 1.12.

The choice of how to finance the public debt appears to be particularly important especially at longer horizons. In particular, an over reliance on capital taxes imposes a large cost on society in terms of growth potential. A sharp rise in the capital tax, reduces investment spending significantly in the short and medium run, which stymies the productive capabilities of the economy in the long run. The output multipliers change sign and become negative, when only capital taxes are used to pay off debt, after approximatively thirty five quarters.

This pattern does not occur, though, when the government relies on labor taxes. In the short run, the output multipliers are marginally smaller, but they remain positive up the forty quarters mark, which is consistent with a smaller negative adjustment in investment spending in this case.

Finally, a more aggressive stance in the repayment of public debt tends to reduce output multipliers at all horizons when labor taxes are used. A larger increase in the labor tax in response to debt will,on one hand, have a significant negative effect on the consumption of constrained agents for which is the main source of income. This will erode over time the effect of fiscal stimulus. On the other hand, by increasing the disutility of labor, the number of hours worked will drop, which will have a negative impact on economic growth and translate into smaller long run multipliers.

When only capital taxes respond to debt, the degree of debt stabilization appears to have a nonlinear effect. A faster response to debt, tends to decrease the short run output multipliers by decreasing private investment, also the short increase in interest rates, has a negative impact on house prices and thus borrowers' consumption. At the same time, once the public debt has been paid off, the relaxation of credit conditions allows for an increase in investment and output which account for larger long run multipliers.

The dynamics of government debt in response to a government spending shock are described in Figures 1.13 through 1.15 for various combinations of fiscal instruments and debt stabilization parameters. In the baseline scenario ($\mu = 1$), when all fiscal processes respond to the state of public finances, debt peaks in approximately ten quarters. After that it starts to decline slowly, and it is paid off in approximately 10 years.

If only labor taxes respond to debt, the build up is a lot longer. Even with a hyper aggressive debt stabilization stance ($\mu = 10$) it takes more than 25 years to pay it off. On a relative basis, rental income taxes are significantly more effective and can eliminate debt in approximately 30 years with a fairly moderate repayment policy ($\mu = 2$). This finding is consistent with the model economy, which tends to concentrate assets with one group of households.

1.5 Concluding Remarks

In a New Keynesian framework that features credit constrained households, distortionary taxation and private debt tied to the value of the housing stock, increases in government expenditures can be a more effective economic stimulus instrument compared to tax reductions.

In the short run, the output response associated with government spending features a Keynesian multiplier (1.03), conditional on a sufficiently large degree of leverage in the model economy (0.85 under the baseline calibration). The central mechanism behind this finding is the consumption response for credit constrained agents, which rises on impact due to a high marginal propensity to consume that makes them very responsive to changes in transitory income.

The increase in aggregate consumption is large enough to offset the corresponding drop associated with the patient agents (savers) who exhibit a Ricardian behavior. The model is thus able to replicate the positive short run comovement between private consumption and government spending observed empirically (Perotti 2008, Ramey 2011, etc).

Quantitatively, both output and consumption multipliers appear smaller at all horizons than those typically reported in the DSGE models that incorporate rule-of-thumb agents (ROT). This literature frequently give values of around of around 1.5 or larger (Gali et. al (2007), Monacelli and Perotti (2008), Romer and Bernstein (2009)).

In the current framework all agents have access to the financial markets which dampens the response of consumption for the constrained agents relative to their ROT counterparts. Furthermore, the use of housing as collateral, introduces an additional transmission channel for policy via changes in housing prices which will affect credit availability to households and limit the response of output.

The loan-to-value ratio plays a key role in terms of the expected expansionary effect of fiscal measures. This parameter is directly tied to the borrowers' credit limit, as it determines the value of the housing stock which is allowed as collateral. Policy experiments have shown that a sufficiently large value of the LTV ratio (of around 0.80) is necessary in order to generate output multipliers above unity. In general, policy effects scale up with the size of credit constrained population.

A worsening in the quality of credit conditions modeled by a drop in the loan-to-value ratio (a forced deleveraging like in a credit crunch) or a reduction in the volume of private credit (modeled as a decrease in the share of borrowers) will reduce the expansionary effects of fiscal stimulus.

1.6 Appendix

1.6.1 Tables

Table 1.1: Calibrated Structural Parameters

Parameter	Value	Parameter	Value
β_1	0.99	η_2	2.00
β_2	0.95	ξ_1	0.66
μ_c	0.35	ξ_2	0.97
μ_h	0.1	α	0.20
δ_h	0.01	r_π	1.44
δ_{kc}	0.025	r_Y	0.052
δ_{kh}	0.03	θ_π	0.83
X, X_{wc}, X_{wh}	1.15	ι_π	0.69
m	0.85	θ_{wc}	0.80
ϵ_1	0.32	ι_{wc}	0.08
ϵ_2	0.58	θ_{wh}	0.80
η_1	2.00	ι_{wh}	0.4
ϕ_g	0.065	ϕ_{tr}	0.082
ϕ_{τ_l}	0.126	ϕ_{τ_k}	0.074

Table 1.2: Shock Processes Parameters

Parameter	Value
ρ_{AC}	0.95
ρ_{AH}	0.99
ρ_j	0.96
ρ_g	0.80
ρ_{tr}	0.85
ρ_{τ_l}	0.85
ρ_{τ_k}	0.90
σ_{AC}	0.01
σ_{AH}	0.0193
σ_j	0.0416
σ_R	0.0034
σ_g	0.0136
σ_{tr}	0.0145
σ_{τ_k}	0.0163
σ_{τ_l}	0.0196

Table 1.3: Business Cycle Properties - Correlations

VARIABLE	Corr(Model)	Corr (Data)
C,GDP	0.86	0.88
IK,GDP	0.88	0.75
IH, GDP	0.64	0.78
Q,GDP	0.68	0.58
Q,C	0.61	0.48
Q,IH	0.47	0.41

Table 1.4: Business Cycle Properties - Standard deviations

VARIABLE	Standard Deviation percent (Model)	Standard Deviation percent (Data)
C	1.62	1.22
IK	4.17	4.87
IH	8.69	9.97
Q	2.20	1.87
GDP	2.27	2.17
R	0.32	0.32

Table 1.5: Present Value Multipliers for an Increase in Government Spending

Quarters	Output	Consumption	Investment
1	1.035	0.122	-0.087
4	0.847	0.043	-0.197
8	0.636	-0.035	-0.328
12	0.527	-0.072	-0.401
20	0.353	-0.134	-0.511

Notes: The multipliers are calculated for output, aggregate consumption and investment. The fiscal shock is a 1 % transitory increase in government spending that is debt financed. All fiscal instruments adjust to stabilize debt. Time is measured in quarters.

Table 1.6: Present Value Multipliers for an Increase in the Government Transfer

Quarters	Output	Consumption	Investment
1	0.125	0.140	-0.015
4	0.074	0.102	-0.028
8	0.041	0.083	-0.042
12	0.013	0.067	-0.054
20	-0.023	0.049	-0.072

Notes: The multipliers are calculated for output, aggregate consumption and investment. The fiscal shock is a 1 % transitory increase in government transfers that is debt financed. All fiscal instruments adjust to stabilize debt. Time is measured in quarters.

Table 1.7: Present Value Multipliers for a Decrease in the Labor Tax

Quarters	Output	Consumption	Investment
1	0.131	0.152	-0.021
4	0.108	0.126	-0.018
8	0.094	0.111	-0.017
12	0.075	0.086	-0.011
20	0.045	0.053	-0.008

Notes: The multipliers are calculated for output, aggregate consumption and investment. The fiscal shock is a 1 % transitory decrease in labor tax that is debt financed. All fiscal instruments adjust to stabilize debt. Time is measured in quarters.

Table 1.8: Present Value Multipliers for a Decrease in the Capital Tax

Quarters	Output	Consumption	Investment
1	-0.011	-0.021	0.011
4	0.025	-0.008	0.034
8	0.053	0.001	0.051
12	0.042	-0.004	0.045
20	0.023	-0.011	0.033

Notes: The multipliers are calculated for output, aggregate consumption and investment. The fiscal shock is a 1 % transitory decrease in labor tax that is debt financed. All fiscal instruments adjust to stabilize debt. Time is measured in quarters.

1.6.2 Figures

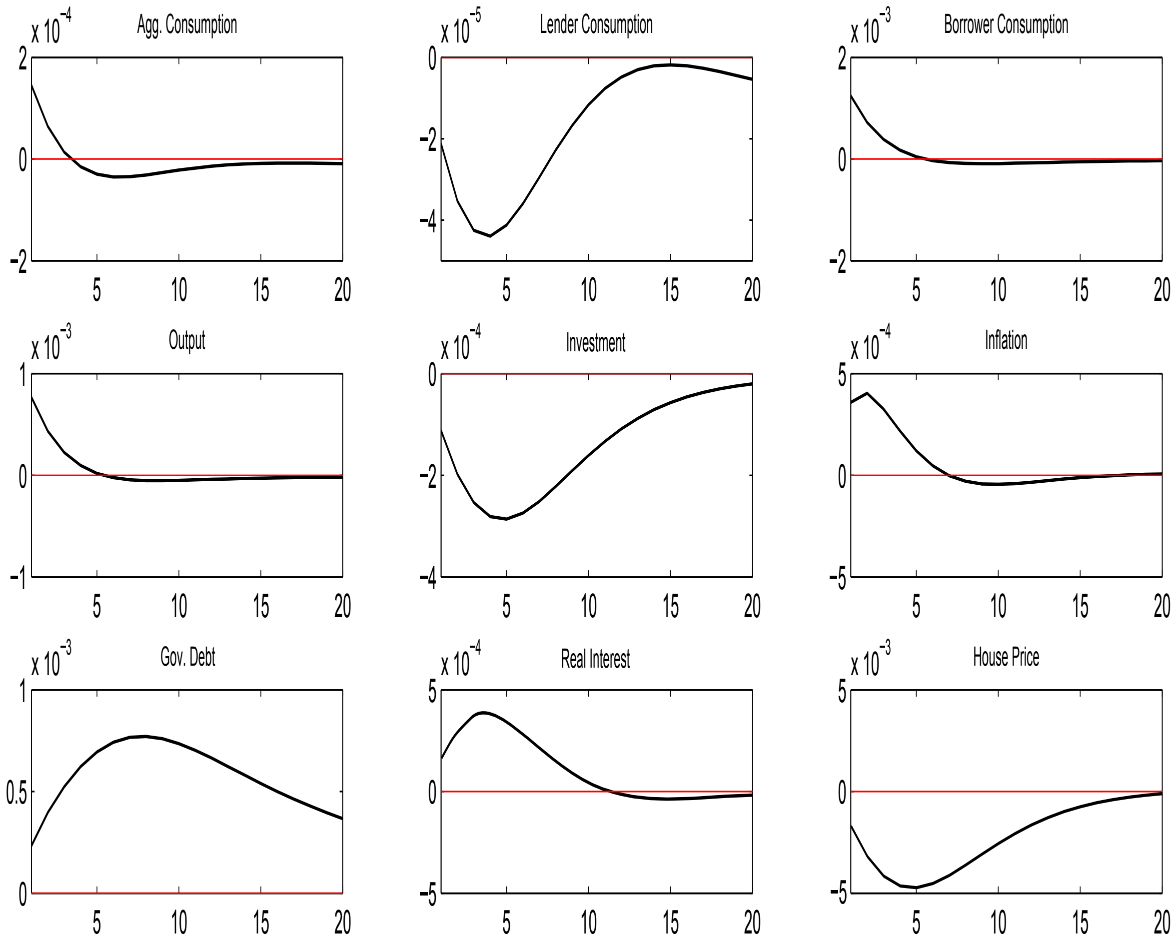

Figure 1.1: Impulse response to a 1 percent increase in government expenditures. X-axis measures quarters, Y-axis (times 100) measures percentage deviations from steady state.

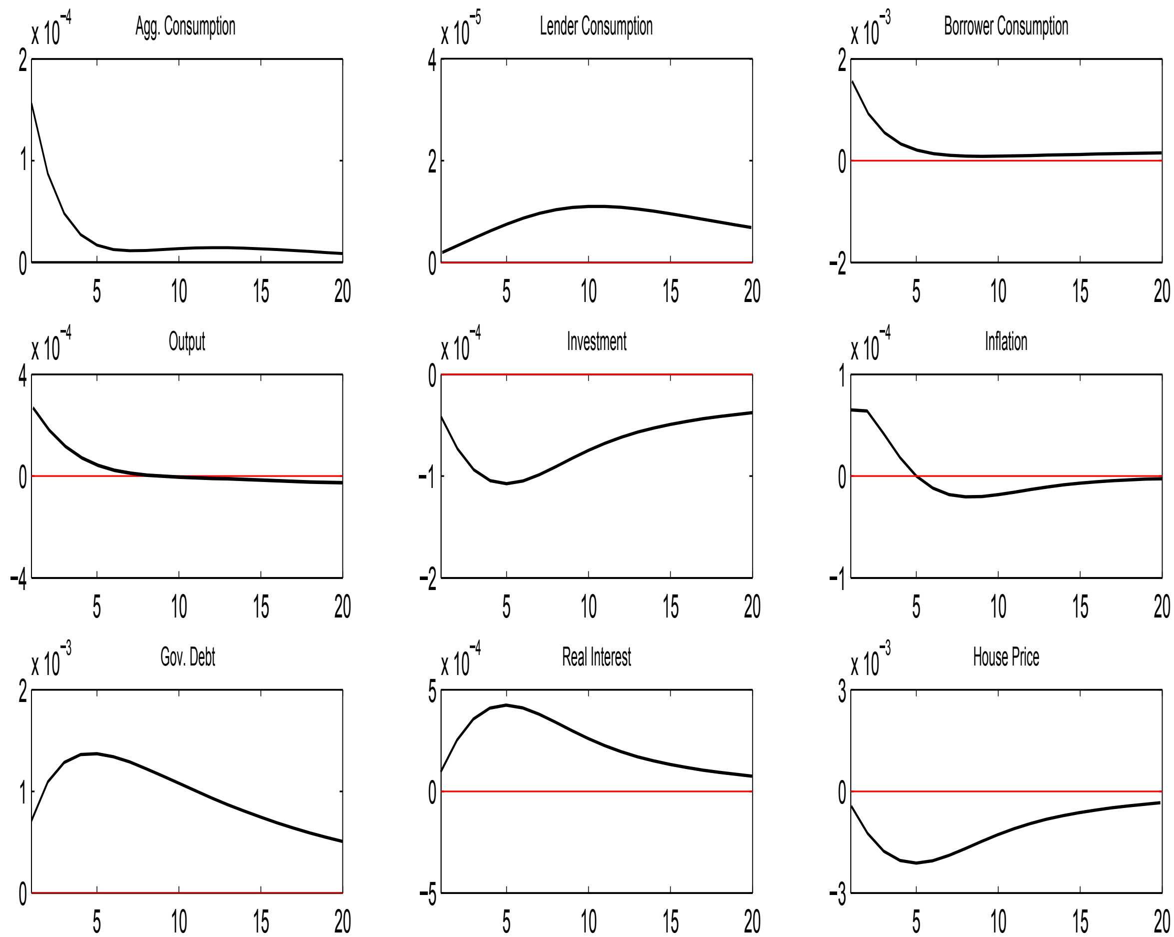

Figure 1.2: Impulse response to a 1 percent increase in government transfers. X-axis measures quarters, Y-axis (times 100) measures percentage deviations from steady state.

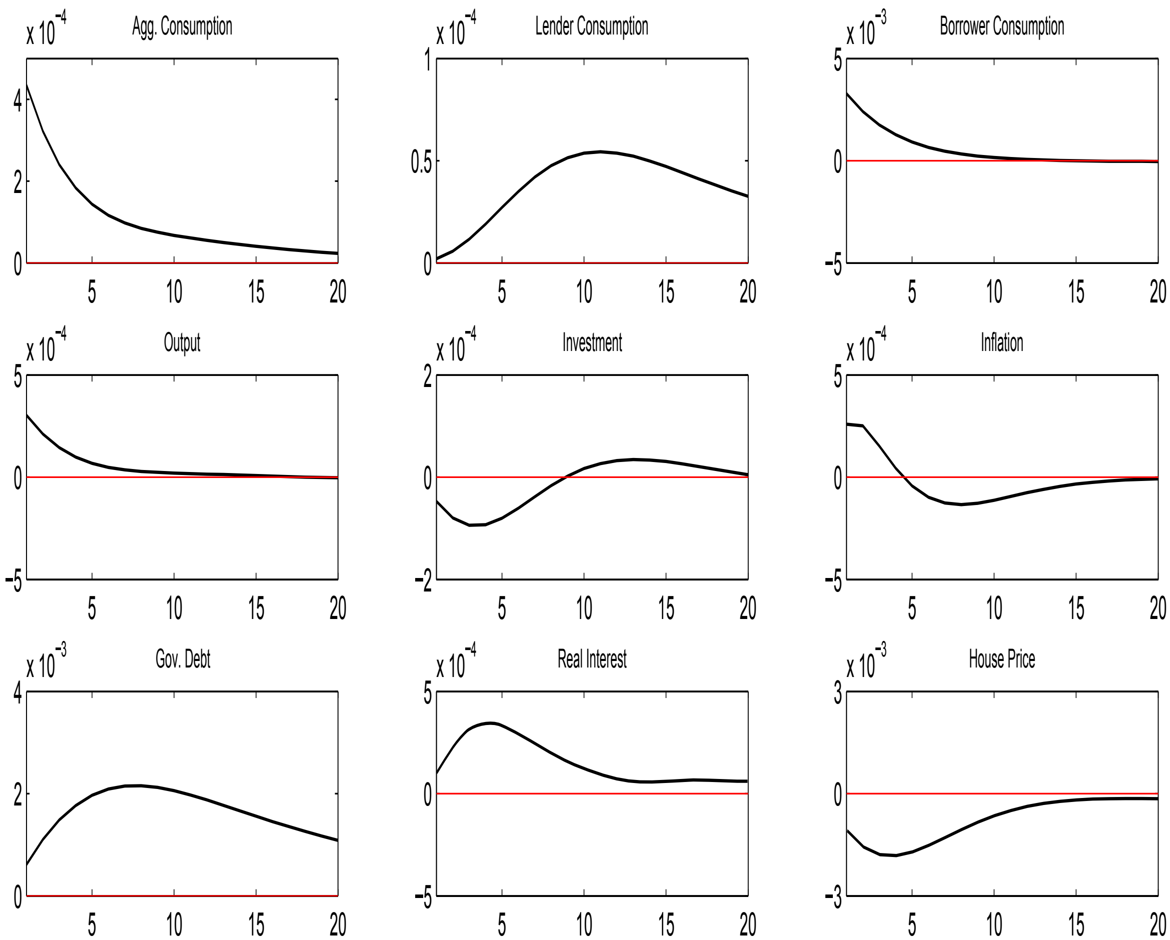

Figure 1.3: Impulse response to a 1 percent cut in the labor income tax. X-axis measures quarters, Y-axis (times 100) measures percentage deviations from steady state.

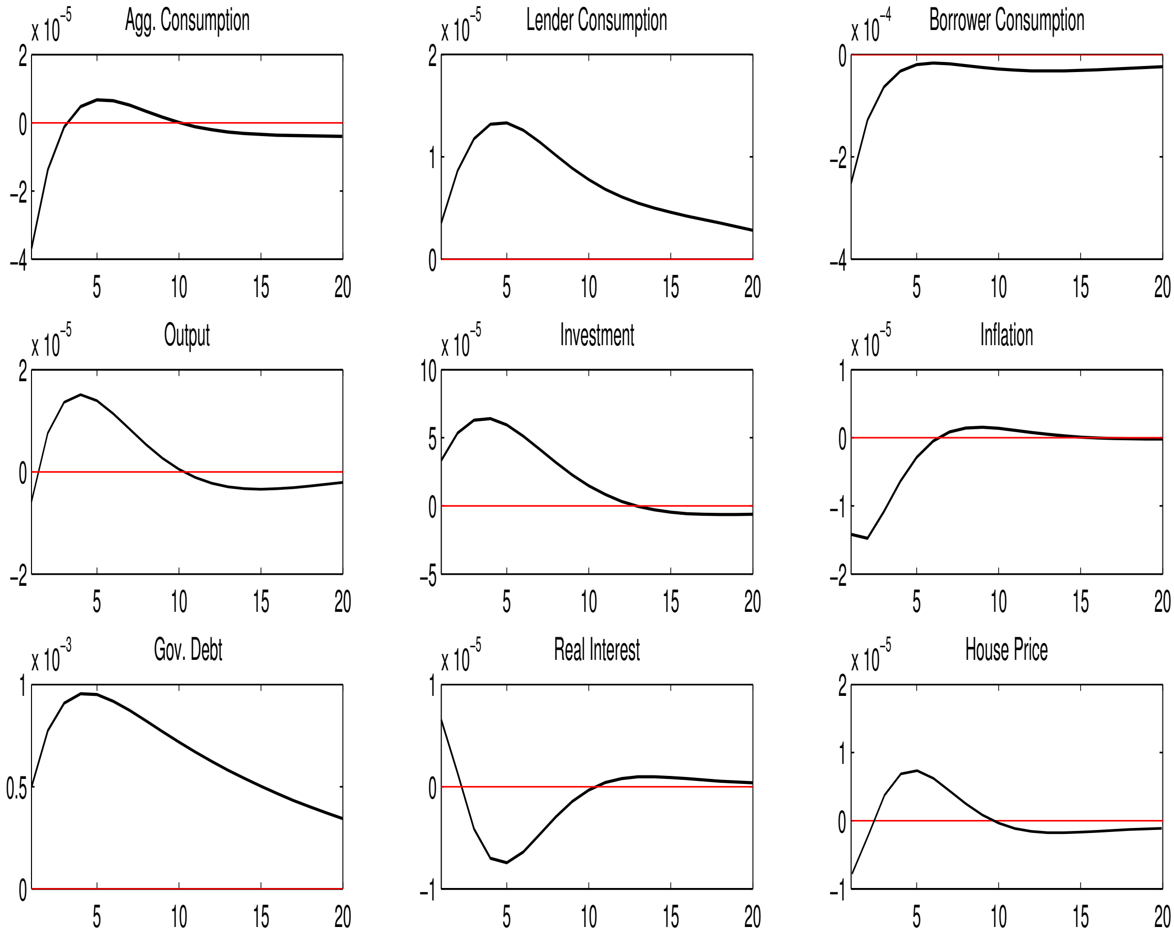

Figure 1.4: Impulse response to a 1 percent increase in the capital income tax. X-axis measures quarters, Y-axis (times 100) measures percentage deviations from steady state.

