



Department of Economics

Fiscal Policy and Consumption

Giovanni Callegari

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

Florence, March 2007

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DEDICATION

This dissertation is dedicated to my wife Cristina, who always supported me in my academic undertakings, during the good and, most importantly, during the bad times.

ACKNOWLEDGMENTS

This thesis would not have been possible without the support of prof. Corsetti, who not only provided me with the technical tools to do research, but also helped me in elaborating a personal approach in tackling economic problems. Moreover, throughout my work on this thesis, I have also greatly benefited from the advice of prof. Ravn.

Among the many people who have provided helpful comments on my papers, I would like to mention more particularly Florin Bilbiie, Charles Engel, Stephan Fahr and Fabio Ghironi.

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Part I

Preface

There is little doubt that fiscal policy plays an important role in business cycle fluctuations; however, the ability of fiscal policy measures to work as a countercyclical stimulus has recently been questioned (see Taylor, 2000), in light of the efficiency and transparency of monetary policy interventions. Far from postulating a definitive answer to the debate, the objective of this dissertation is to contribute to a better understanding of the transmission mechanism of fiscal policy shocks, through their interaction with the consumption behavior of private agents. The fundamental contribution of this thesis is the introduction of different forms of households' heterogeneity in the analysis of the effects of government expenditure shocks and tax cuts.

The standard neoclassical paradigm is hard pressed to explain important features of the life-cycle such as the failure of consumption smoothing, or the near-zero level of wealth that is observed at the level of both individual households and income cohorts — as it is forcefully argued by Mankiw (2000), among others. This author proposes a new framework to reconcile theory with these facts, in which standard infinite-horizon agents coexist with agents who consume all their income period by period (rule-of-thumb consumers). Gali, Lopez-Salido and Vallés (2005) — further refined by Bilbiie and Straub (2004) — find that in a general equilibrium model after Mankiw government expenditure shocks generate a positive consumption response, a piece of evidence from macro VARs which cannot be reconciled with standard business cycle models. The three chapters in this thesis contribute to this literature by presenting a criticism and, at the same time, an extension of this approach. A *criticism* because my analysis shows that small departures from the assumptions defining the rule-of-thumb behavior à la Mankiw make the model unable to generate a positive consumption response to spending shocks; an *extension* because, adopting a two-group (Ricardian/ Non-Ricardian) framework, my work provides a more detailed and explicit microfoundation of Non-Ricardian behavior. This is essentially achieved by introducing household debt and collateral constraints.

While my approach in this dissertation is mainly theoretical, the analysis systematically refers to empirical evidence, particularly to the growing VAR literature on fiscal policy pioneered by Blanchard and Perotti (2002). In the last chapter, the theoretical study is complemented by a VAR estimation of the effects of tax cuts and government expenditure shocks on trade.

The motivation for this thesis can be easily identified. Models with rule-of-thumb consumers are criticized as being too simplistic and based on incredible assumptions. As an alternative, I initially explored the possibility of modelling Buffer Stock consumers as in Carroll (1997). Indeed, in the first chapter of this dissertation, I analyze government shocks

using a model which displays some of the features of Buffer Stock savings — a reduced form mirroring the simulation results in Carroll’s article.

The need for more carefully defined microfoundations of Non-Ricardian agents led me to refocus my attention on models with financial frictions and collateral constraints. Building again on a two-consumer-group framework, I model consumption heterogeneity in terms of the rate of time preferences, as in Iacoviello (2005). This approach has proven particularly successful in monetary policy analysis; furthermore, models with financial frictions are able to fit many of the micro stylized facts on consumption smoothing, household debt and wealth holding. In chapter 2 and 3 I adopt this approach to assess the impact of fiscal policy shocks in closed and open economy, with and without sticky prices.

The first chapter entitled *Government Spending, Consumption and Cash-on-Hand Dynamics* sets up a model in which, as in the work by Gali, Lopez-Salido and Vallés (2005), the behavior of Non-Ricardian agents is determined by an ad-hoc assumption. Namely, for this group of consumers, I assume a negative relation between expected rate of growth of consumption and the current level of cash-on-hand, defined as the sum of disposable income and the bonds inherited from last period. Such a relation has been obtained by Carroll (1997) through simulation, and is indeed the characterizing feature of Buffer stock savings behavior — as it emerges from Carroll’s work. In this model, consumption tracks current income fairly closely, in line with the evidences on individual consumption as in Carroll and Summers (1991) and Carroll (1994).

Non Ricardian agents are introduced in an otherwise standard New-Keynesian model where price-setting is subject to the Calvo (1983) mechanism. The interaction between sticky prices and Non Ricardian agents is at the basis of the positive consumption response to a government expenditure shock: the expenditure shock induces an increase in labor demand and in real wages, which is emphasized by the presence of sticky prices; labor income thus increases on impact, while taxes rise slowly because of deficit financing. The consequent rise in cash-on-hand translates into a lower growth rate of consumption, accommodated by increasing current consumption. The paper then studies the theoretical conditions under which this result arises.

Notably, a positive consumption response to fiscal shocks is associated with a real wage response much in line with the VAR evidence (Fatas and Mihov, 2003 and Gali, Lopez-Salido and Vallés, 2006); moreover, Buffer Stock agents increase savings together with consumption after a government expenditure shock. Both these features are critical aspects of which the model with original rule-of-thumb consumers failed to reproduce satisfying impulse responses.

In the second chapter entitled *Government Spending, Durable Goods and Rule-of-Thumb*

behavior I still rely on the two-group modelling framework to introduce financial friction and household debt. The model draws upon a modified version of Iacoviello (2005) to study the effects of government expenditure shocks. The economy is characterized by two groups of agents (patient and impatient), two goods (durable and non-durable), monopolistic competition and sticky prices. The introduction of a collateral constraint (Impatient agents use durable goods as collateral to buy from Patient households) affects the way in which the main aggregate variables respond to a government expenditure shock. This chapter demonstrates that endogenous variations in the price of collateral constitute an important propagation channel: to the extent that relative price changes following expenditure shocks reduce the value of the inherited stock of collateral, valuation effects introduce an additional, indirect negative wealth effect which pushes down the households' consumption response.

The rule-of-thumb model is nested into this specification: shutting down the durable sector prevents agents from borrowing and, given that they are relatively impatient, without any incentive to save. By moving from the most to the least restrictive specification, I show that the positive consumption response generated by the rule-of-thumb model is extremely sensitive to slight deviations from its basic assumptions, once the indirect wealth effect is taken into account.

The results in chapter 2 suggest that a model with financial frictions can have promising implications for the transmission mechanism of fiscal policy shocks in an open economy context. This insight is developed in chapter 3, entitled *Financial Frictions and Household Debt: a New Perspective on Twin Deficits* where I study the transmission mechanism of tax cuts and government expenditure shocks in a two-country model with patient and impatient agents and collateral constraint. The analysis is designed to focus on the positive correlation between budget deficit and current account deficit, the so-called *Twin Deficit* hypothesis (TDH).

While most of the DSGE