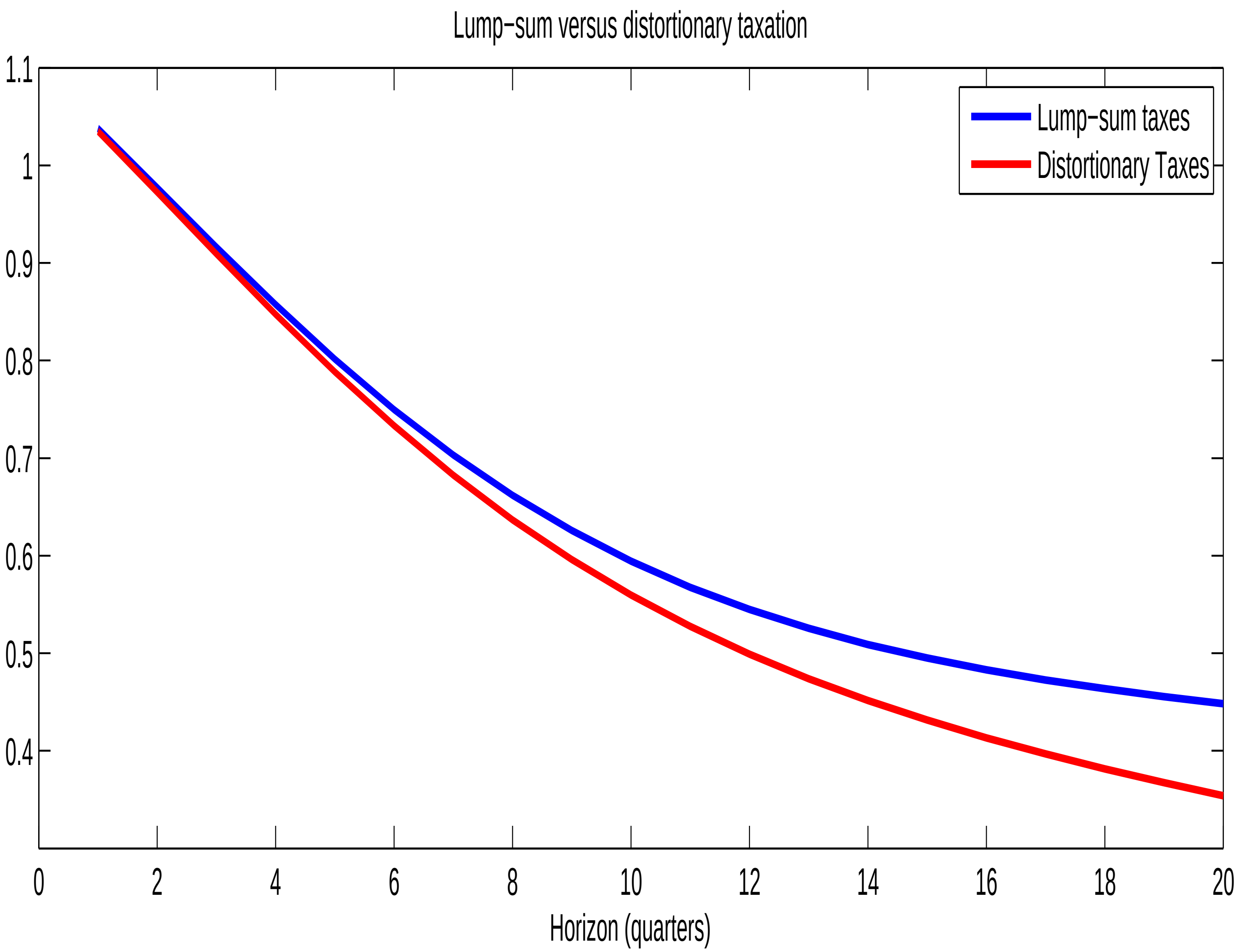

Figure 1.5: Output Present Value Multipliers for a Government Spending shock under two alternative forms of taxation: lump-sum (counterfactual) and distortionary (baseline). X-axis measures the calculation horizon (in quarters) .

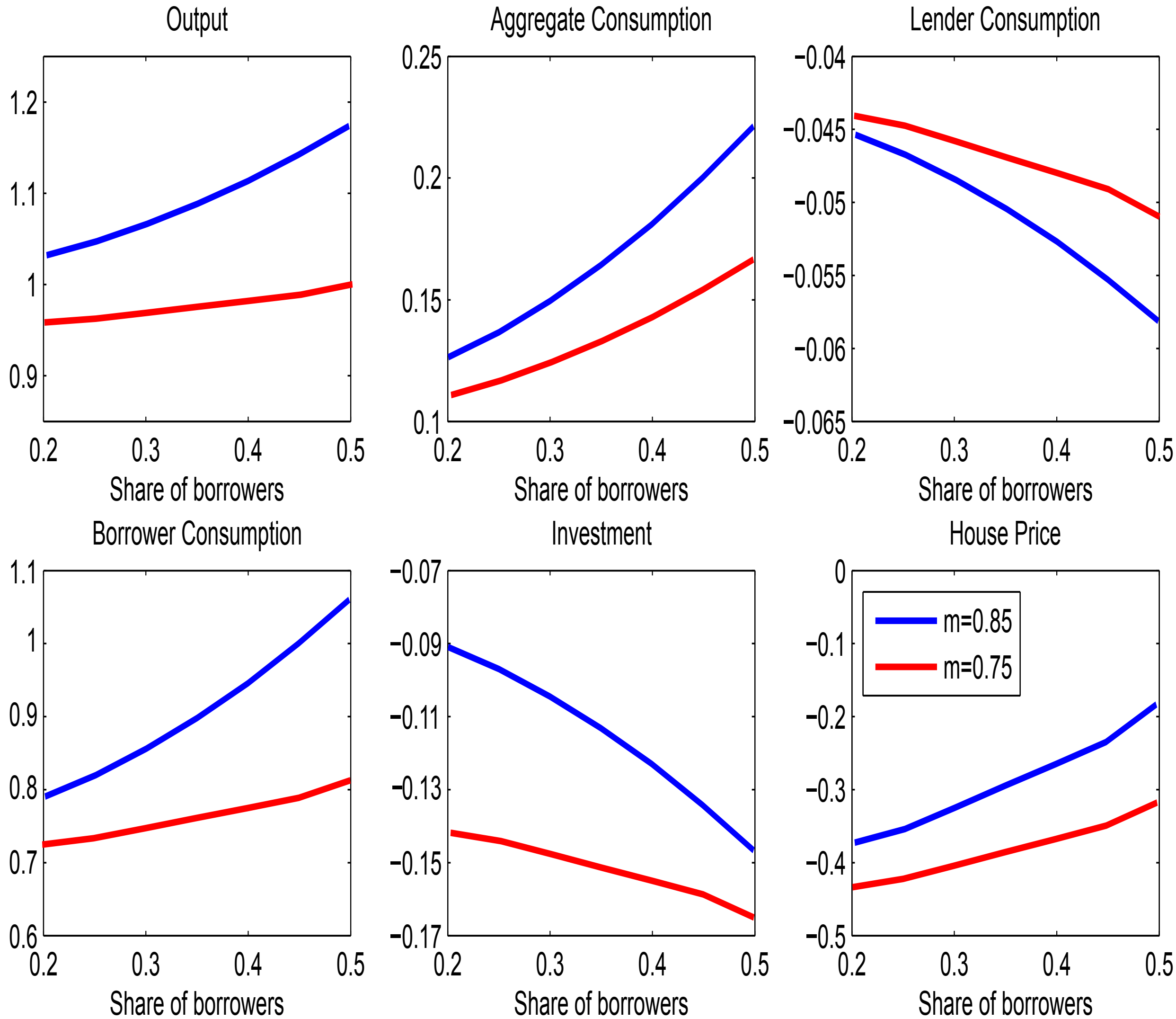

Figure 1.6: Fiscal Impact Multipliers as a Function of the Share of Credit Constrained Agents. X-axis measures the share of borrowers (as a %) starting with baseline value.

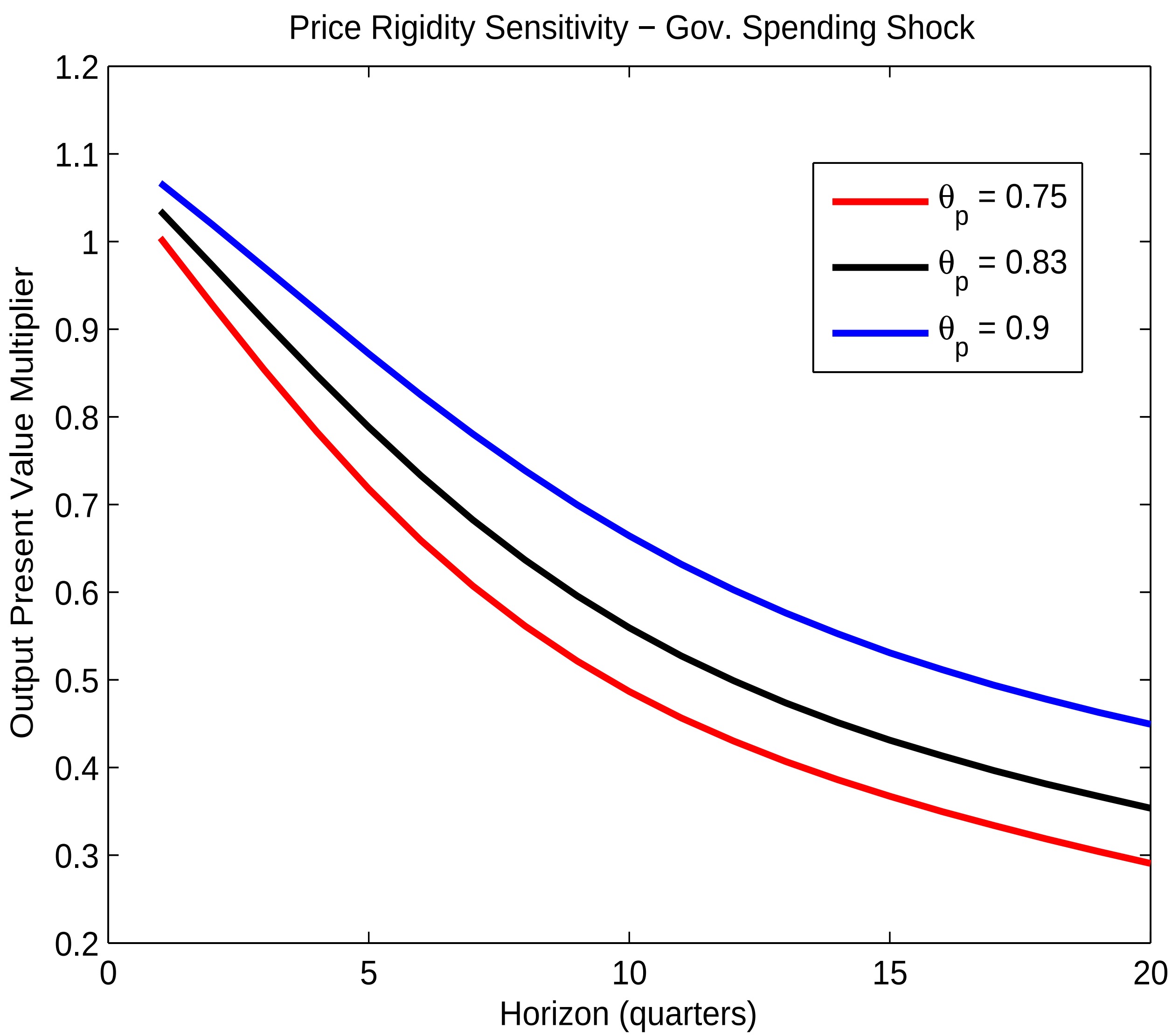

Figure 1.7: Output Present Value Multipliers as a Function of Price Rigidity (θ_p). X-axis measures the calculation horizon (in quarters) .

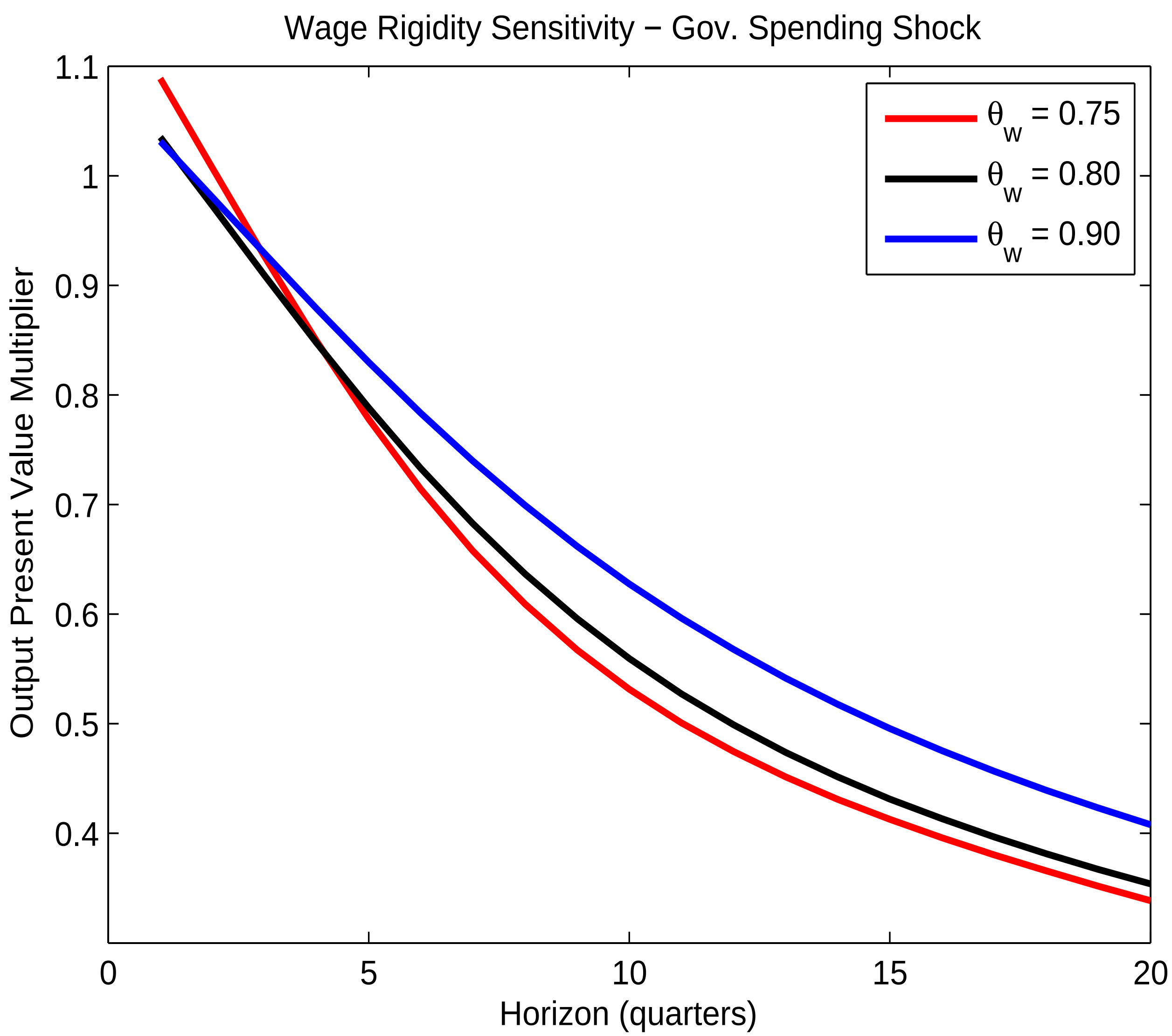

Figure 1.8: Output Present Value Multipliers as a Function of Wage Rigidity (θ_w). X-axis measures the calculation horizon (in quarters) .

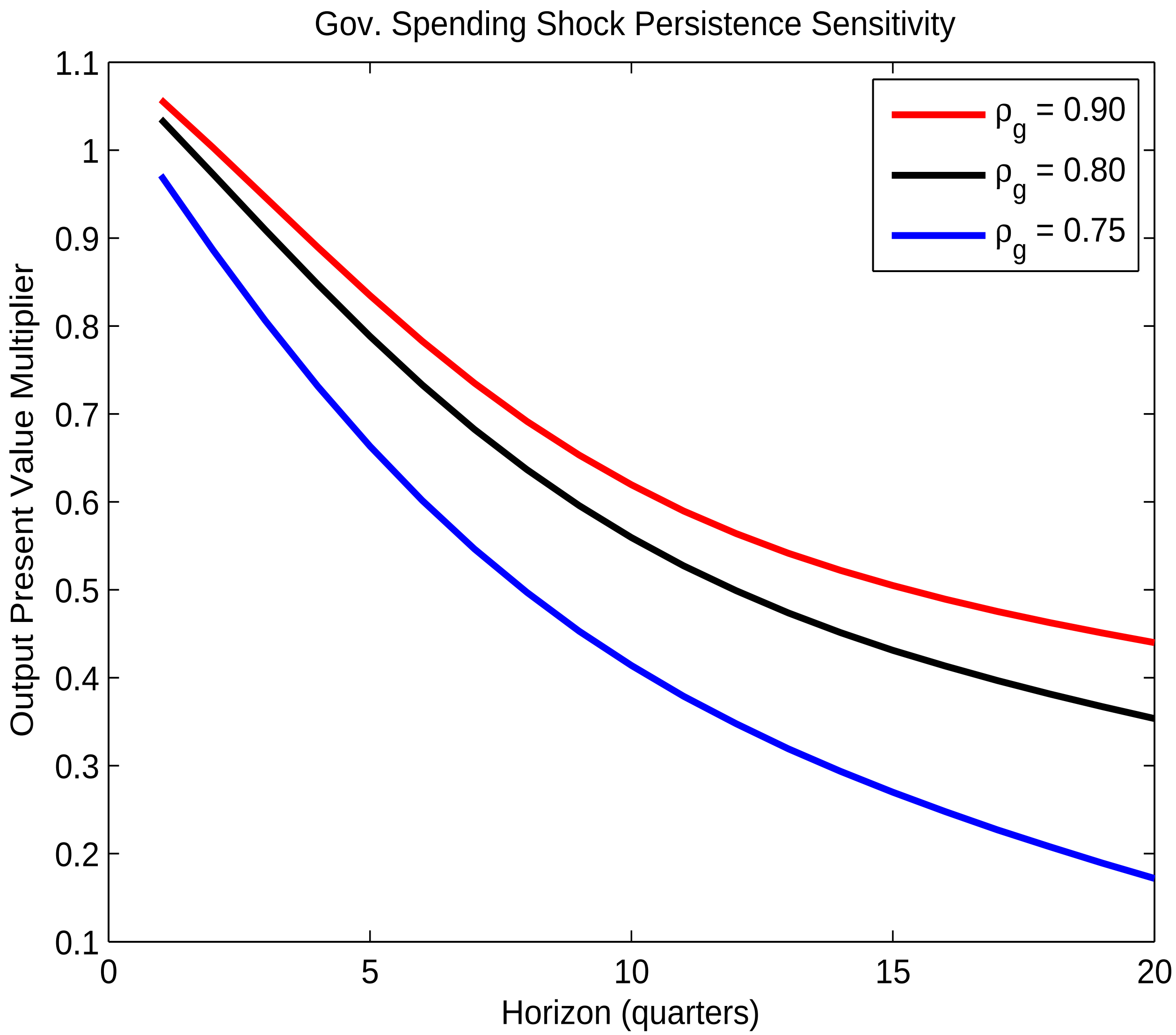

Figure 1.9: Output Present Value Multipliers as a Function of Government Spending Shocks Persistence (ρ_g). X-axis measures the calculation horizon (in quarters) .

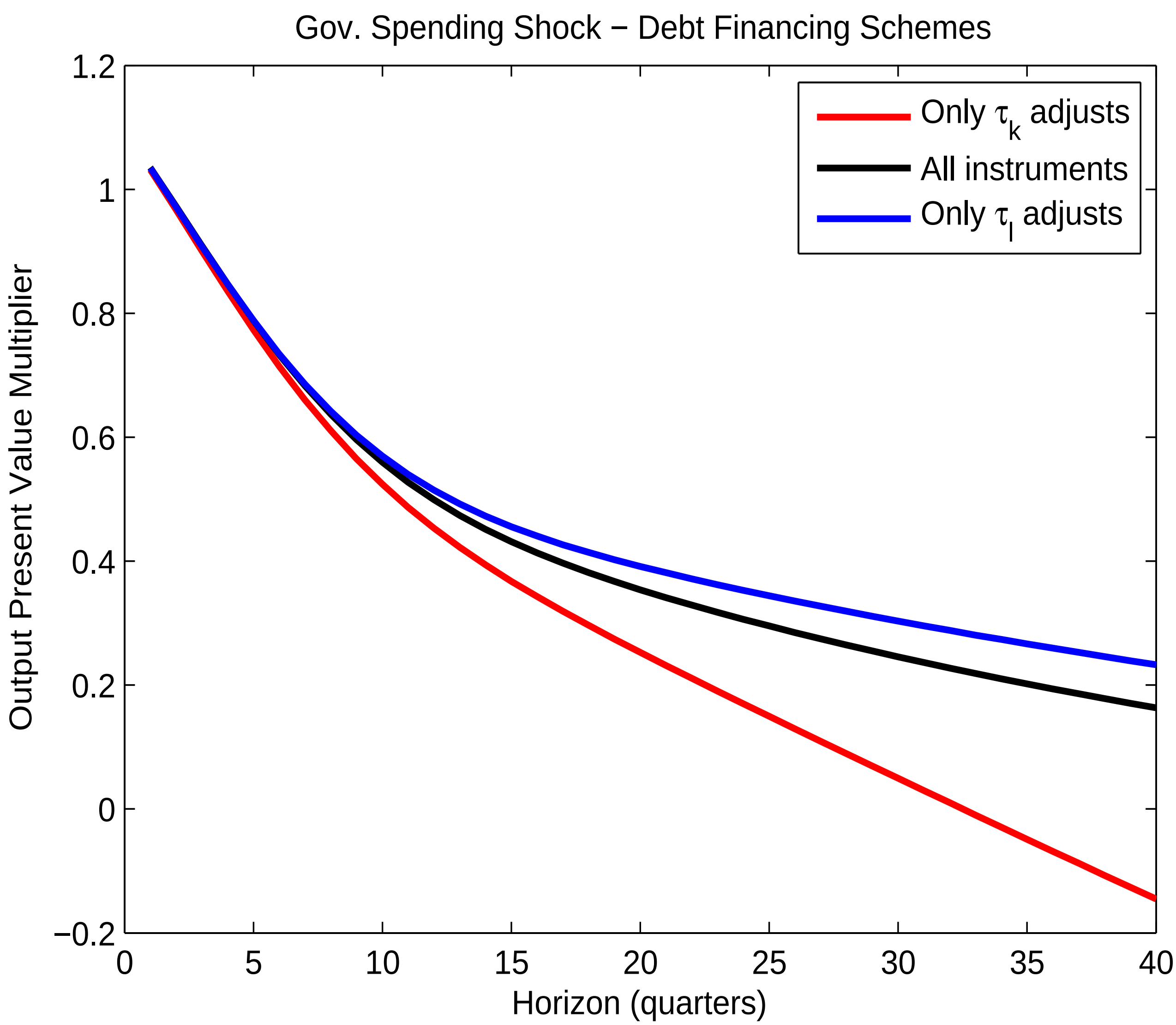

Figure 1.10: Output Present Value Multipliers under Alternative Debt Financing Schemes. X-axis measures the calculation horizon (in quarters) .

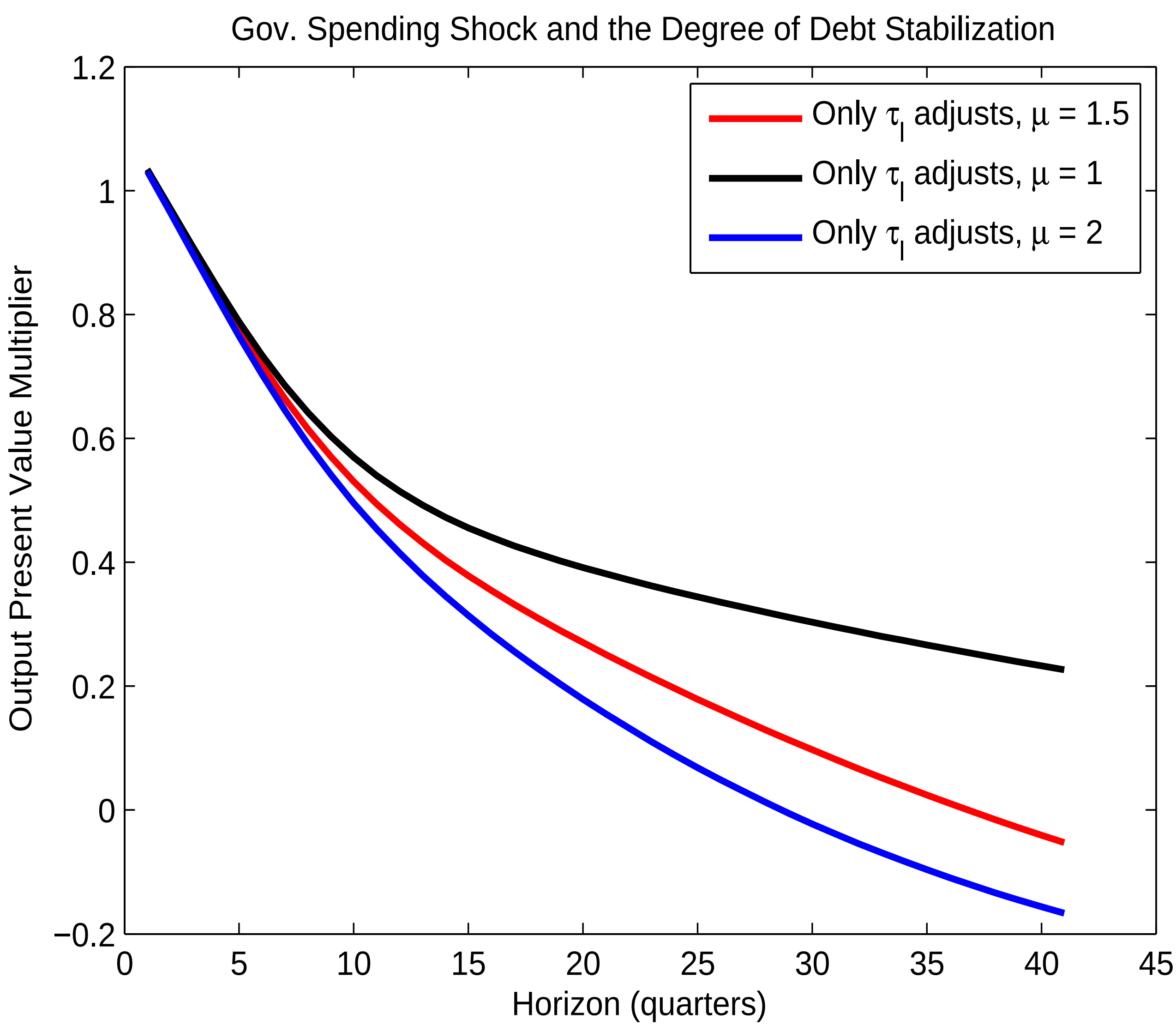

Figure 1.11: Output Present Value Multipliers when only Labor Taxes adjust to Debt. Parameter μ is a scaling factor of the debt stabilizing component. X-axis measures the calculation horizon (in quarters) .

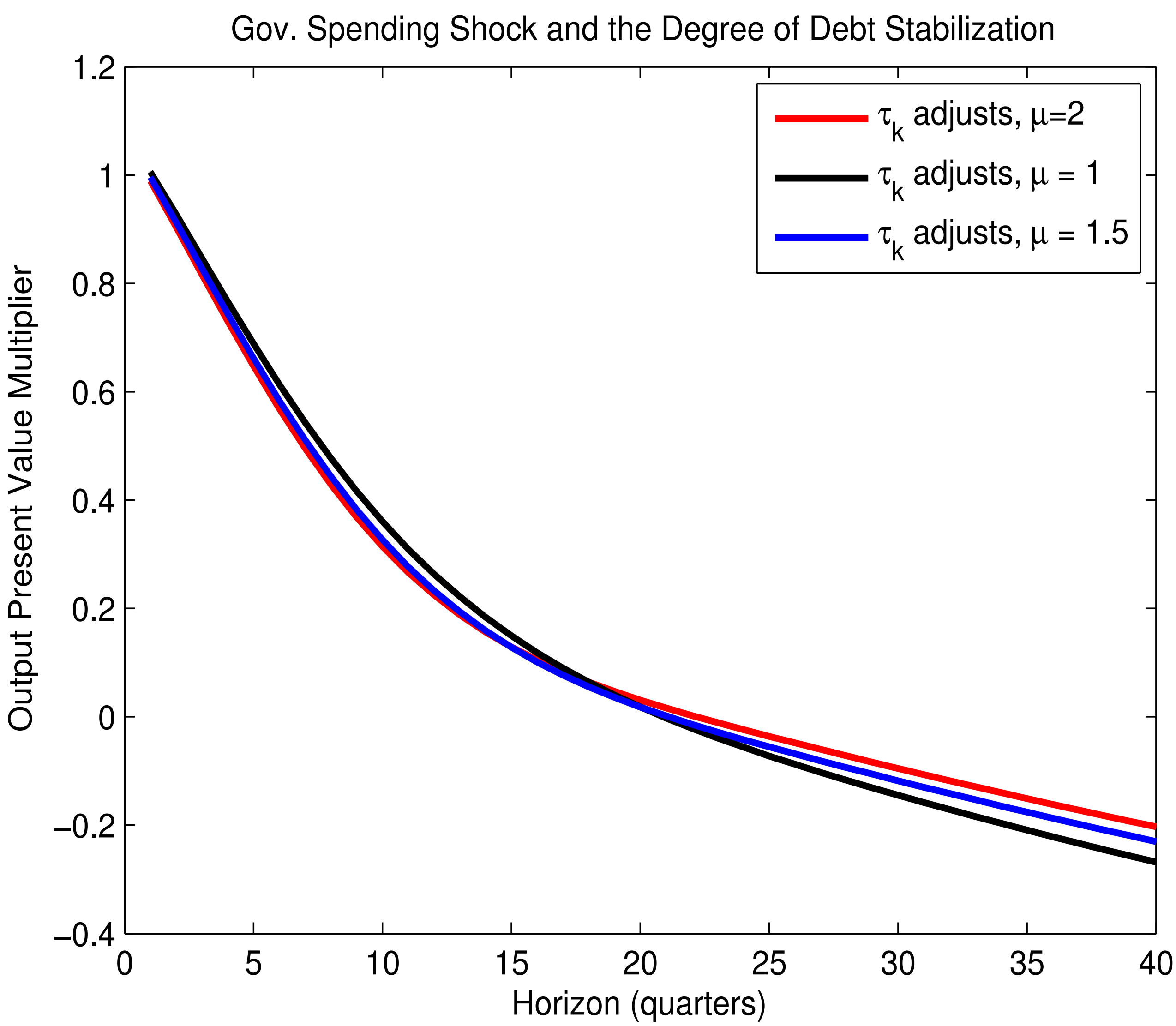

Figure 1.12: Output Present Value Multipliers when only Capital Taxes adjust to Debt. Parameter μ is a scaling factor of the debt stabilizing component. X-axis measures the calculation horizon (in quarters) .

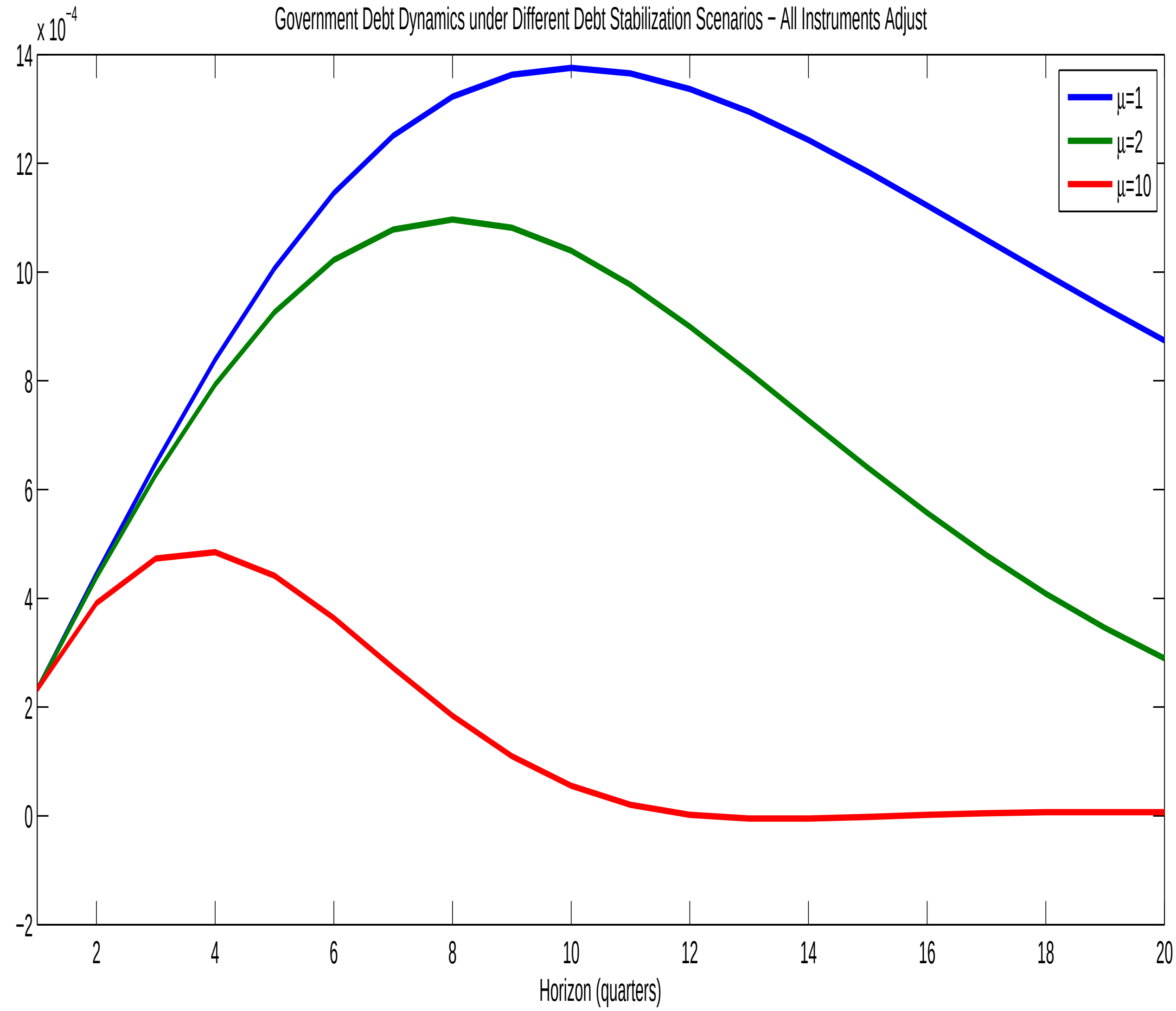

Figure 1.13: Response of public debt to a government spending shock when all fiscal instruments adjust. Parameter μ is a scaling factor of the debt stabilizing component. X-axis measures the calculation horizon (in quarters). Y - axis (times 100) measures percentage deviations.

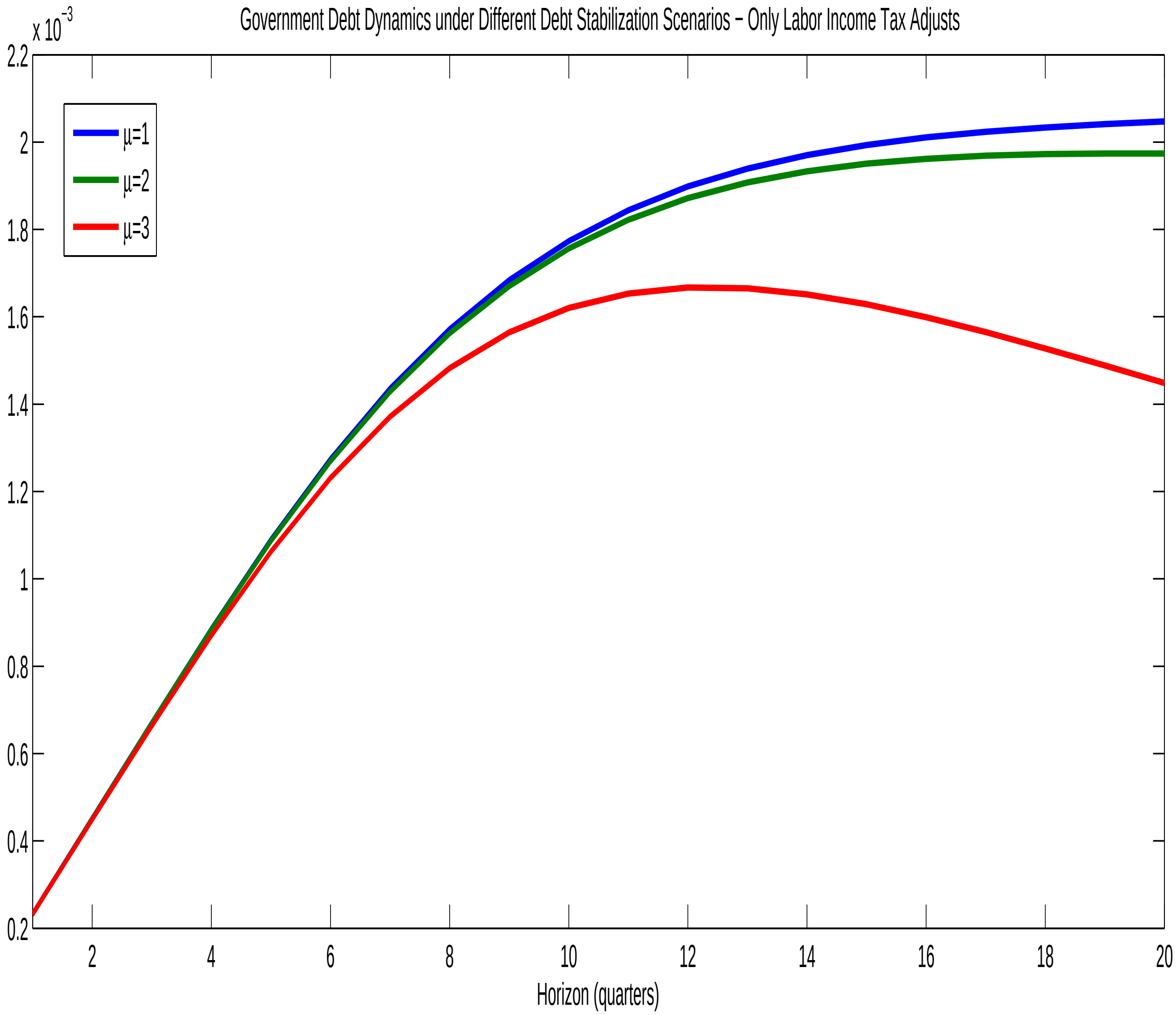

Figure 1.14: Response of public debt to a government spending shock when only the labor income tax adjusts. Parameter μ is a scaling factor of the debt stabilizing component. X-axis measures the calculation horizon (in quarters). Y - axis (times 100) measures percentage deviations.

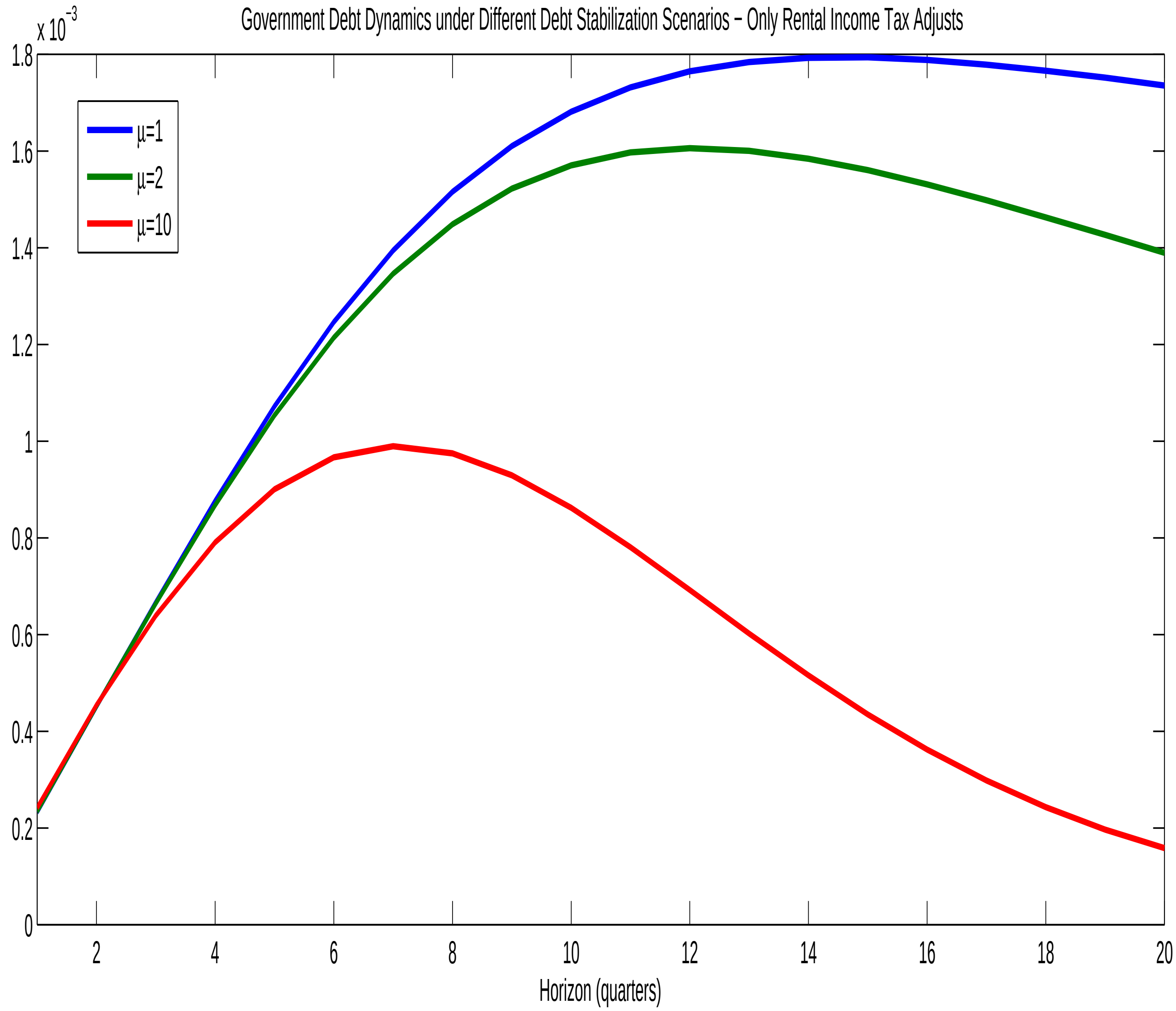

Figure 1.15: Response of public debt to a government spending shock when only the rental income tax adjusts. Parameter μ is a scaling factor of the debt stabilizing component. X-axis measures the calculation horizon (in quarters). Y - axis (times 100) measures percentage deviations.

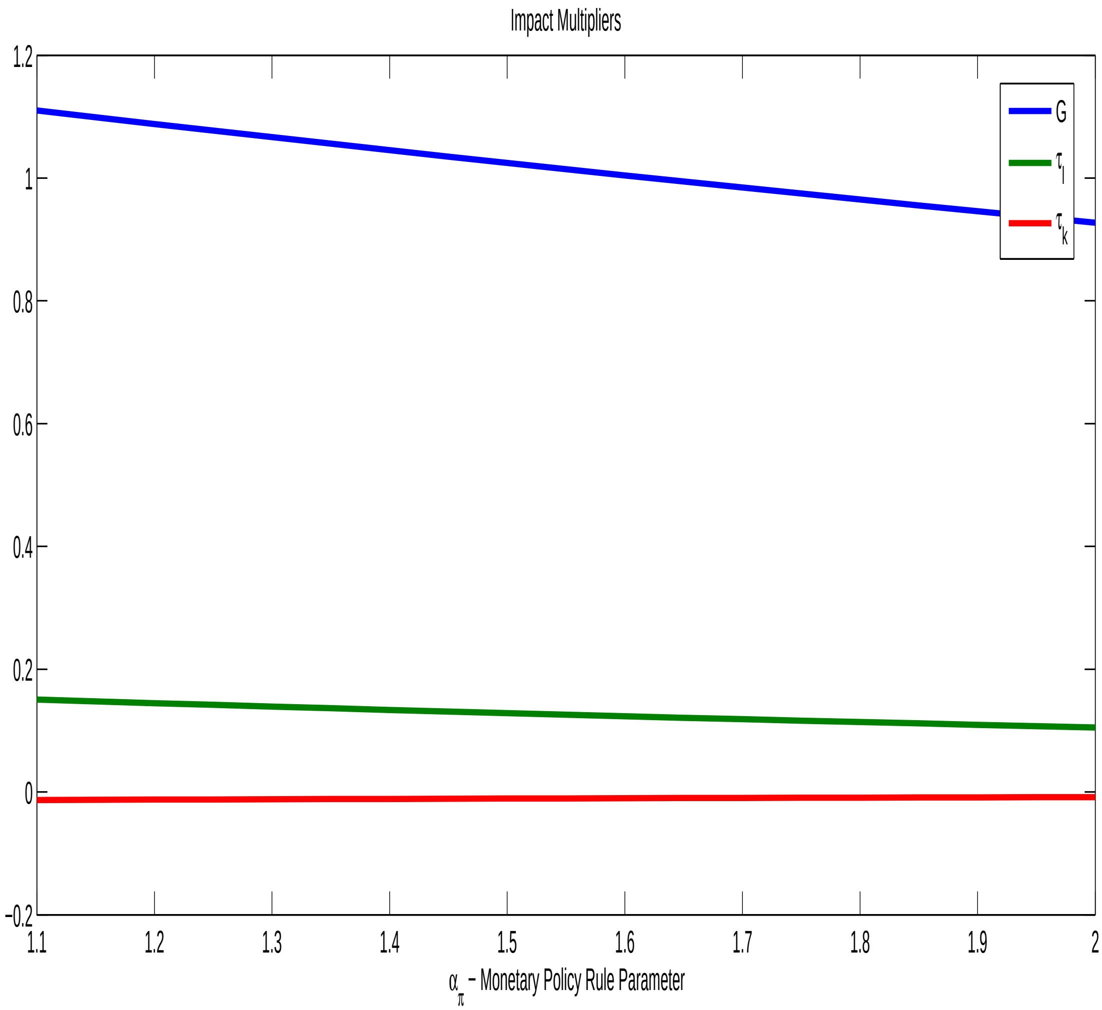

Figure 1.16: Output Impact Multipliers for Fiscal Instruments.

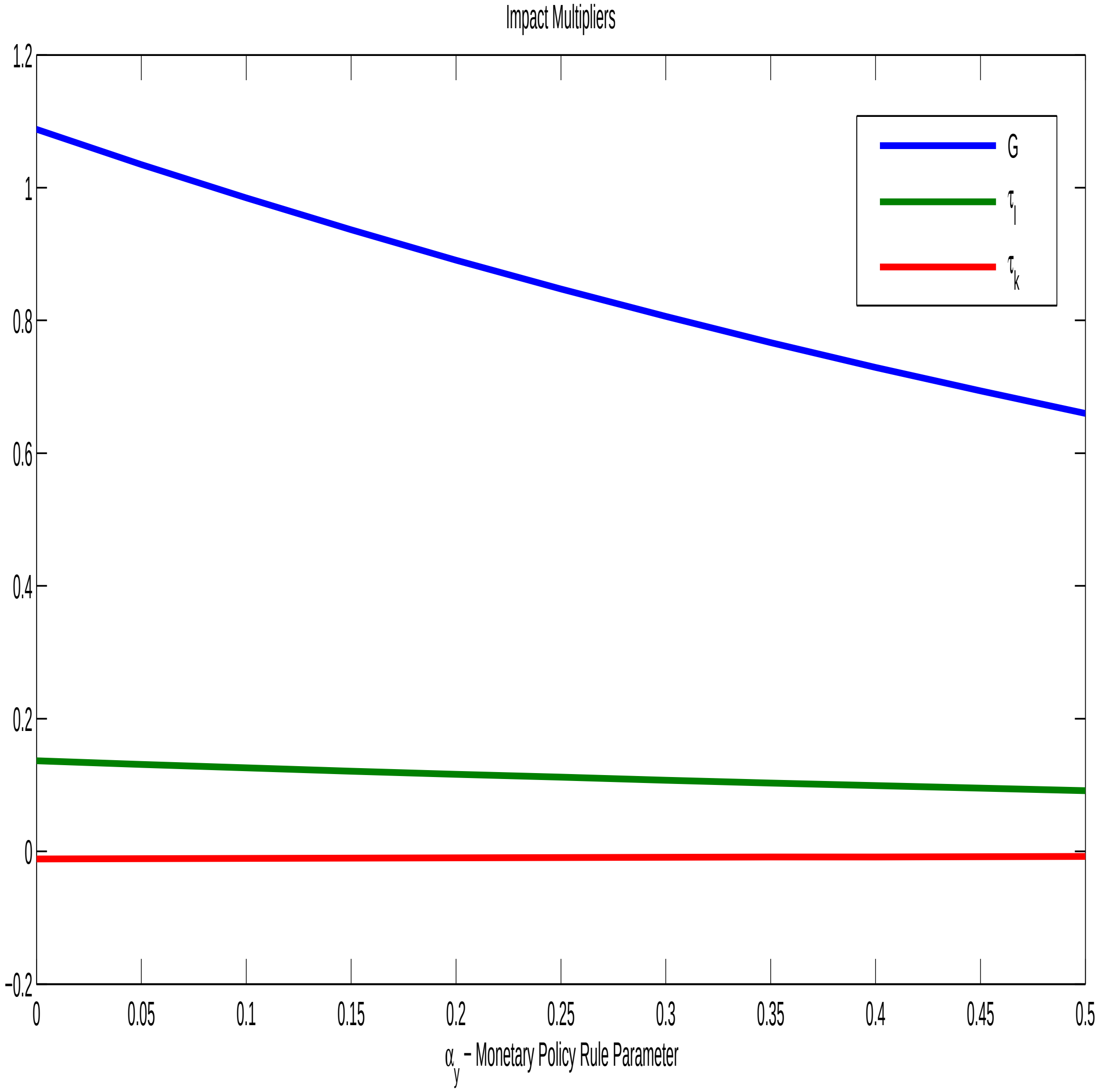

Figure 1.17: Output Impact Multipliers for Fiscal Instruments.

1.6.3 Fiscal Data Description

My construction of the fiscal data follows Leeper et. al (2009). The main data source is the National Income and Product Accounts Tables from the National Bureau of Economic Research. To convert nominal series into real terms I used the GDP deflator for Personal Consumption Expenditures (Table 1.1.4, line 2).

For capital and labor taxes, I calculate an average personal income tax, following Jones (2002):

$$\tau^p = \frac{IT}{W + PRI/2 + CI}$$

where IT is personal income tax revenue calculated as the sum between federal income taxes FIT and state and local income taxes SIT (Table 3.2, line 3). W is wages and salaries (Table 1.12, line 3). PRI is proprietor income (Table 1.12, line 9). CI denotes capital income which is defined as half of proprietor's income, rental income (Table 1.12, line 12), corporate profits (Table 1.12, line 13) and net interest (Table 1.12, line 18).

Average labor income tax is:

$$\tau^l = \frac{\tau^p(W + PRI/2 + CSI)}{EC + PRI/2}$$

where CSI denotes total contributions to government social insurance (Table 3.2, line 11) and EC denotes compensation of employees (Table 1.12, line 2).

The average capital income tax rate is calculated as:

$$\tau^k = \frac{\tau^p CI + CT}{CI + PT}$$

where CT is taxes on corporate income (Table 3.2, line 7) and PT is property taxes (Table 3.3, line 8).

The capital and labor tax revenues are calculated as the product between the corresponding average tax rate and its tax base.

Government Consumption. Government consumption includes consumption expenditures (Table 3.2, line 22), interest payments (Table 3.2, line 24), and government net purchases of non-produced assets (Table 3.2 line 43), minus government consumption of fixed capital (Table 3.2 line 44).

Transfers. The transfer payment is defined as net current transfers, net capital transfers, and subsidies (Table 3.2, line 32), minus the tax residual. Net current transfers are current transfer payments (Table 3.2, line 22) minus current transfer receipts (Table 3.2, line 16). Net capital transfers are capital transfer payments (Table 3.2, line 42) minus capital transfer receipts (Table 3.2, line 38). The tax residual is defined as current tax receipts (Table 3.2line 2), contributions for government social insurance (Table 3.2, line 11), income receipts on assets (Table 3.2, line 12), and current surplus of government enterprises (Table 3.2, line 19) minus total tax revenue (consumption, labor, and capital tax revenues).

Government debt is based on data from the Dallas Federal Reserve Bank series.

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Chapter 2
Financial Conditions and The Effects of Government Spending Changes: Evidence from a Non-Linear VAR

2.1 Introduction

The U.S. subprime mortgage crisis of 2007 is largely thought as the starting point of a Global financial meltdown which has sent shockwaves through the entire World Economy. The downturn in economic activity that ensued was systemic, with numerous European countries and the U.S., in particular, experiencing prolonged and deep recessions. The sheer scale of the event, comparable only to the Economic Depression of 1929, and its overarching implications create significant challenges in both the academic and policy oriented analysis.

This contemporary Great Recession has reaffirmed, in a very dramatic way, the role and importance of the macro linkages between the real economy and the financial sector. Theoretical dynamic stochastic general equilibrium (DSGE) models, such as those proposed by Kiyotaki and Moore (1997) and Bernanke et al. (1999) have already offered tractable mechanisms for incorporating credit market imperfections in a New Keynesian framework.

The two seminal papers, mentioned above, have clearly established a significant role for financial frictions in the amplification and propagation of structural disturbances, inspiring a new strand of research in the field, generically referred to as "the financial accelerator literature."

Nevertheless, at least until the crisis, the normative implications of the mechanism, and in particular the link with asset price changes, have received less attention. At the time and still to a large extent today, a lot of the research effort (both empirical and model based) has been focused on the role of asset prices in the conduct of monetary policy, as the primary stabilization instrument and significantly less on fiscal activism. [1]

In this chapter, I revisit the topic from the perspective of fiscal policy. In particular, I study the effects of fiscal stimulus, in the form of government spending increases, on aggregate economic activity, private consumption and housing prices, contingent on the prevailing financial conditions.

Policy makers are called to intervene only when specific circumstances arise, which makes a state dependent analysis both necessary and highly informative. A number of related papers, like Agnello and Sousa (2013) have also considered the connection between asset prices and fiscal policy in the context of a multi-country study. An important limitation of their study refers to the empirical methodology employed which is based on a (panel) linear VAR that does not allow for potential asymmetric policy effects in different states of the world.

In my analysis, I address this caveat by means of a regime switching SVAR that controls for two financial regimes (identified based on an aggregate financial conditions index) with a smooth transition between the states. The technique was proposed by Aurebach and Gorodnichenko (2012a) as a more general approach compared to Threshold VAR models and it can provide more accurate estimates.

[1] The findings in the monetary literature are fairly diverse, with papers such as Bernanke and Gertler (2001) who recommend against monetary policy reacting to asset prices, while others like Cecchetti, et al. (2002), or Dupor (2005) find some evidence in favor of an asset price response. Examples of other papers that consider the empirical link between house prices and policy include: McCarthy and Peach (2002), Iacoviello (2005) and Iacoviello and Neri (2007).

The field of fiscal studies that focus on state dependent policy effects is still relatively new. Most of the existing papers focus, either on the variation across the business cycle or changes in the public debt level. Less attention has been given to financial factors.

A notable exception is the paper by Afonso et al. (2011), who study the effects of fiscal policy in a Threshold VAR that controls for financial stress. Different from my work, they do not consider the role of asset prices and they only approximate fiscal policy through one variable (public debt ratio), instead of including both an expenditure and revenue channel. I also allow for regime specific covariance matrices and I employ a different measure for financial conditions.

My empirical results suggest an asymmetric impact for fiscal policy across different financial regimes. Under difficult (tight) credit conditions increases in government spending have a negative, short run impact, on output, private consumption and house prices.

By contrast in a relaxed credit regime, fiscal stimulus appears far more effective and induces an increase in both output and private consumption. The initial effect on house prices, is also positive, but modest with fairly flat dynamics afterwards. The results are robust to a number of specifications, such as policy anticipation effects, the inclusion of short term real interest rates, as well as the use of a larger sample with post-crisis data.

The rest of the paper is organized as follows: section two discusses the related literature, section three introduces the non-linear SVAR model, data and identification strategy. This section also provides an overview of the estimation and inference techniques. Section four presents the main findings and discusses their robustness to alternative specifications. Section five concludes.

2.2 Literature Review

Over the past fifteen years, and especially after the Great Recession, there has been a significant surge in the research on fiscal policy. This section presents a succinct overview of the literature, with a particular emphasis on recent empirical papers that study the US economy and are of direct interest to the current work.[2]

The limitations of the large-scale Keynesian macro-econometric models, used in the eighties and nineties, motivated researchers to look for new empirical estimation methods in order to study the effects of fiscal policy. In particular, the vulnerability to the Lucas critique (1976), as well as, their sharply distinct predictions compared to neoclassical models and the response of private consumption and output to fiscal shocks observed in the data, played an important role in the development and adoption of fiscal vector autoregressive (VAR) models.

Initially used for monetary policy analysis (like in Bernanke and Mihov (1998)), the VAR framework was adapted for fiscal policy by Blanchard and Perotti (2002), who proposed a structural identification method for government spending and revenue shocks. The Structural VAR (SVAR) takes into account changes in policy and, by allowing multiple causal relationships between variables, can improve estimation precision relative to standard regressions.

Blanchard and Perotti (2002) applied the SVAR methodology on quarterly U.S. data between 1960 and 1997 and their results suggest a positive response of both output and private consumption to government spending shocks, with crowding out of private investment. The reported fiscal multipliers on impact (dollar response of each variable to a dollar shock in a fiscal variable) are between 0.84 and 0.9 for output (depending on the type of trend assumed in estimation) and 0.5 for consumption. Positive tax shocks appear to have a negative impact on output, with multiplier values of around 0.7.

The identification strategy developed by Blanchard and Perotti (2002) assumes that discretionary fiscal policy cannot respond contemporaneously to output, a fact consistent

[2] A more comprehensive treatment of the literature can be found in Hall (2009), Spilimbergo et al. (2009), Ramey (2011), and more recently, Mineshima et al. (2014).

with implementation lags. Therefore in their model the fiscal variables are ordered first. Furthermore, responses to non-discretionary policy have to be consistent with estimates of fiscal output elasticities in order to isolate he automatic response of fiscal measures. Finally, unexpected fiscal policy is characterized as innovations in the fiscal variables that are not predicted in the VAR.

Many other studies, Fatas and Mihov (2001), Perotti (2005) - a multi-country analysis, or Gali et. al (2007) among others, have used similar methods and reported consistent results. These papers generally document a positive response of output and private consumption to fiscal stimulus and, in some cases, they also find increases in real wages like Fatas and Mihov (2001). The reported output multipliers fall in the range of 0.6 to 1.8, depending on the sample and controls used.

Mountford and Uhlig (2009), building on Uhlig (2005), proposed an alternative, more robust, identification scheme for fiscal shocks based on sign restrictions on impulse response correlations. Using U.S. quarterly data from 1955 to 2000 and fiscal variables defined as in Blanchard and Perotti (2002), in order to make the results comparable, they find larger output multipliers for taxes, than for spending increases. The maximum present value multiplier for a deficit financed tax cut is achieved after 14 quarters and is 5.33 dollars compared to 0.65 dollars on impact for deficit spending. Mountford and Uhlig (2009) also report a small, but positive effect on private consumption, crowding out of investment and a negative response of real wages.

Canova and Pappa (2007) use a similar method to identify fiscal shocks in a multi-country study that includes 47 U.S. states and nine European Countries. They focus on regional fiscal expenditures and revenue shocks and their effects on price differentials in a monetary union. The results suggest a positive response in prices to expenditure shocks, but negative to changes in tax revenues that is consistent with changes in aggregate demand and private consumptions found by the other studies.

An important critique of Blanchard and Perotti (2002), which has received considerable attention in the literature (Ramey and Shapiro (1998), Romer and Romer (2010), and Ramey (2011)), suggests that in their framework fiscal shocks may not be truly exogenous, due to policy anticipation effects. Instead these papers propose methods to identify fiscal shocks directly using additional information available - a so called "narrative or action based approach."

Romer and Romer (2010) focus on tax effects and suggest a technique they have initially developed to study monetary policy. The authors use Congressional records, President speeches and other budget documents to filter out tax measure associated with short-run economic fluctuations (and thus predicted), in order to obtain a series of exogenous tax shocks. Their results suggest a contractionary role for tax increases, with multipliers as high as three (after 10 quarters).

A hybrid method, suggested by Favero and Giavazzi (2012), integrates Romer and Romer (2010) narrative approach into a SVAR framework. Their results are qualitatively similar, but much closer to the range of values found in traditional fiscal VARs (around one).

Other papers, such as Ramey (2011), have analyzed the effects of government expenditures, using defense spending news to isolate the timing of government spending shocks. Military expenditures are primarily determined by the requirements of foreign policy and wars and, thus, are less influenced by more predictable factors such as the state of the business cycle. Ramey (2011) reports for the period 1939 to 2008 a spending multiplier for the US economy of approximatively 1.2. Due to their significant data requirements, narrative methods are less well represented in international studies, most of the existing research focusing on developed economies such as the US, UK, or Germany.

A more recent contribution to the literature is the development of empirical methods that attempt to provide insight regarding potential state-contingent effects for fiscal interventions. The existing studies have focused in particular on the impact of business cycle conditions and the state of public finances.

One approach, followed by Pereira and Lopes (2010), relies on Bayesian estimation in a SVAR with time varying parameters. Using US data between 1965 and 2009, they find only limited evidence to suggest an increase in fiscal policy effectivness during recessions.

A different method was proposed by Auerbach and Gorodnichenko (2012a), who estimate a smooth transition threshold SVAR model for the US between 1947 and 2008. The empirical specification includes government spending, taxes, and output and is consistent with the approach given in Blanchard and Perotti (2002). A moving average of output growth is the regime switching variable that controls for business cycle conditions. The authors conclude that the effects of fiscal policy are significantly larger in recessions compared to expansions.

In a related study, Auerbach and Gorodnichenko (2012b), conducted on a panel of OECD countries they confirm their earlier findings. The reported average (across countries) output multiplier after the first year is approximatively 0.5 in a recession compared to -0.2 for an expansion. Similar results were reported by Bachmann and Sims (2012), Candelon and Lieb (2013) who use long run restrictions and Owyang, Ramey, and Zubairy (2013) that employ a narrative approach based on military spending news.

2.3 Empirical Methods

2.3.1 Model and Data

The empirical specification I use is based on Auerbach and Gorodnichenko (2012a) and is given by a regime switching structural VAR model that controls for two financial regimes. One regime is described by difficult (tight) credit conditions, while the other refers to a scenario where access to credit is more facile (relaxed credit conditions).

A characteristic of the assumed framework is that the transition between the two states of nature is done in a continuous fashion. In particular, in this Smooth Transition Vector

Autoregressive model (STVAR) a logistic function models the probability of being in one regime versus the other. The state of nature is described by an appropriate index switch variable which, here, characterizes national financial conditions in the US over the sample period.

The STVAR represents a more general specification of the standard Threshold VAR (TVAR) model. It has the added benefit of allowing for a larger number of observations to be used in estimation (particularly in the extreme regime) which helps improve precision.

Intuitively, an STVAR can be understood as a weighted average of two piecewise linear combinations of the endogenous variables, each corresponding to one regime. The weights are given by the probability of being in that particular regime and are determined by the logistic function, based on the values of the index variable.

The model is specified as follows:

$$(1)\quad \mathbf{X}_t = [1 - F(z_{t-1})]\mathbf{\Pi}_R(L)\mathbf{X}_{t-1} + F(z_{t-1})\mathbf{\Pi}_T(L)\mathbf{X}_{t-1} + \mathbf{u}_t,$$

$$(2)\quad \mathbf{u}_t \sim N(0, \mathbf{\Omega}_t),$$

$$(3)\quad \mathbf{\Omega}_t = \mathbf{\Omega}_R[1 - F(z_{t-1})] + \mathbf{\Omega}_T F(z_{t-1}),$$

$$(4)\quad F(z_{t-1}) = \frac{exp(-\gamma z_t)}{1+exp(-\gamma z_t)}, \gamma > 0,$$

$$(5)\quad var(z_t) = 1, E(z_t) = 0.$$

where X_t is the vector of endogenous variables, $\mathbf{\Pi}_R(L)$ and $\mathbf{\Pi}_T(L)$ are regime specific lag polynomials allowing for dynamic difference in the propagation of structural shocks, while $\mathbf{\Omega}_R$ and $\mathbf{\Omega}_T$ are the corresponding covariance matrices for disturbances in a relaxed credit regime R and in a difficult (tight) regime T, respectively. $F(.)$ is the regime weighting function and it takes values in the $(0, 1)$ interval, based on the financial conditions index variable z_t, γ is, by convention, a positive parameter that controls the curvature of the weighting function.

The sample period is 1973:Q1-2008:Q4 and the starting date is determined by data availability for the financial index variable. I choose to leave out the post-2008 period in order to avoid potential distortions induced by structural changes in the conduct of monetary policy (Zero Lower Bound). Nevertheless, as a robustness check, I extend the sample period until the end of 2013[3].

In the baseline specification, I consider the following endogenous variables: government spending (which includes consumption and gross investment), tax receipts (less transfer payments to businesses and individuals), output, total private consumption and an index of house prices.

All data is at quarterly frequency, seasonally adjusted by the source and expressed in real terms (2005 chained dollars) by the means of the implicit GDP deflator. The VAR is specified in log-levels and the lag order is three, based on the Akaike information criterion.[4]. In the appendix I provide a more detailed description of the data and sources used.

The regime switch variable z_t is the National Financial Conditions Index (NFCI) published by the Federal Reserve Bank of Chicago. It provides information on the status of aggregate financial conditions, while minimizing the contribution of the business cycle[5].

In order to insure scale invariance, it was normalized to have mean zero and variance equal to one. Figure 2.1 presents the index over the considered sample. Positive values of the NFCI indicate financial conditions that are tighter than on average, while negative values signal financial conditions that are better than on average.

I have calibrated the curvature parameter (γ) of the weighting function at 8, in order to match the frequency of the bad state of the world in the data, which is around 35 percent.

[3] The data set for house prices only has preliminary information for 2014, so I did not include it.

[4] Many papers use four or more lags, like Blanchard and Perotti (2002), Mountford and Uhlig (2009), or Auerbach and Gorodnichenko (2012a). In my case the VAR includes more endogenous variables and the sample size is smaller, as it only starts in 1973 compared to the late 40's or early 50's in the other studies.

[5] An alternative measure could have been the Adjusted National Financial Conditions Index available from the same source. Nevertheless compared to NFCI, the calculation methodology for this index also includes a three-month moving average of the Chicago Fed's National Activity Index (CFNAI-MA3) and three-month total PCE inflation which makes it sensitive to changes in economic growth and inflation.

In principle, it can be estimated jointly with the other VAR parameters, but it proves costly to do so in terms of degree of freedoms (due to the reduced number of observations in the tight credit regime). Figure 2.2 plots the calibrated weight function $F(.)$ over the sample. The gray bands represent periods of financial stress identified by the index (an observed positive value for NFCI).

The identification of government expenditure shocks is based on a Cholesky decomposition with government spending ordered first, followed by taxes, output, consumption and house prices, along the lines of Blanchard and Perotti (2002). That is $\mathbf{X}_t = [G_t\ T_t\ Y_t\ C_t\ H_t]'$.

This order reflects the fact that discretionary fiscal policy is not likely to react to an output change within a quarter due to implementation lags. Or in other words, that shocks in tax revenue, output, private consumption and house prices do not have a contemporaneous effect on the government spending, while house prices respond contemporaneously to all other variables.

As discussed in Blanchard and Perotti (2002), the SVAR framework can also be used to identify tax revenue shocks, by including information on the elasticity of revenues to output, in order to isolate the effect of automatic stabilizers. However, in practice, the range of estimates for the tax revenues elasticity turns out to be fairly wide. In a recent paper, Caldara and Kamps (2012) attribute the large dispersion observed in the fiscal multipliers reported in the literature to relatively small variations in the assumed tax elasticity priors.

Furthermore, from a conceptual point of view, discretionary tax policy is probably better described by changes in the marginal tax rate which affect the structure of taxation, rather than by changes in the volume of tax revenues. For these reasons, my analysis focuses on the effects of government expenditures, while controlling for taxes in order to allow an extra channel for fiscal policy.

2.3.2 Estimation

Following the approach given in Auerbach and Gorodnichenko (2012a), estimation is performed using maximum likelihood methods. The model log-likelihood function is described by:

$$logL = const - \frac{1}{2}\sum_{t=1}^{T} log|\boldsymbol{\Omega_t}| - \frac{1}{2}\sum_{t=1}^{T} \mathbf{u}_t'\boldsymbol{\Omega}_t^{-1}\mathbf{u}_t \tag{2.6}$$

where $\mathbf{u}_t = \mathbf{X}_t - (1 - F(z_{t-1}))\boldsymbol{\Pi}_R(L)\mathbf{X}_{t-1} - F(z_{t-1})\boldsymbol{\Pi}_T(L)\mathbf{X}_{t-1}$.

The vector of the model parameters is given by $\boldsymbol{\Psi} = \{\gamma,\ \boldsymbol{\Omega}_T,\ \boldsymbol{\Omega}_R,\ \boldsymbol{\Pi}_T(L),\ \boldsymbol{\Pi}_R(L)\}$.

Based on the fact that conditional on the parameter set $\{\gamma,\ \boldsymbol{\Omega}_T,\ \boldsymbol{\Omega}_R\}$ the model will be linear in the lag polynomials $\{\boldsymbol{\Pi}_T(L),\ \boldsymbol{\Pi}_R(L)\}$, the latter can be estimated using the weighted least squares method for a given set $\{\gamma,\ \boldsymbol{\Omega}_T,\ \boldsymbol{\Omega}_R\}$. $\boldsymbol{\Omega}_t^{-1}$ provides the weights and the estimates of $\{\boldsymbol{\Pi}_T(L),\ \boldsymbol{\Pi}_R(L)\}$ must minimize $\frac{1}{2}\sum_{t=1}^{T}\mathbf{u}_t'\boldsymbol{\Omega}_t^{-1}\mathbf{u}_t$.

Let $\mathbf{W}_t$ represent the full vector of regressors, with:

$$\mathbf{W}_t = [(1 - F(z_{t-1}))\mathbf{X}_{t-1}\ F(z_{t-1})\mathbf{X}_{t-1} \ldots (1 - F(z_{t-1}))\mathbf{X}_{t-p} F(z_{t-1})\mathbf{X}_{t-p}].$$

By labeling $\boldsymbol{\Pi} = [\boldsymbol{\Pi}_T\boldsymbol{\Pi}_R]$, $\mathbf{u}_t = \mathbf{X}_t - \Pi\mathbf{W}_t'$ and the objective function can be written as:

$$\frac{1}{2}\sum_{t=1}^{T}(\mathbf{X}_t - \boldsymbol{\Pi}\mathbf{W}_t')'\boldsymbol{\Omega}_t^{-1}(\mathbf{X}_t - \boldsymbol{\Pi}\mathbf{W}_t'). \tag{2.7}$$

or equivalently:

$$\frac{1}{2}\sum_{t=1}^{T}(\mathbf{X}_t - \mathbf{\Pi}\mathbf{W}'_t)'\mathbf{\Omega}_t^{-1}(\mathbf{X}_t - \mathbf{\Pi}\mathbf{W}'_t) = \frac{1}{2}\sum_{t=1}^{T} Trace[(\mathbf{X}_t - \mathbf{\Pi}\mathbf{W}'_t)(\mathbf{X}_t - \mathbf{\Pi}\mathbf{W}'_t)'\mathbf{\Omega}_t^{-1}].$$

Taking the first order condition with respect to $\mathbf{\Pi}$ and vectorization leads to:

$$vec\left(\sum_{t=1}^{T}\mathbf{W}'_t\mathbf{X}_t\mathbf{\Omega}_t^{-1}\right) = vec\mathbf{\Pi}'\left(\sum_{t=1}^{T}[\mathbf{\Omega}_t^{-1}\otimes\mathbf{W}'_t\mathbf{W}_t]\right)^{-1}$$

Solving for $\mathbf{\Pi}$ gives an equivalent formula:

$$vec\mathbf{\Pi}' = \left(\sum_{t=1}^{T}[\mathbf{\Omega}_t^{-1}\otimes\mathbf{W}'_t\mathbf{W}_t]\right)^{-1} vec\left(\sum_{t=1}^{T}\mathbf{W}'_t\mathbf{X}_t\mathbf{\Omega}_t^{-1}\right). \tag{2.8}$$

The likelihood and the $\mathbf{\Pi}$ are obtained through iterations on $\{\gamma,\ \mathbf{\Omega}_T,\ \mathbf{\Omega}_R\}$ until an optimum is attained. The standard VAR estimates result from allowing for $\mathbf{\Omega}_t$ to be constant (homoskedastic error term).

2.3.3 Non-linear Impulse Response Functions

In linear VAR models, the impulse response functions (IRFs) are constructed directly using the estimated VAR coefficients, by assuming the effect of a single initial shock. This accounts for the fact that the moving average representation of the VAR is linear in the structural disturbances, which makes the IRFs constant over time, as well as symmetric in terms of the size and sign of the shock.

In the current framework this approach is no longer valid, because shocks may lead to regime switches which makes the IRFs depend both on the initial conditions and the properties of the shock. Therefore, in order to determine the system's dynamic properties the impulse response functions have to be simulated for a particular history of shocks, conditional on initial values.

The simulation methodology was proposed by Koop, Pesaran and Potter (1996) and the nonlinear impulse response functions (NIRFs) are defined as follows:

$$NIRF_{\mathbf{Y}}(\epsilon_t, \mathbf{\Omega}_{t-1}, k) = E(\mathbf{Y}_{t+k}|\epsilon_t, \mathbf{\Omega}_{t-1}) - E(\mathbf{Y}_{t+k}|\mathbf{\Omega}_{t-1})$$

where $\mathbf{\Omega}_{t-1}$ represents the information set known before the shock ϵ_t at time t, while $\mathbf{Y}_{t+k}$ is the vector of variables observed k time periods later.

In order to compute the impulse response functions, the initial conditions are needed ($\mathbf{\Omega}_{t-1}$) together with information about the shock (ϵ_t), and then the difference in the conditional expectations is calculated by simulation. This time, we have no restrictions in terms of the symmetry of the shocks.

In the first step, shocks for the periods 0 to q (the IRF time horizon) are drawn from the residuals of the estimated VAR model, which are then fed through the model for a given initial condition (point in the sample). This represents the forecast of the variables, conditional on the initial information set and shock sequence.

In the second step, the process is repeated for the same initial value and a new forecast is generated. This time, though, the shock to government spending in period 0 is fixed at 1%. Step three calculates the impulse response function as the differences between the forecasts obtained in the previous steps. An average impulse response is then produced for that particular initial information set by iterating the entire process 500 times.

To determine the final impulse responses, steps one through 3 are repeated for each sample point and averages are computed over regimes.

2.3.4 Inference

To address the fact that the model is highly non-linear in parameters which makes optimization challenging and to simplify inference, Auerbach and Gorodnichenko (2012) use a Markov Chain Monte Carlo (MCMC) approach.

The method was originally developed by Chemozhukov and Hong (2003) and in this case it helps find a global optimum and generate empirical distributions for the model parameters. The Metropolis-Hastings algorithm constructs chains of length N and is succinctly summarized below:

Step 1: $\mathbf{\Theta}^{(n)}$, the candidate vector of parameter values is drawn for the chain's $n+1$ state based on $\mathbf{\Psi}^{(n)}$, the current n state of the model parameter vector and $\boldsymbol{\psi}^{(n)}$, the i.i.d. vector of shocks. $\boldsymbol{\psi}^{(n)}$ is sampled from $N(0, \mathbf{\Omega}_\psi)$ with $\mathbf{\Omega}_\psi$ a diagonal matrix.

$$\mathbf{\Theta}^{(n)} = \mathbf{\Psi}^{(n)} + \boldsymbol{\psi}^{(n)}$$

Step 2: The $n+1$ state of the chain is given by:

$$\mathbf{\Psi}^{(n+1)} = \begin{cases} \mathbf{\Theta}^{(n)}, \text{ with probability } \min\{1, \exp[\log L(\mathbf{\Theta}^{(n)}) - \log L(\mathbf{\Psi}^{(n)})]\} \\ \mathbf{\Psi}^{(n)}, \text{otherwise} \end{cases}$$

$L(\mathbf{\Psi}^{(n)})$ and $L(\mathbf{\Theta}^{(n)})$ are the values of the likelihood function at the current state of the chain ($\mathbf{\Psi}^{(n)}$) and at the candidate parameter vector ($\mathbf{\Theta}^{(n)}$).

The following steps are performed in order to obtain $\mathbf{\Psi}^{(0)}$, the starting value. $\mathbf{X}_t$ is regressed on lags of $\mathbf{X}_t$, $\mathbf{X}_t z_t, \mathrm{X}_t z_t^2$ and use the residual to fit equation (3). MLE is used to estimate

$\mathbf{\Omega}_T$ and $\mathbf{\Omega}_R$ are estimated by MLE. These estimates are used to construct starting values for the lag polynomials $\{\mathbf{\Pi}_T(L),\ \mathbf{\Pi}_R(L)\}$ based on equation (8).

The initial covariance matrix of the shock ($\mathbf{\Omega}_\psi$ for $\boldsymbol{\psi}^{(0)}$) is calibrated to approximately one percent of the parameter value. For the first 20,000 draws, $\mathbf{\Omega}_\psi$ is adjusted such that it generates 0.3 acceptance rates of candidate draws, following Gelman et al. (2004). The number of draws is set at 100,000 and the first 20,000 are dropped as burn-in.

To construct confidence intervals for the impulse responses, 1,000 draws (with replacement) are made from the generated chain of parameter values ($\{\mathbf{\Psi}^{(n)}\}_{n=1}^{N}$). For each draw, the impulse response is is calculated.

The parameters $\{\mathbf{\Pi}_T(L),\ \mathbf{\Pi}_R(L)\}$ are drawn from $\{\mathbf{\Psi}^{(n)}\}_{n=1}^{N}$ and the covariance matrix of residuals in regime $s \in \{T, R\}$ is drawn from $N(vec(\mathbf{\Omega}_s),\ \mathbf{\Sigma}_s)$.

$$\mathbf{\Sigma}_s = 2[(\mathbf{D}_n'\mathbf{D}_n)^{-1}\mathbf{D}_n]\{\text{var}(vec(\mathbf{\Omega}_s)) \otimes \text{var}(vec(\mathbf{\Omega}_s))\}[(\mathbf{D}_n'\mathbf{D}_n)^{-1}\mathbf{D}_n])',$$

$\mathbf{D}_n$ is the duplication matrix, and $\text{var}(vec(\mathbf{\Omega}_s))$ is computed from $\{\mathbf{\Psi}^{(n)}\}_{n=1}^{N}$. For inference, the 5^{th} and 95^{th} percentiles of the generated impulse responses are used to compute the 90 percent confidence bands.

2.4 Results

2.4.1 The Effects of Fiscal Shocks in the Baseline Model

The VAR model, in its baseline specification, includes five endogenous variables with the policy instruments ordered first (government expenditures and tax revenues followed by output, private consumption and house prices). The sample period considered is from 1973:1 - 2008:4.

The dynamic responses of each variable, to an increase in government expenditures, are summarized in Figures 2.3 through 2.7. The graphs describe the impulse response function of the VAR variables to a 1 % positive government spending shock. The black line is generated from a linear VAR that does not control for credit regimes and is included as a comparison point. The blue line is the response in the tight credit regime, while the red line refers to the case when credit conditions are relaxed. The corresponding 90% confidence intervals are represented by gray shaded areas (one type of IRF per panel).

Table 2.1 quantifies the policy effects in terms of fiscal multipliers for output, consumption and house prices. The output and consumption multipliers give the dollar change in each variable to a one dollar increase in government spending, while the house price multiplier presents the response in percentage points . I report the value of the multipliers on impact, at the peak (maximum), and a cumulative measure defined as the ratio between the sum of the responses in the variable of interest and the sum of responses in government spending over 20 quarters. Standard errors are calculated and provided in each case.

For output, the linear model predicts a positive and statistically significant response on impact (with a 1.07 multiplier) and then for approximatively 4 quarters. At longer horizons the effect becomes negative and insignificant. This pattern is very similar to that reported by Mountford and Uhlig (2009).

When controlling for financial conditions, the observed response of output appears very asymmetric across regimes. Under tight credit conditions, there is a sizable and significant drop on impact (-1.66), while in the relaxed regime output goes up (1.41) and continues to be positive for more than 10 quarters. Overall, fiscal policy is expansionary in the good state of the world and contractionary in the bad one, although changes in output are not statistically significant, in the latter, past the first few quarters.

The response of private consumption is consistent with the dynamics observed for output. In the linear VAR, consumption increases on impact, with a multiplier of approximatively 0.57 (which is also the maximum) and it declines afterwards. The effect is only significant for four or five quarters. This is again consistent with the findings of Mountford and Uhlig (2009).

In a relaxed credit regime, consumption is expected to increase on impact relatively more (0.69). It peaks after three quarters, and then it continues to remain positive for another 8 quarters. Under the tight credit state, on the other hand, there is an initial drop (-0.26), but after that private consumption recovers gradually, catching up to the level predicted by the linear VAR in approximatively 6 quarters. The effects are statistically significant for the relaxed credit scenario, but not for the tight credit regime.

I also find evidence about an asymmetric response of house prices across regimes. There is a large and significant drop on impact (-0.88%) in the bad state of the world, after which prices start to rebound. In the good credit state, house prices increase only slightly on impact (0.05%) and show a gradual deterioratian afterwards. The linear model predicts an initial smaller decline (-0.02%), with dynamics that are similar to the relaxed regime. Neither of the last two reported impact effects is significant statistcally though. Overall, all three scenarios suggest a negative effect, which is comparatively larger for the difficult credit state.

The response of fiscal variables is fairly standard. In the case of government expenditures, the model predicts, after the initial increase, a decline in spending across all specifications. For the first 6 quarters the drop in expenditures appears to be in steeper in the negative regime, but it levels off afterwards. This may suggest a potential worsening in credit conditions, induced by the government's financing positions. All dynamics are significant.

Tax revenues are predicted to decrease sharply in the tight credit regime, which is consistent with the observed negative adjustment in output under this scenario. The effect is significant up to five quarters. The other two cases suggest a positive response on impact, that is larger with relaxed credit and also statistically significant.

Overall, the results suggest that, at least in the short run, credit conditions may play an important role in the economy's response to fiscal stimulus. When financial conditions are difficult, increases in government spending lead a drop in private consumption and a negative (or reduced) effect on output. There is also a sharp decline (on impact) in house prices.

These findings are qualitatively compatible with the existence of a credit channel and a financial amplification mechanism tied to credit constrained households. This would work similarly to the financial accelerator described in theoretical DSGE literature and it links movements in asset prices to changes in private consumption and output. The observed rebound in house prices at longer horizons, is also consistent with the mechanism, as it would help relax borrowing limits, sustain consumption and increase output.

In contrast, in a relaxed credit regime, fiscal stimulus appears to be far more effective, leading to a positive response in both output and private consumption, along the lines of the existing empirical literature. House prices will also increase on impact, suggesting a less negative impact on private borrowing. This finding can again be reconciled with the existence of credit constrained agents who will be able to expand their consumption relatively more under this scenario, as the collateral constraint they are facing will be less severe due to overall better credit terms.

In the literature, Agnello and Sousa (2013), also document a negative response of asset prices (stocks and housing) to expansionary fiscal policy using a panel VAR (PVAR) for 10 industrialized countries (including the U.S.). They find this consistent with a deterioration of credit conditions due to the government's increased financing needs. According to their results the response of house prices is persistent, while the effect on stock prices appears transitory, suggesting that policy makers might find it difficult to stabilize both markets using a single policy instrument.

2.4.2 Fiscal Policy and Anticipation Effects

A common criticism of fiscal structural VARs in the spirit of Blanchard and Perotti (2002) is that they do not account for policy anticipation effects[6]. Due to the, usually extensive, procedural mechanism that the Government has to follow in order to implement a discretionary fiscal measure, as well as various other implementation lags, it is reasonable to assume a certain degree of fiscal foresight.

Economic agent thus have, in many cases, opportunities to learn beforehand about an upcoming policy intervention and respond to it in advance as part of their rational behavior. This leads to potential endogenity problems in empirical analysis, if there is no control for public's expectations, as the error terms would no longer be orthogonal to the control variables.

In order to address this concern, I include in the VAR a forecast for the growth rate of government spending ($\Delta G^F_{t|t-1}$), ordered first in the vector of variables, which is now given by: $\tilde{X}_t = [\Delta G^F_{t|t-1}\ G_t\ T_t\ Y_t\ C_t\ Q_t]'$.

In this framework, a government spending innovation (G_t) orthogonal to the growth rate of government spending ($\Delta G^F_{t|t-1}$) forecasted at time $t-1$ for the next period t is interpreted as an unanticipated expenditure shock, thus directly removing the predictable component from government spending innovations.[7]

The forecast data is obtained from Auerbach and Gorodnichenko (2012a). The two authors have produced a continuous quarterly series that runs until 2009, by splicing data from two different sources of forecasts on government spending and its components. One of them is the Survey of Professional Forecasters (SPF) available from 1982, while the other is Greenbook prepared by the Federal Reserve Board (FRB) for the Federal Open Market

[6]See for example: Ramey and Shapiro (1998), or Leeper et al. (2013)

[7]The growth rate rather than the level of government spending is used in order to account for the fact, that the aggregate data, typically undergoes numerous revisions before the final release. This makes the forecasts less sensitive to such subsequent changes in data.

Committee (FOMC) meetings and it goes back to 1966.

Figure 2.8 presents a scatter plot of the residuals obtained by projecting the forecast variable ($\Delta G^F_{t|t-1}$) on the VAR lags and the residuals from the projection of the growth rate of the observed government spending variable. As shown by the regression line fitted through the data points, government spending shocks appear predictable at least to a moderate degree.

Figures 2.9 through 2.11 describe the response of output, consumption and house price in each regime with and without a control for anticipation effects. Table 2.2 gives the values of the multipliers and their corresponding standard errors. Overall, the dynamics of the variables appear very similar across specifications. The cumulative multiplier values are also comparable, although a somewhat larger in absolute values when we account for anticipation effects in fiscal shocks.

2.4.3 Government Spending Shocks and The Short-term Real Interest Rate

In order to account for the role of monetary factors, I consider a measure of the short term interest rates that is also directly tied to the financing process of government deficits. Therefore, I control in the VAR for the real, secondary market, 3 month T-bill rate ($TB3M_t$). In this specification the vector of endogenous variables is given by: $\mathbf{X}_t = [G_t\ T_t\ Y_t\ TB3M_t\ H_t]'$.[8]

The dynamics of the variables to a government spending shock are included in Figures 2.12 through 2.16, while Table 2.3 provides the values for the fiscal multipliers. The sample period is the same as before, from 1973:1 to 2008:4.[9]

The responses of output, house prices and fiscal variables appear consistent and very

[8] As mentioned the other variables used in the VAR are given expressed in natural logs, while the interest rate enters in levels.

[9] The Federal Funds rate has been cut to its current low level, in the last quarter of 2008, effectively starting the Zero Lower Bound period.

similar to the baseline scenario. In particular, we observe the same, short run, negative adjustment during financial duress and an expansionary effect, during good financial times.

Regarding the multipliers, in both the linear specification and relaxed credit regime, the values are directly comparable to baseline. For output we have 1 (compared 1.07) and 1.52 (compared to 1.41), respectively. While for house prices it is -0.02% (versus -0.09%) and 0.05% (to 0.05%). All are significant.

In the difficult credit regimes, the signs of the impact multipliers remain the same, but the values are smaller in absolute terms relative to baseline. For output it is -1.66 (compared to -0.51) and -0.2% (compared to -0.88%) for house prices which suggests a more important role for the interest rate in this case.

Finally, the real interest rate appears to increase, in a hump shaped pattern, under all three scenarios. By far the largest response (in absolute terms) is in the tight credit regime with a peak response of 0.42% compared to 0.20% for the other two cases that occurs after approximatively 4 quarters.

In the literature, Gale and Orszag (2004) suggest that budget deficits will affect credit availablitity and negatively impact interest rate when private savings does not increase enough to meet the government financing requirements (for example, Ricardian equivalence does not hold) and there are no other compensating inflows of capital (from abroad).

2.4.4 Controlling for the post-Financial Crisis Data

As a robustness check, I extend my data sample thought 2013, in order to include the post-crisis data. The VAR specification is identical to baseline, with the the exception of the weighting function curvature parameter γ. Almost all the new data points (with the exception of two observations in the first half of 2009) fall in a relaxed credit regime, as characterized by the financial index variable. This reduces the frequency of the extreme regime observations in the sample from 34% to around 32%. In order to account for this, I recalibrate γ at 6.

The results for this experiment are presented in Figures 2.17 to 2.21 and Table 2.4. They are all consistent with the baseline findings, both in terms of regime dynamics and magnitude. One comment refers to the impact multipliers for consumption and output in the tight credit regime. The former is still negative, but smaller (-0.29 compared to -1.66), while the other changes sign (0.22 compared to -0.26). Also, both output and consumption (as well as house prices) appear to show a more accelerated response at longer horizons (which are just marginally significant).

Even so, qualitatively the response to fiscal policy across regimes is similar to previous findings, with a largely negative or reduced short term effect in the unfavorable state and a more expansionary response in the favorable state. I attribute the quantitative difference outlined above to the easy monetary policy that characterizes this period.

Regarding the long term dynamics of output specifically, Afonso et. al (2011), who use a threshold VAR to study the effects of fiscal policy on output under two different financial stress regimes, find a similar pattern. They report that in a high financial stress regime increases in government spending are contractionary on impact, but overall the output rate of growth will be higher relative to the low stress regime.

2.5 Concluding Remarks

Using a regime switching SVAR which controls for two credit regimes, I find evidence that under the bad state of the world the expansionary effects of policy are reduced, as opposed to normal or (more) relaxed financial conditions. The empirical results show a negative, short run impact, for aggregate output, private consumption, as well as, house prices. At longer horizons, both output and asset prices start to recover.

In a relaxed credit regime, fiscal stimulus appears to be for more effective and induces an increase in both output and private consumption. The effect on house prices, on impact, is positive but modest with fairly flat dynamics, although the confidence intervals include zero.

Considered together, the variations in output, consumption and house prices in response to government spending shocks are consistent with the existence of credit constrained agents and collateral requirements.

In a scenario where access to external financing is already difficult (due to a worsening in credit conditions), the hike in real interest rates associated with the the government's additional borrowing needs, will make private borrowing even more expensive.

Furthermore, the drop in the value of collateralizable assets may further downsize borrowing, accounting for the sharp negative adjustment in private consumption and output.

These results are robust to a number of specifications, such as policy anticipation effects, the inclusion of short term real interest rates, as well as the use of a larger sample with post-crisis data.

As a direction for future work, the findings in this paper can be further strengthened by using an alternative, more rigorous, identification strategy based on sign restrictions and by allowing the regime threshold to be determined endogenously in the model.

2.6 Appendix

2.6.1 Tables

Table 2.1: Response to a 1% Government Spending Shock - Baseline Model

	Impact		Maximum		Cumulative	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Output ($)						
Linear	1.07	0.34	1.07	0.34	-0.52	0.40
Relaxed	1.41	0.22	1.81	0.21	0.75	0.26
Tight	-1.66	0.80	0.28	1.27	-1.18	1.19
Consumption ($)						
Linear	0.57	0.23	0.57	0.23	0.14	0.28
Relaxed	0.69	0.10	1.06	0.08	0.84	0.14
Tight	-0.26	0.56	0.72	1.02	0.28	0.94
House Price (%)						
Linear	-0.02	0.16	-0.02	0.16	-1.00	0.12
Relaxed	0.05	0.16	0.11	0.12	-0.23	0.13
Tight	-0.88	0.27	-0.15	0.16	-1.22	0.16

Table 2.2: Response to a 1% Government Spending Shock - Anticipation Effects

	Impact		Maximum		Cumulative	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Output ($)						
Relaxed	0.50	0.44	0.86	0.42	1.29	0.37
Tight	-0.20	0.61	0.49	0.43	-1.58	0.36
Consumption ($)						
Relaxed	0.31	0.05	0.40	0.05	0.90	0.05
Tight	-0.46	0.11	0.33	0.20	0.44	0.18
House Price (%)						
Relaxed	0.19	0.04	0.32	0.03	-0.25	0.04
Tight	-0.75	0.14	-0.60	0.21	-1.34	0.22

Table 2.3: Response to a 1% Government Spending Shock - Interest Model

	Impact		Maximum		Cumulative	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Output ($)						
Linear	1.00	0.34	1.22	0.42	0.63	0.14
Relaxed	1.52	0.25	2.10	0.22	-0.17	0.21
Tight	-0.51	0.40	2.10	0.92	0.74	0.57
Interest Rate (%)						
Linear	0.07	0.07	0.20	0.05	0.11	0.02
Relaxed	0.10	0.04	0.21	0.03	0.15	0.03
Tight	-0.08	0.09	0.42	0.18	0.14	0.23
House Price (%)						
Linear	-0.09	0.13	0.29	0.11	0.20	0.09
Relaxed	0.05	0.13	0.18	0.12	-0.01	0.13
Tight	-0.20	0.08	0.17	0.46	-0.16	0.23

Table 2.4: Response to a 1% Government Spending Shock - Extended Sample Model

	Impact		Maximum		Cumulative	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Output ($)						
Linear	1.11	0.31	1.10	0.31	-0.25	0.37
Relaxed	1.28	0.21	1.67	0.20	1.34	0.22
Tight	-0.29	0.53	1.70	0.78	1.25	0.59
Consumption ($)						
Linear	0.50	0.20	0.59	0.23	0.21	0.27
Relaxed	0.54	0.11	0.92	0.08	0.94	0.14
Tight	0.22	0.34	0.95	0.55	1.28	0.47
House Price (%)						
Linear	0.08	0.15	0.08	0.15	-0.80	0.10
Relaxed	0.01	0.15	0.03	0.12	-0.35	0.11
Tight	-0.86	0.26	-0.24	0.16	-1.42	0.19

2.6.2 Figures

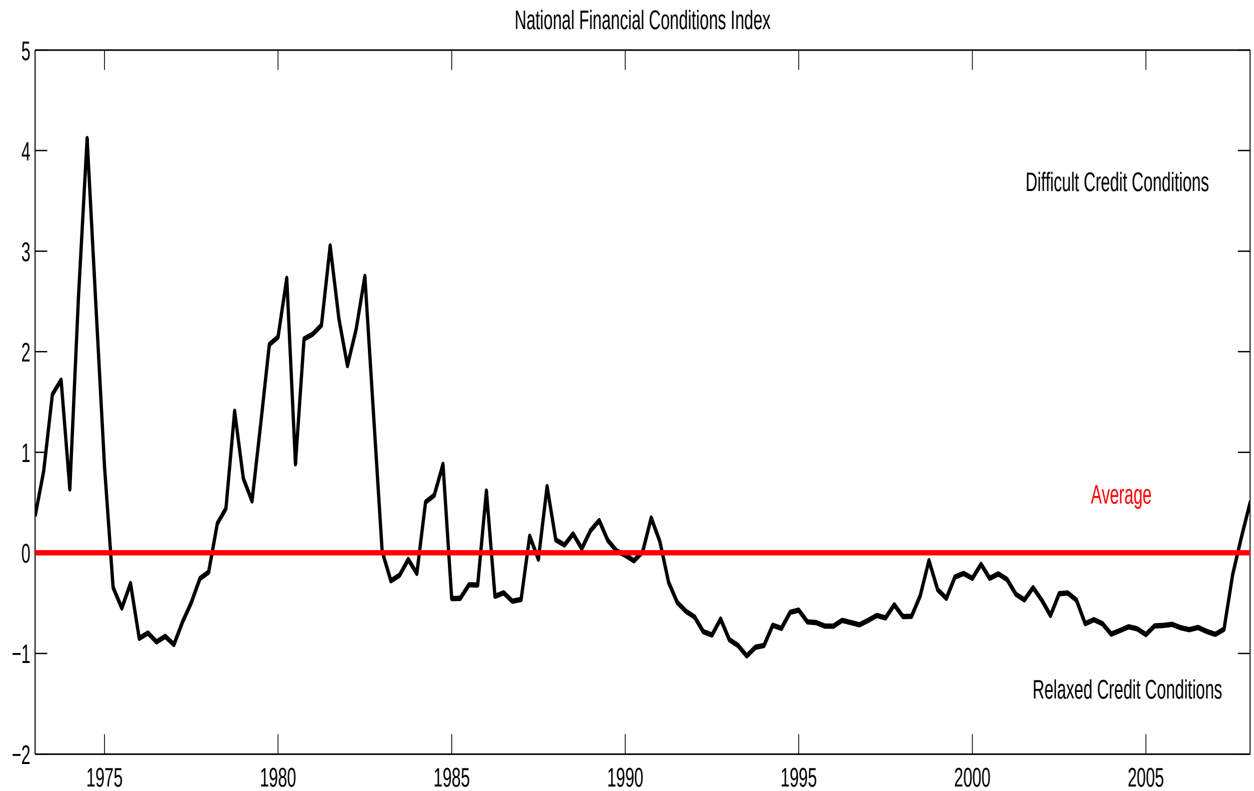

Figure 2.1: National Financial Conditions Index 1973:Q1 - 2007:Q4 . X-axis measures time (in quarters) .

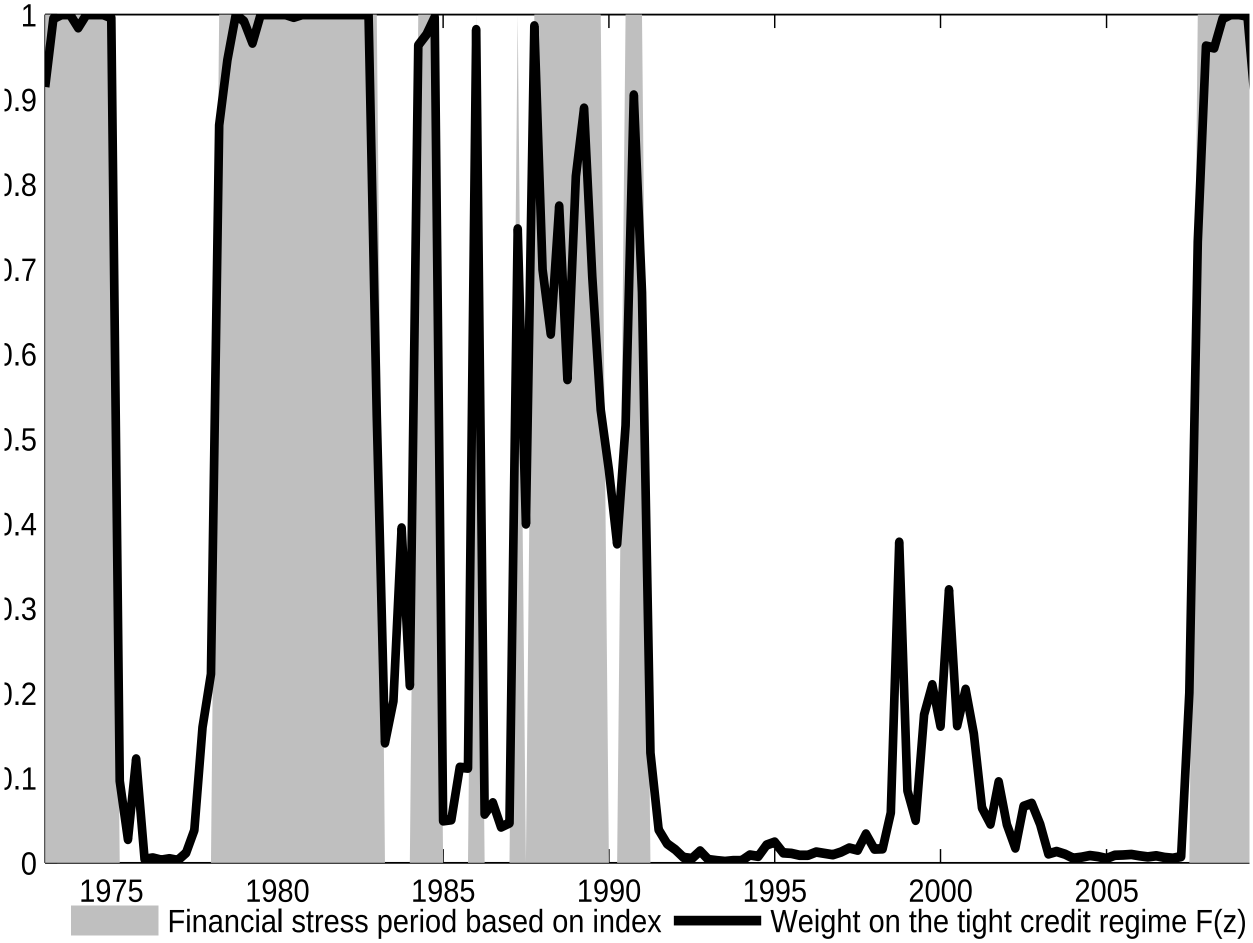

Figure 2.2: Weight function $F(z_t)$ 1973:Q1 - 2008:Q4 . X-axis measures time (in quarters) .

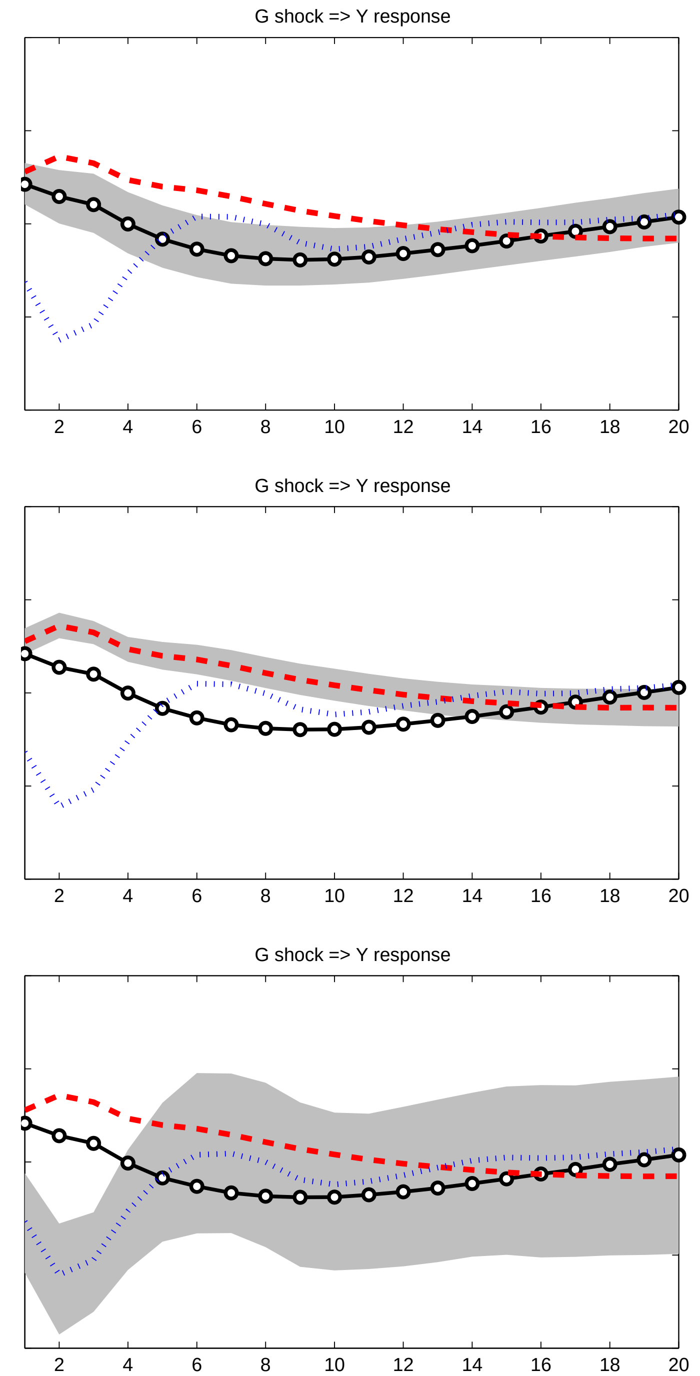

Figure 2.3: Baseline - Output Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

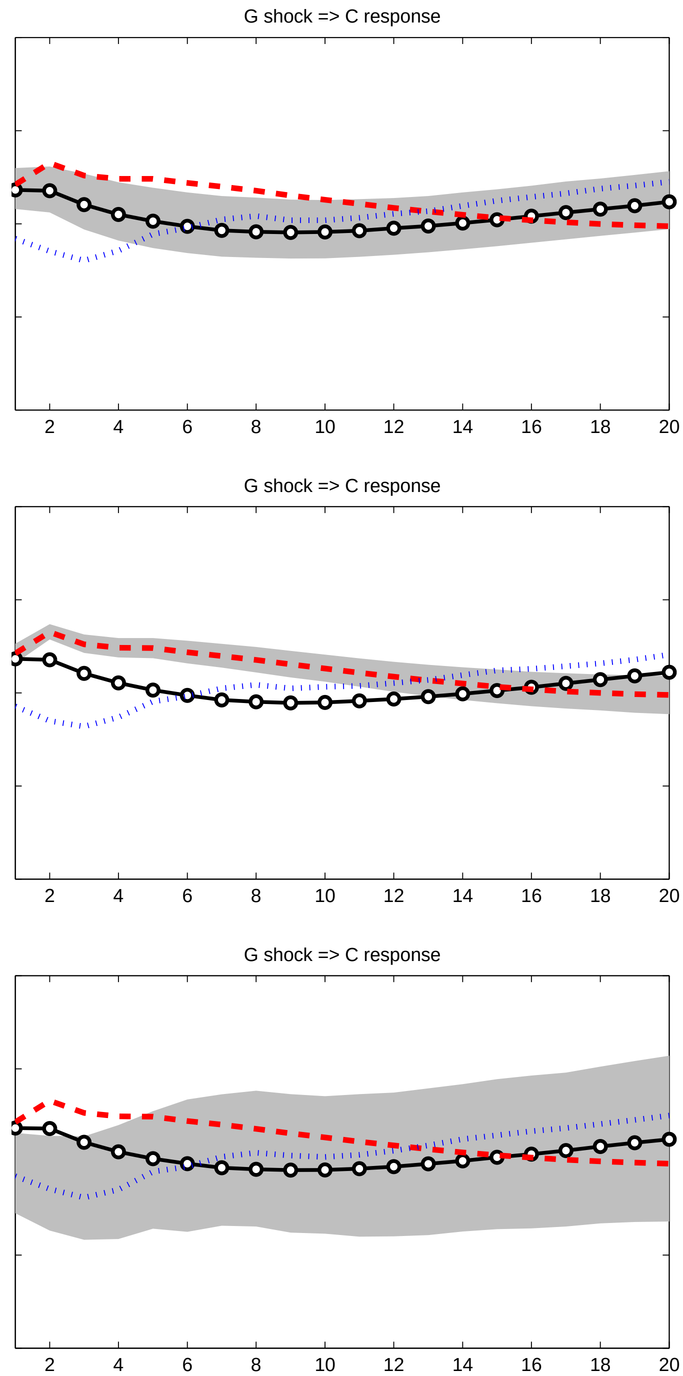

Figure 2.4: Baseline - Private Consumption Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

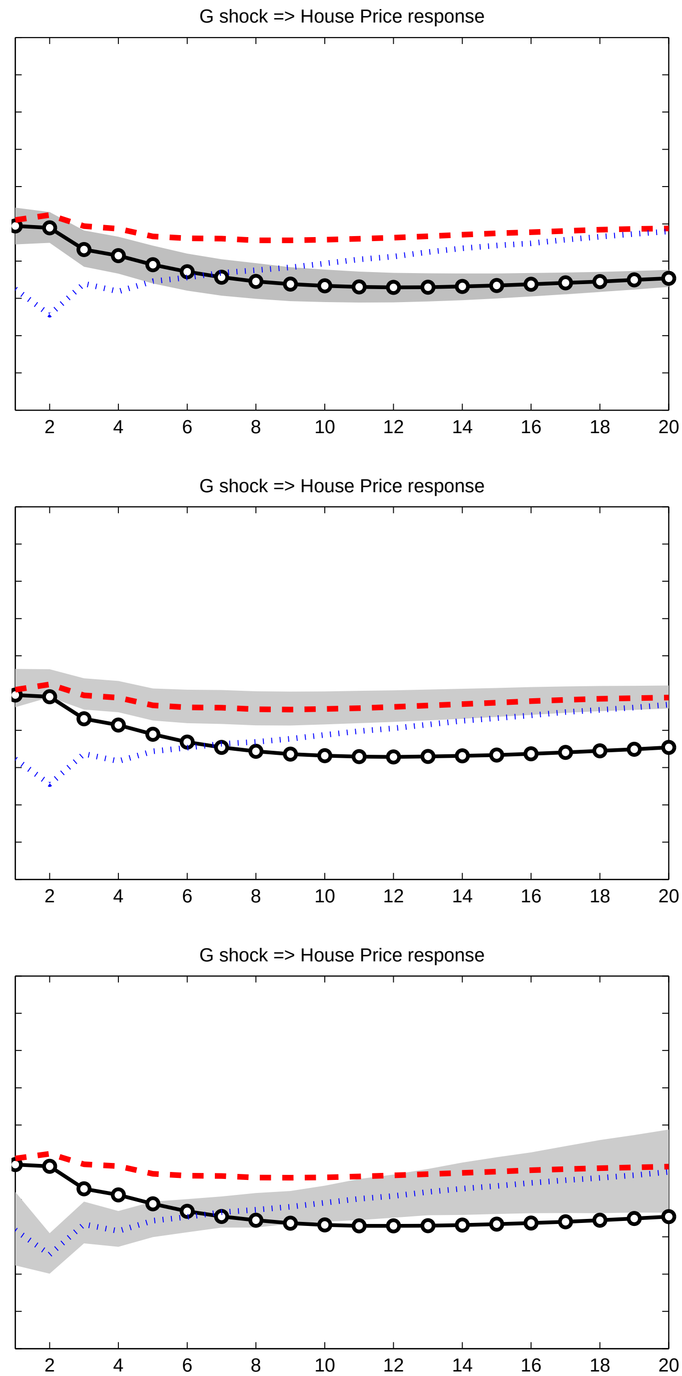

Figure 2.5: Baseline - Housing Price Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

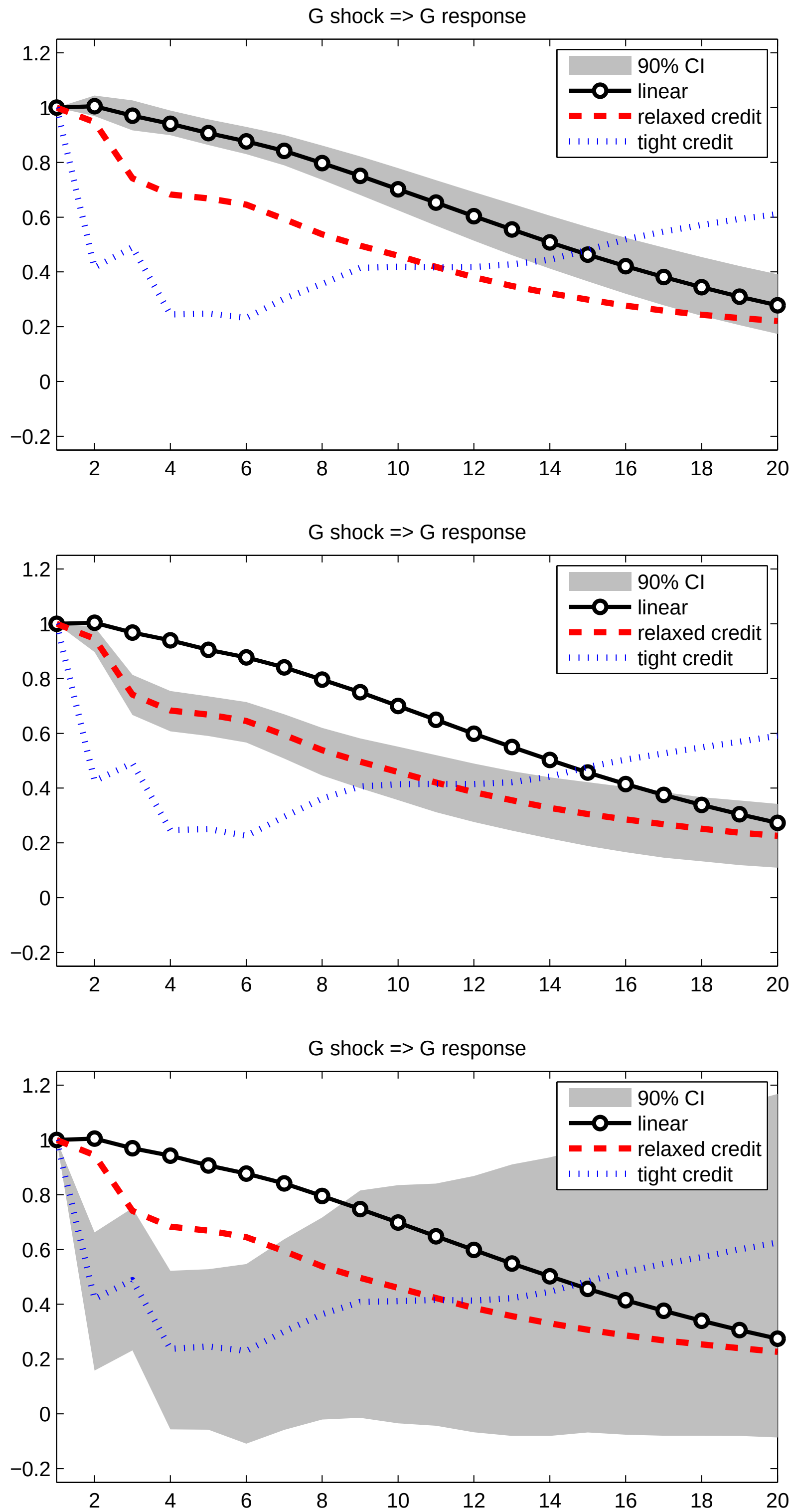

Figure 2.6: Baseline - Gov. Spending Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line). X-axis measures time (in quarters) .

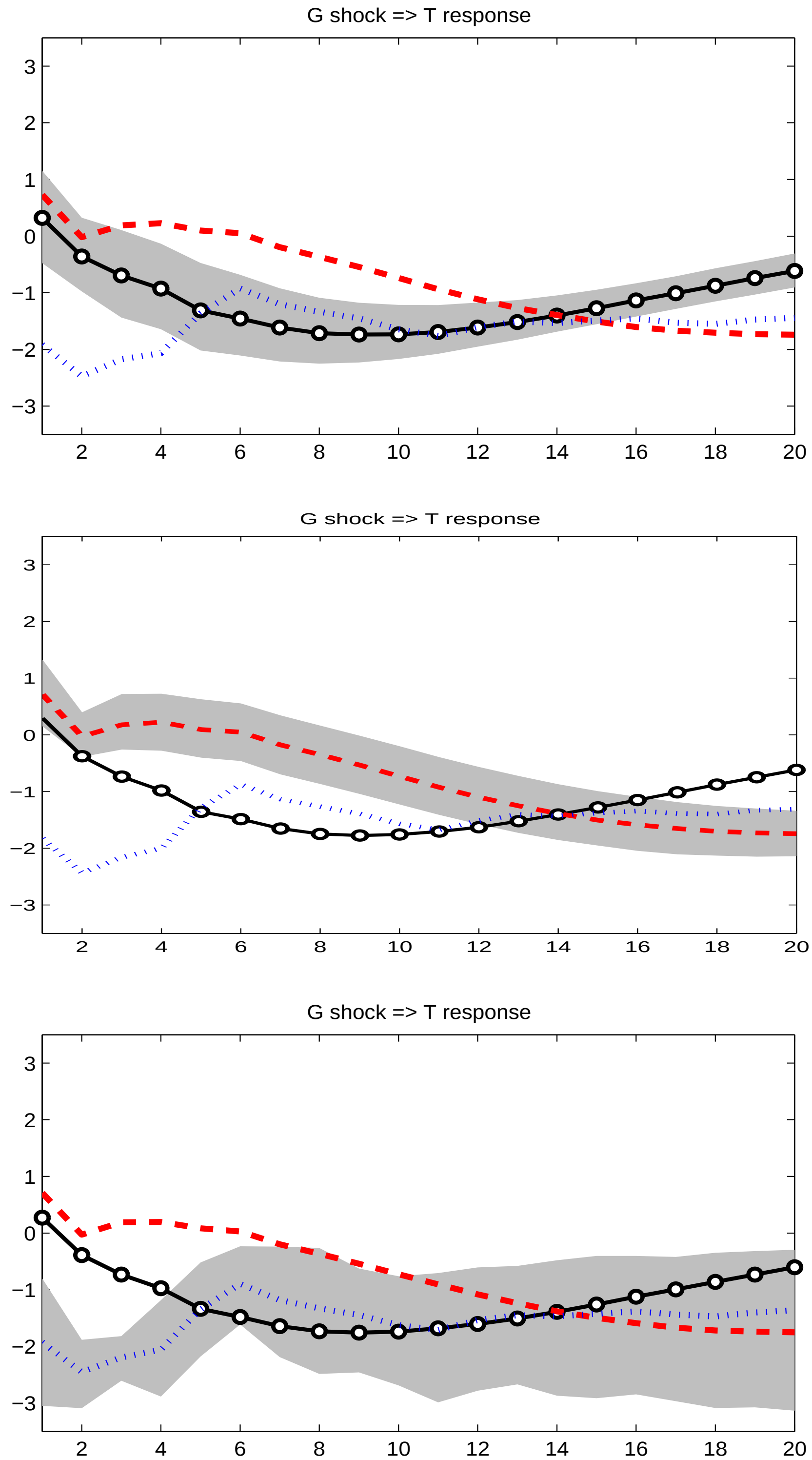

Figure 2.7: Baseline - Tax Revenue Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

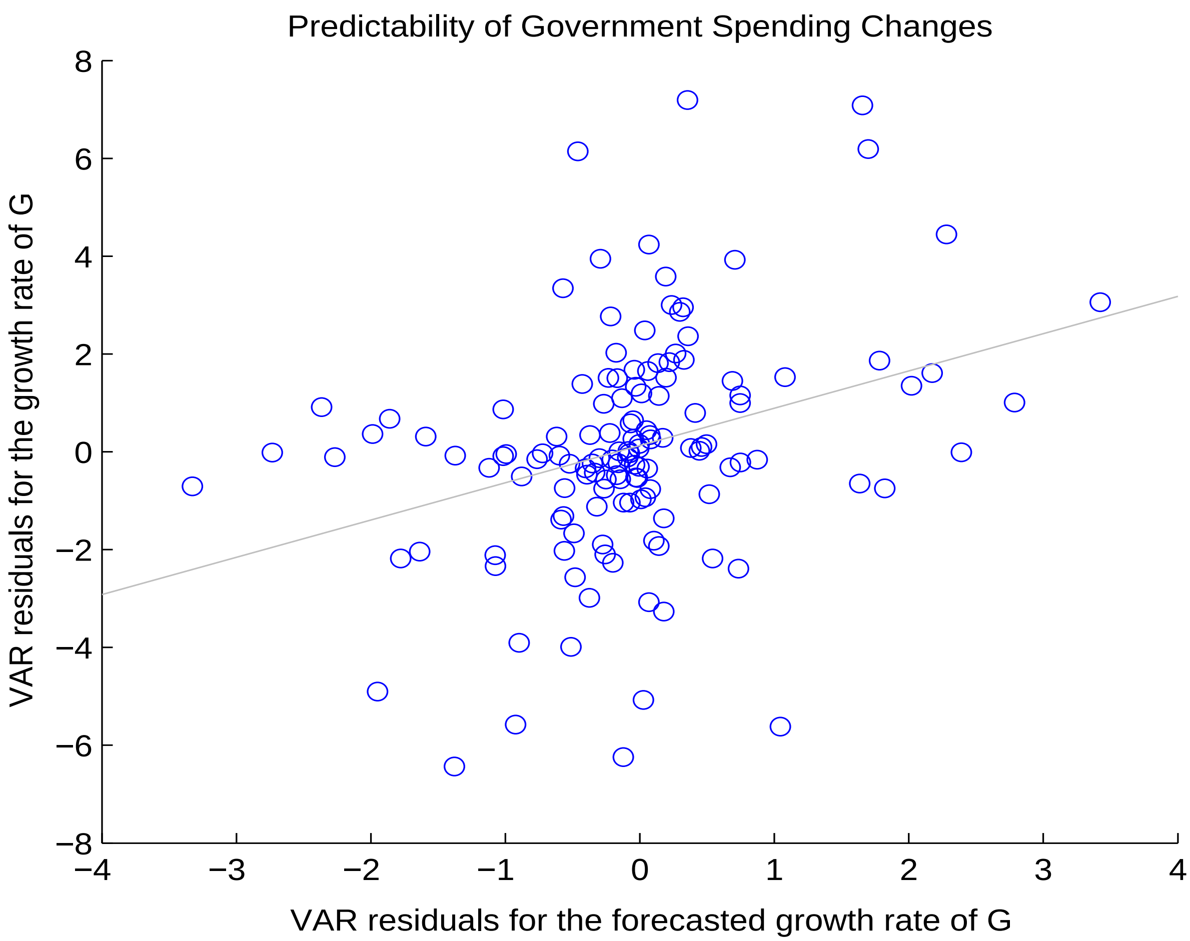

Figure 2.8: Government Spending Shocks Forecastability .

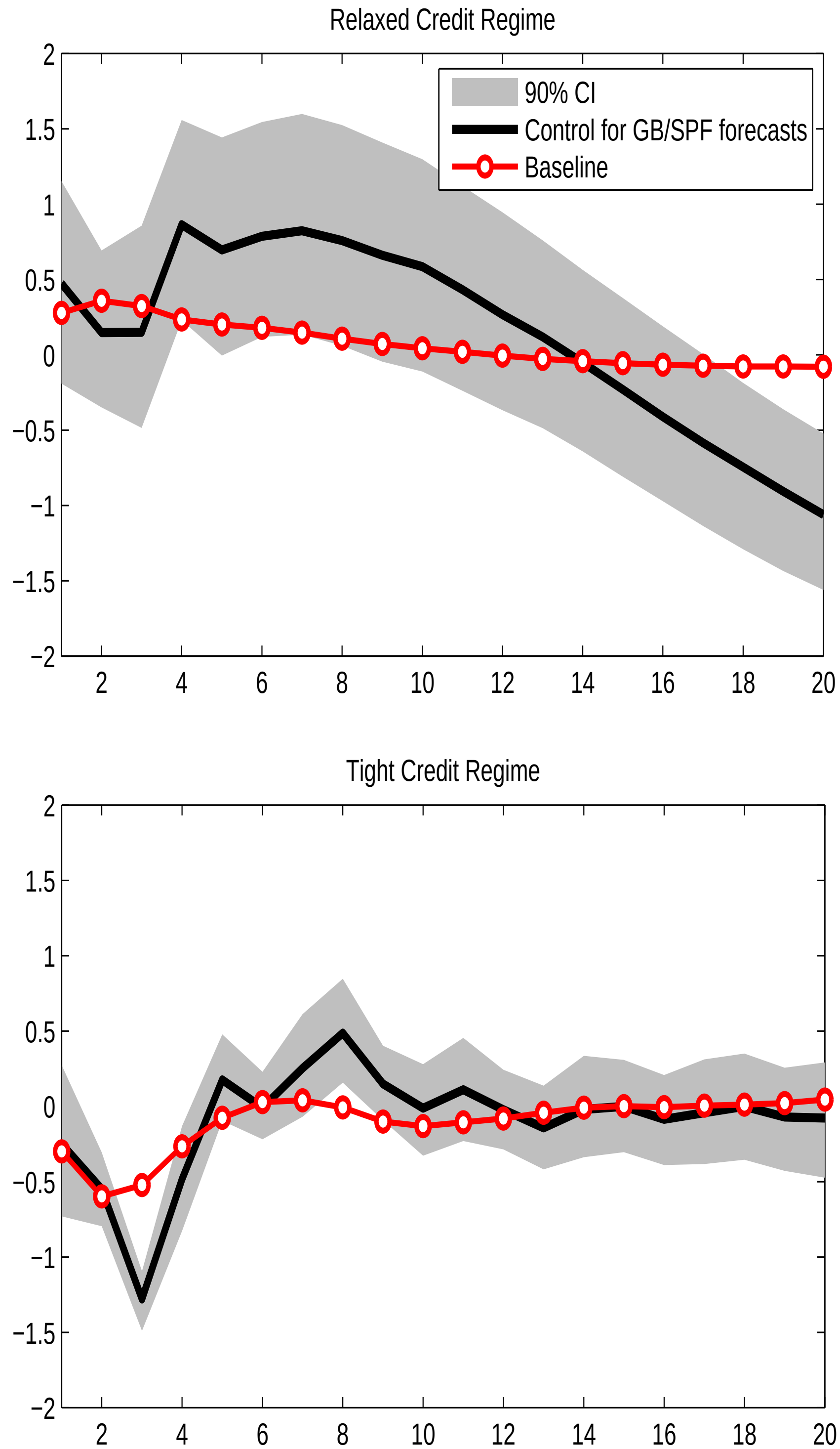

Figure 2.9: Anticipation Effects - Output Response Function to a 1% unexpected Gov. Spending Shock compared to Baseline. X-axis measures time (in quarters) .

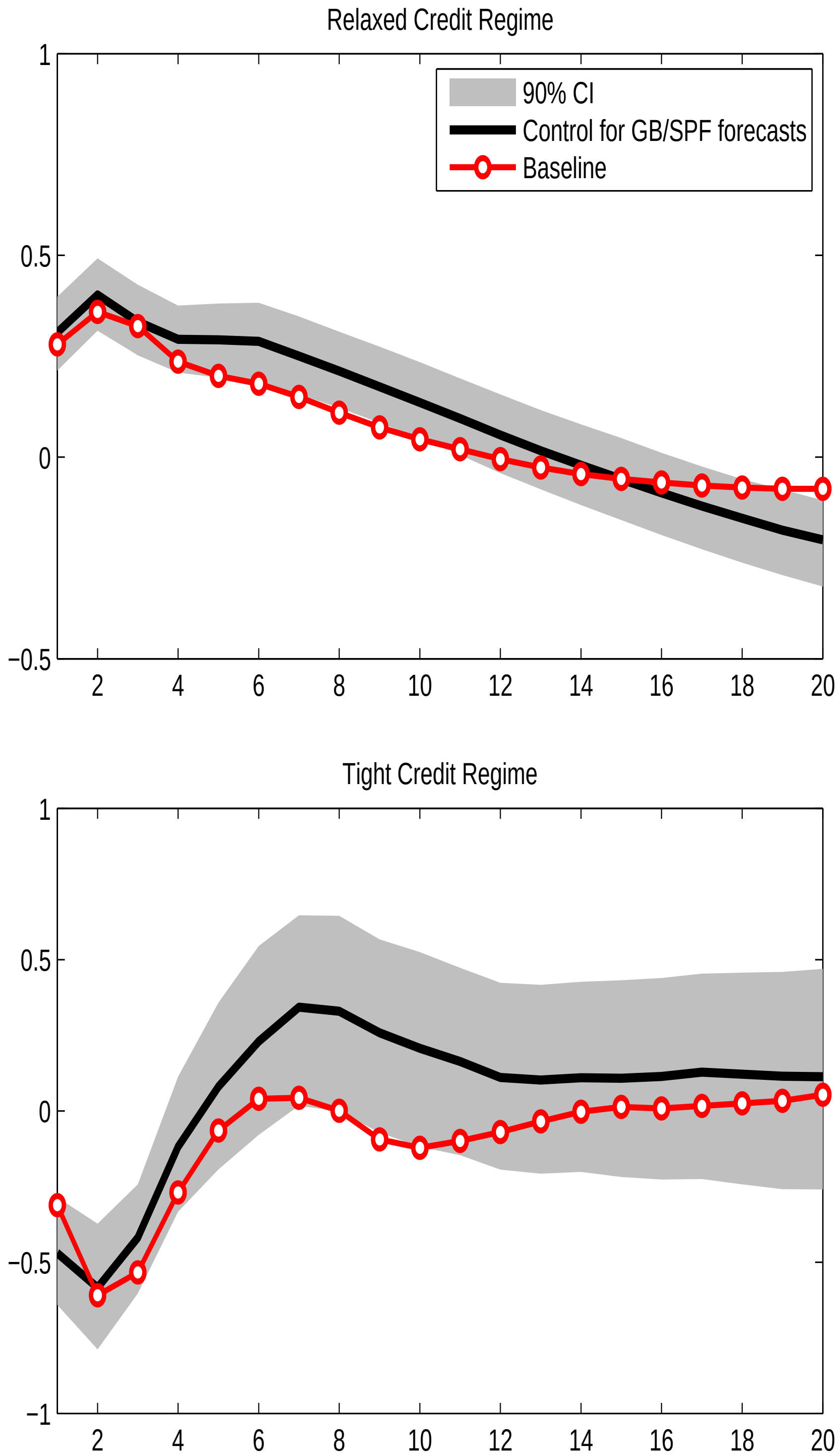

Figure 2.10: Anticipation Effects - Consumption Response Function to a 1% unexpected Gov. Spending Shock compared to Baseline. X-axis measures time (in quarters) .

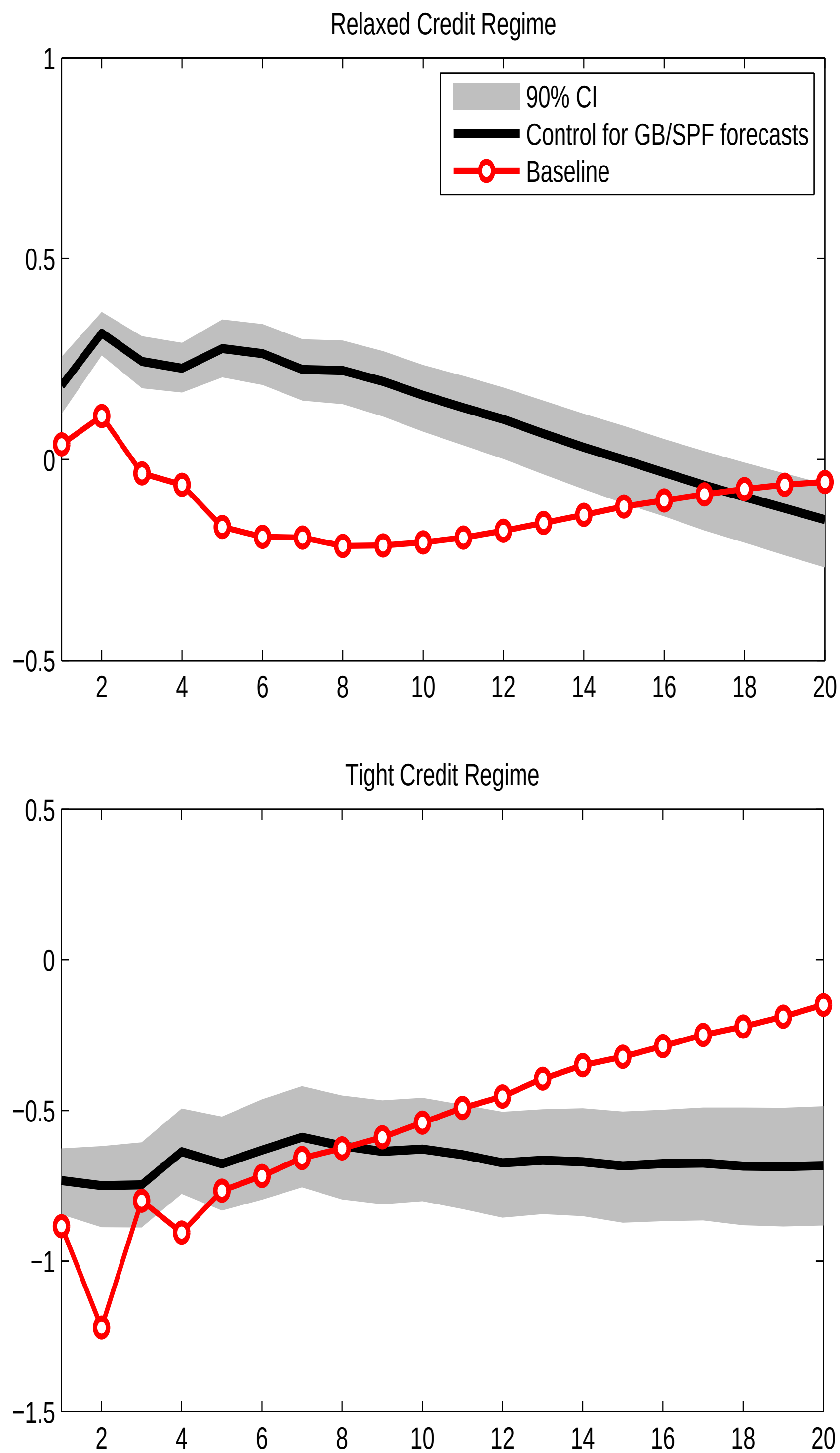

Figure 2.11: Anticipation Effects - House Price Response Function to a 1% unexpected Gov. Spending Shock compared to Baseline. X-axis measures time (in quarters) .

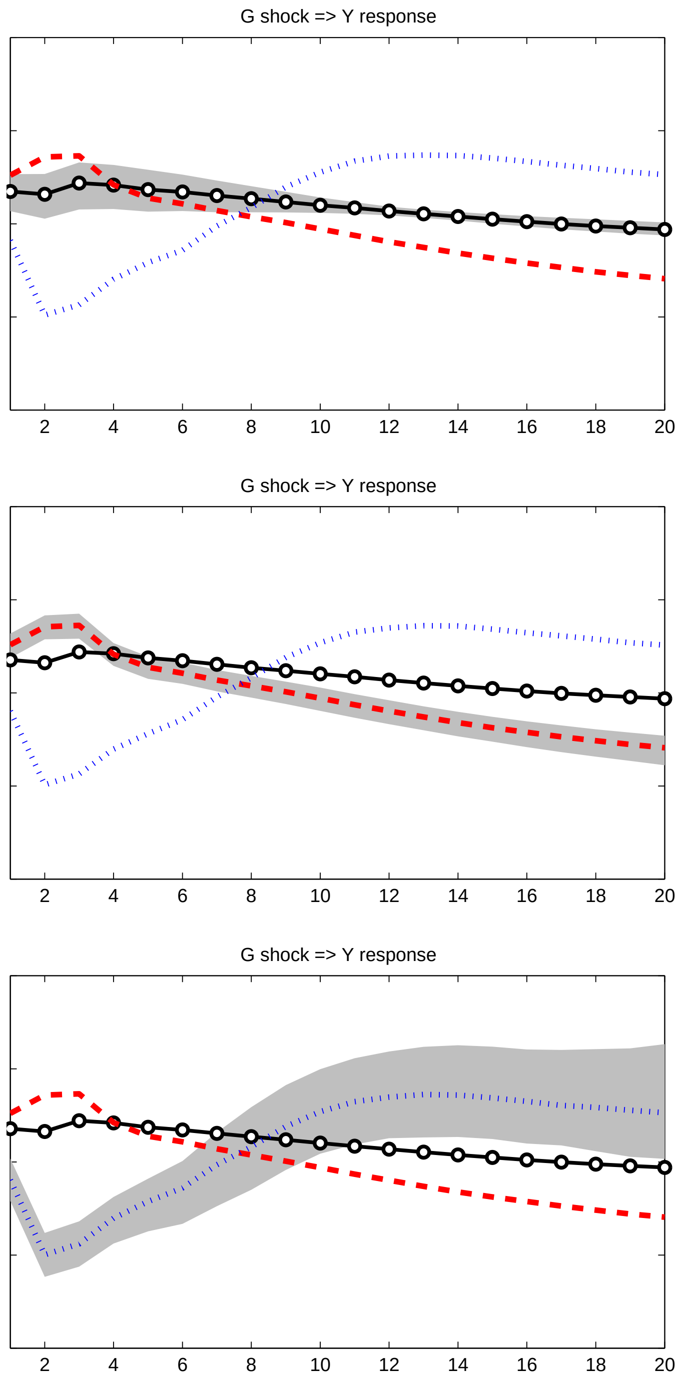

Figure 2.12: Monetary Stance - Output Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

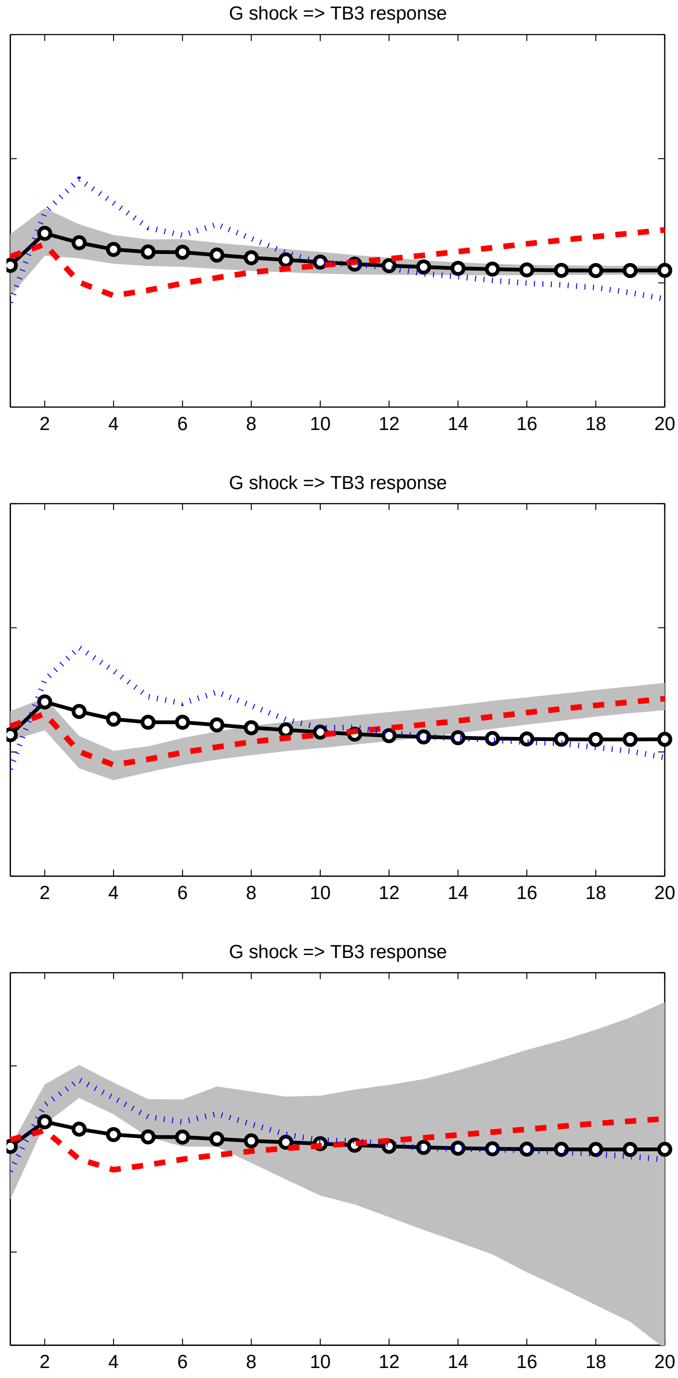

Figure 2.13: Monetary Stance - Short Term Real Interest Rate (TB3M) Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

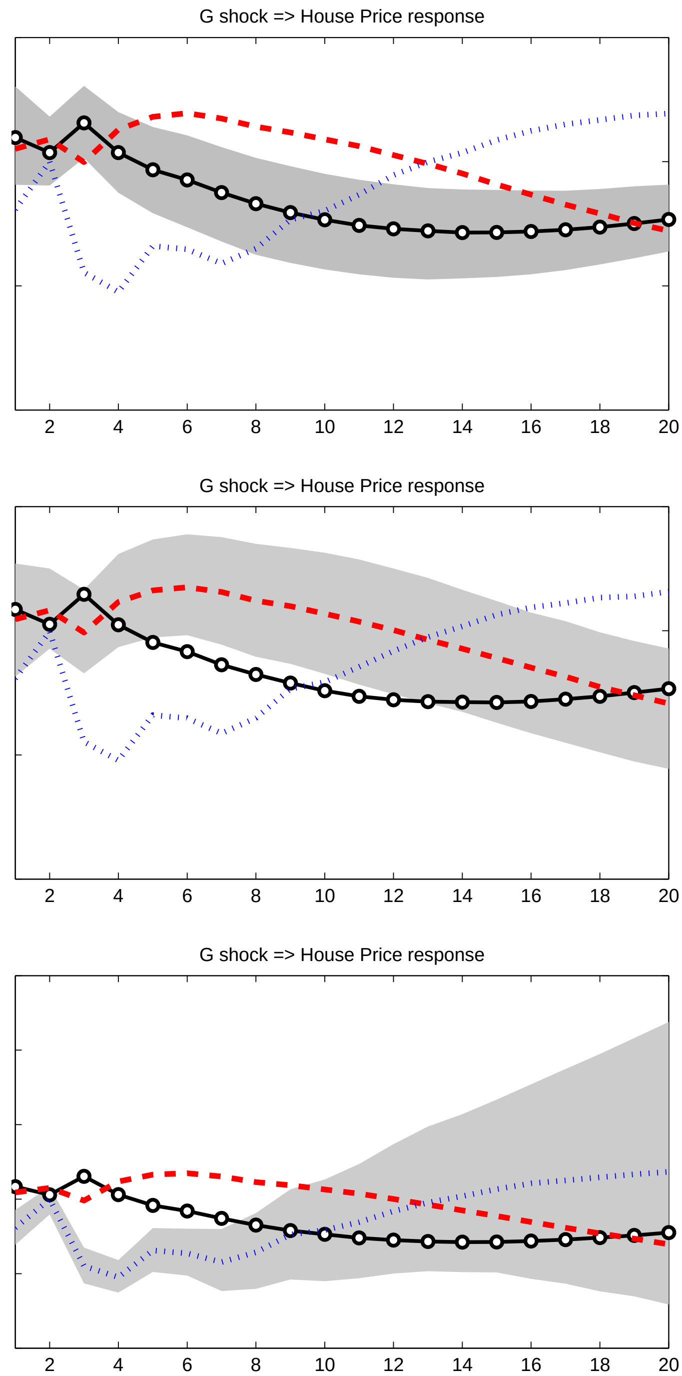

Figure 2.14: Monetary Stance - Housing Price Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

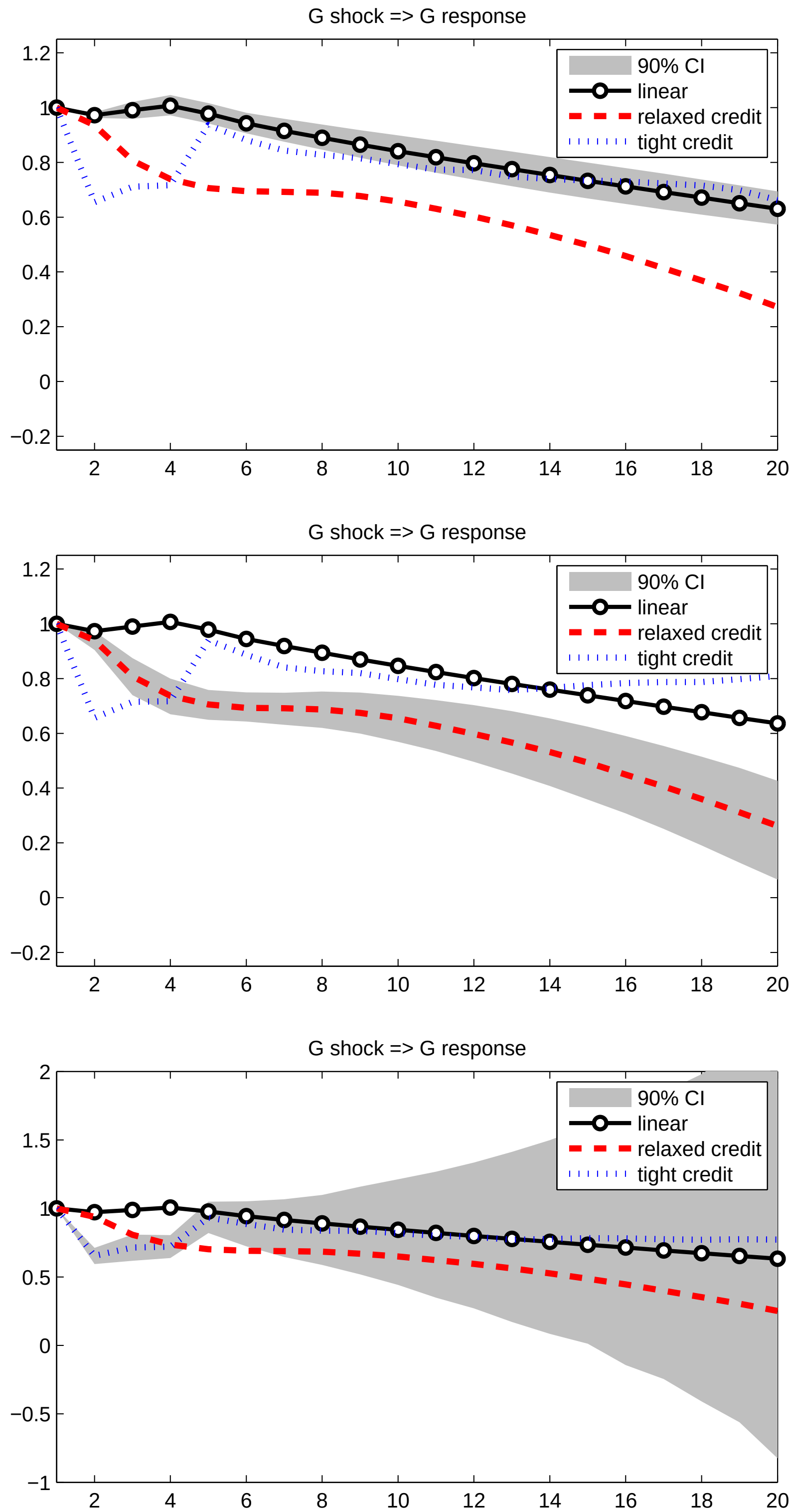

Figure 2.15: Monetary Stance - Gov. Spending Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line). X-axis measures time (in quarters) .

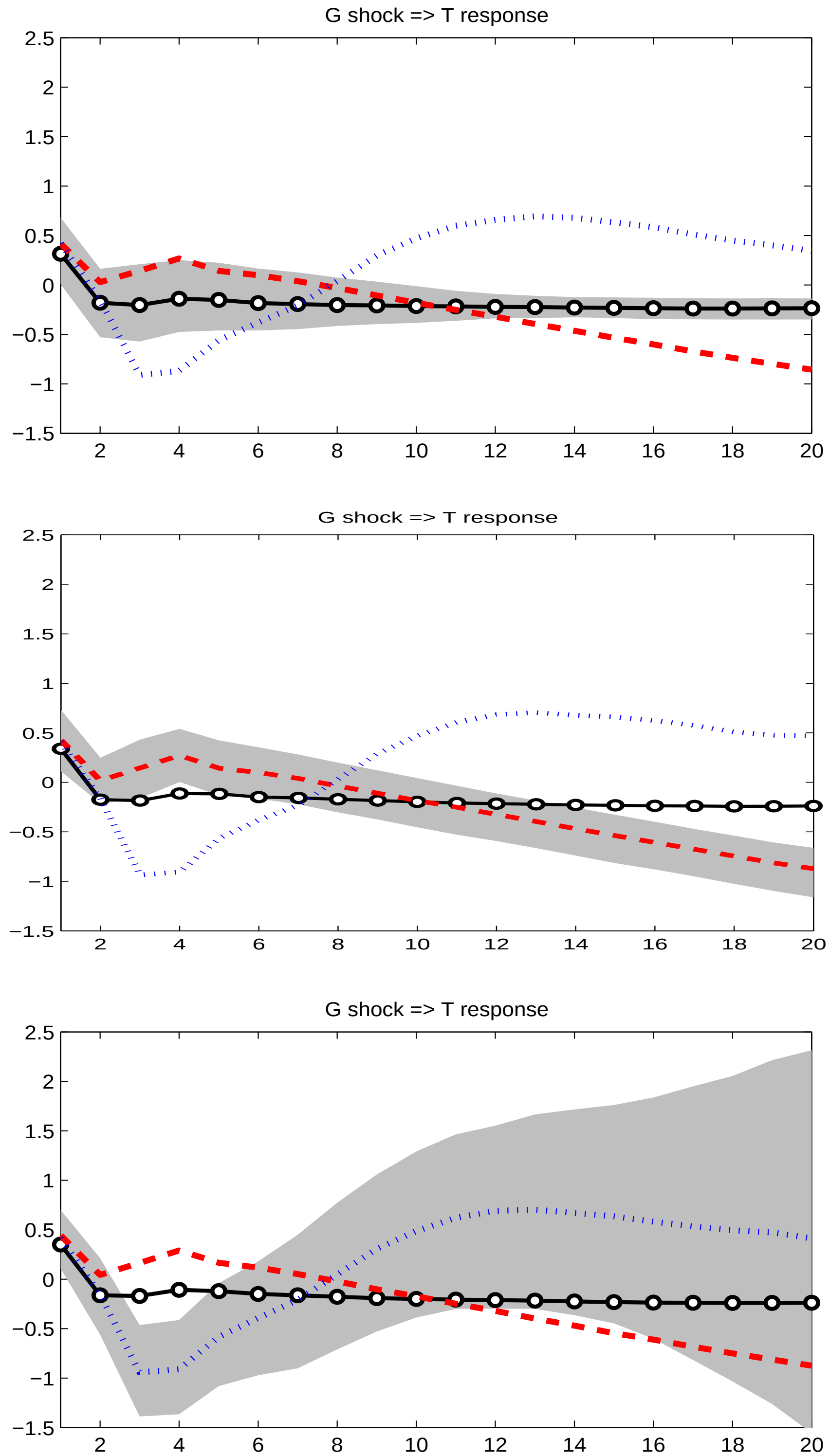

Figure 2.16: Monetary Stance - Tax Revenue Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

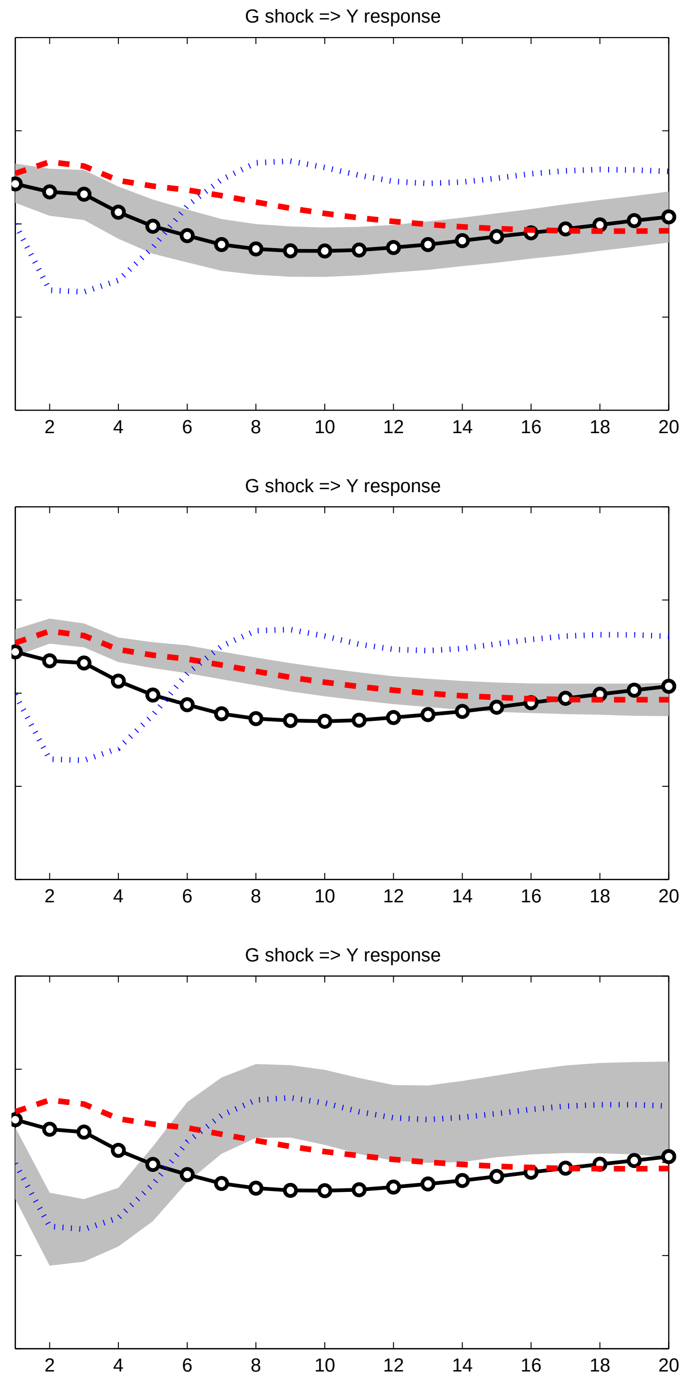

Figure 2.17: Extended Sample - Output Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

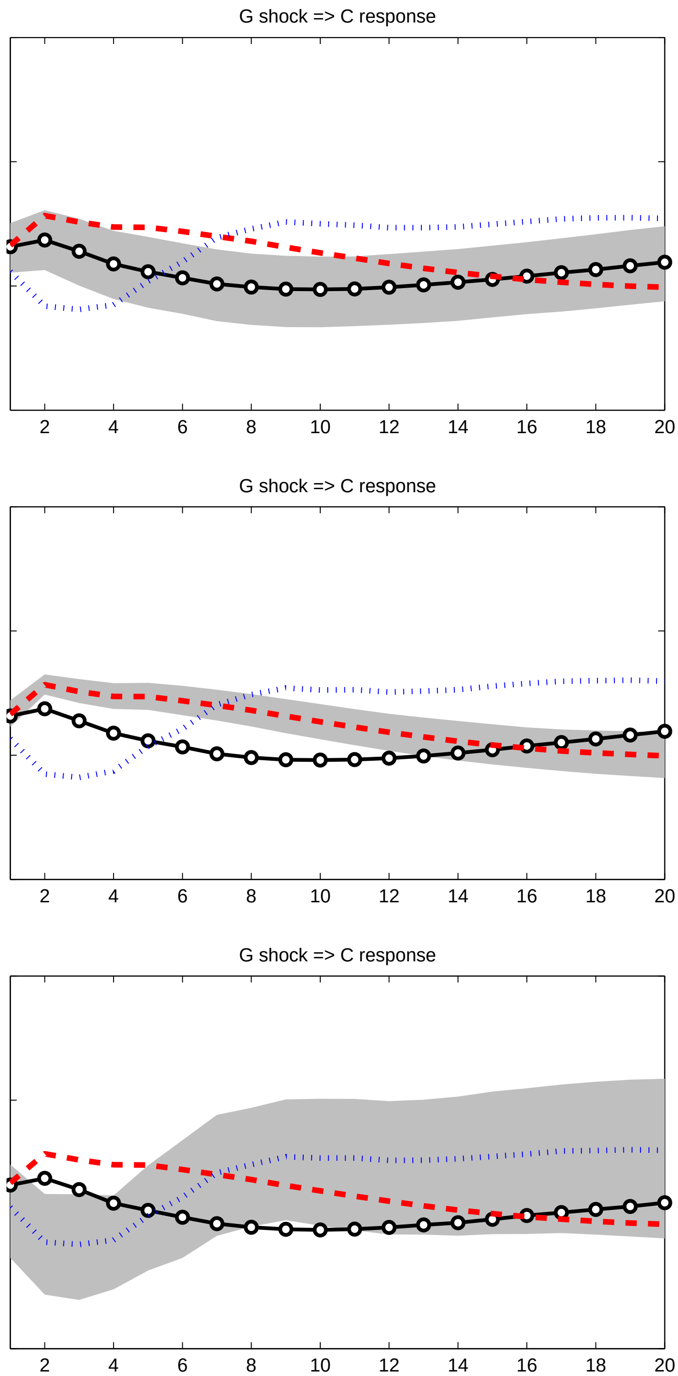

Figure 2.18: Extended Sample - Private Consumption Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

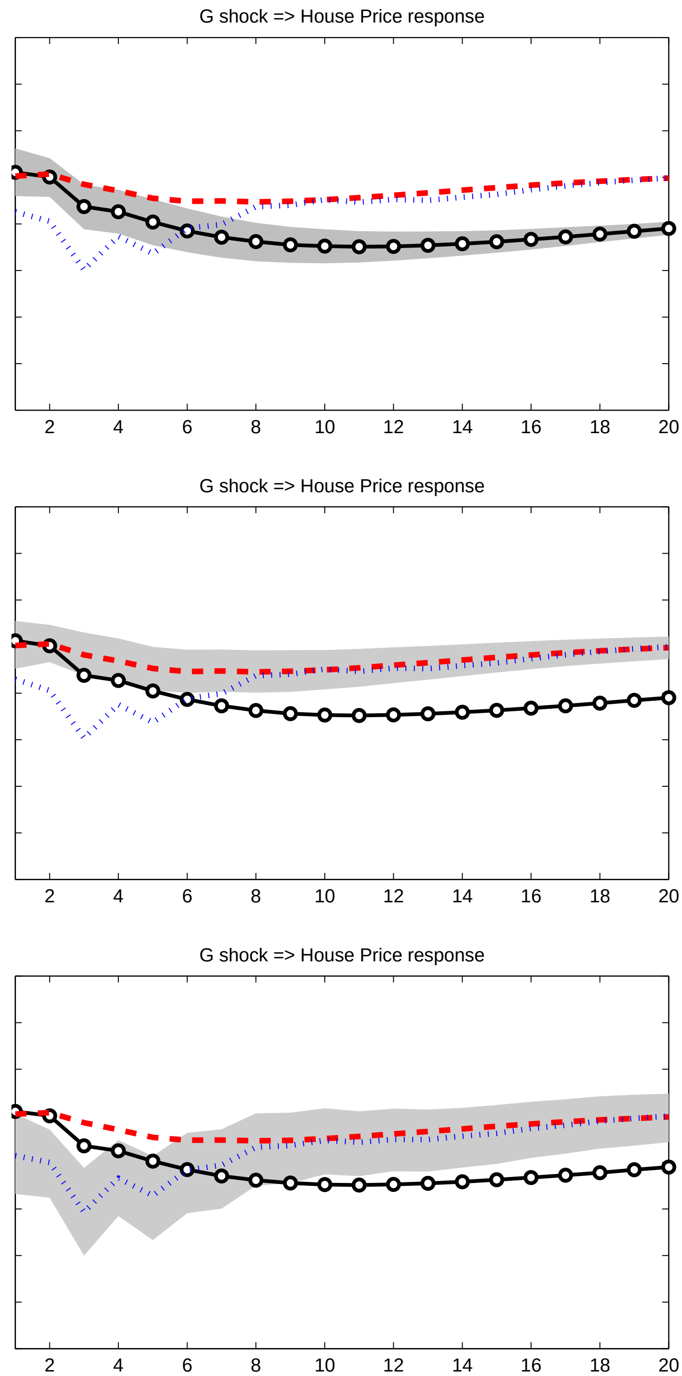

Figure 2.19: Extended Sample - Housing Price Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

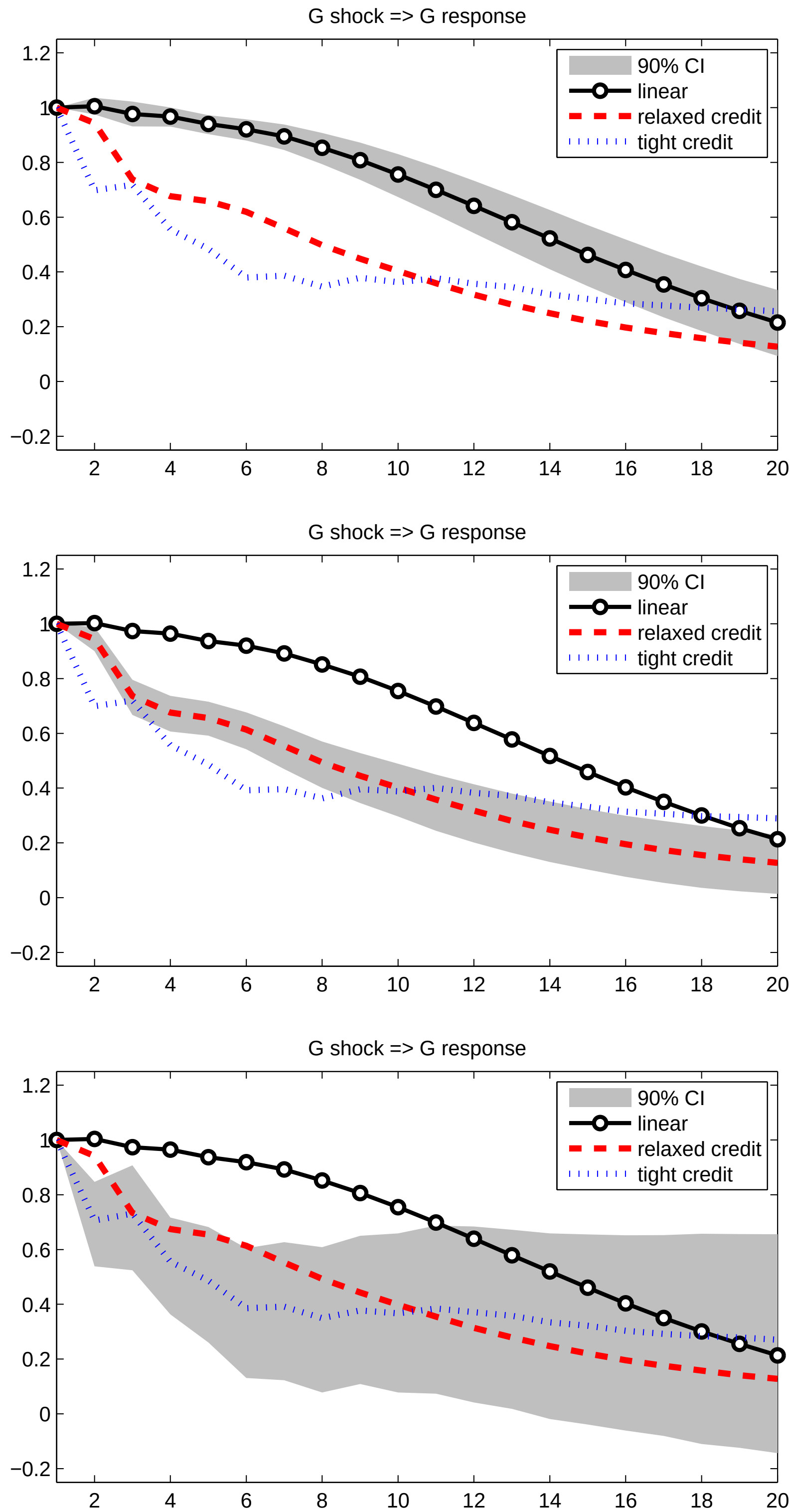

Figure 2.20: Extended Sample - Gov. Spending Impulse Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line). X-axis measures time (in quarters) .

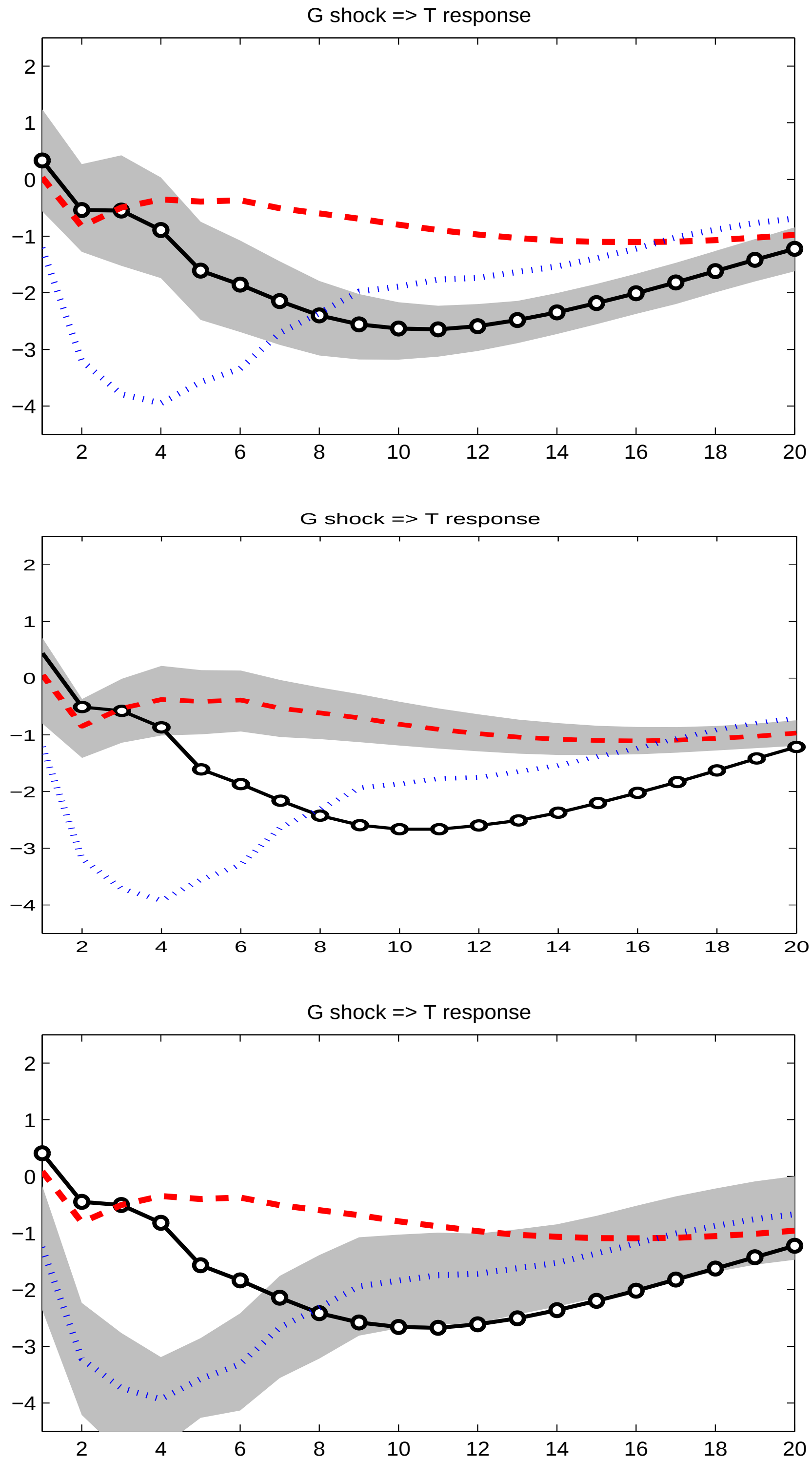

Figure 2.21: Extended Sample - Tax Revenue Response Function to a 1% Gov. Spending Shock with 90% CI (linear VAR - black line, Tight Credit - red line, Relaxed Credit - blue line) . X-axis measures time (in quarters) .

2.6.3 Data Sources and Definitions

The data used in the VAR analysis comes from the following sources. The National Income and Product Accounts (NIPA) published by the Bureau of Economic Analysis (BEA) were used for the fiscal data. The monetary information (interest rates and deflators), as well as, data on output and private consumption are taken from the Federal Reserve Economic Data (FRED) maintained by the St. Louis Fed. The house price index is from the Census Bureau, while the financial index is made available by the Chicago Fed.

Government Spending includes Government consumption expenditures and gross investment excluding imputations. Sources: NIPA Table 3.9.5 and Table 7.12.

Tax Revenue: is calculated as government current receipts net of transfers to business and individuals. Source: NIPA Table 3.1.

Output: Gross Domestic Product. Source: BEA, Account Code: A191RC1 (from FRED)

Deflator: Gross Domestic Product, Implicit Price Deflator. Source: BEA, Account Code: A191RD3 (from FRED)

Consumption: Personal Consumption Expenditures. Source: BEA, Account Code: DPCERC1 (from FRED).

Interest Rate: 3-Month Treasury Bill (Secondary Market Rate) Source: Board of Governors of the Federal Reserve System (from FRED).

House Prices: Price Index of New Single-Family Houses Sold Including Lot Value. Source: US Census Bureau, quarterly frequency, with base year 2005.

NFCI - National Financial Conditions Index. Source Chicago Fed, converted from weekly into quarterly frequency by simple averaging.

Real variables where calculated by applying the Implicit Price Deflator to their nominal counterparts. In the case of the interest rate the inflation rate was used instead. With the exception of the interest rate, the natural logarithm is used in the VAR.

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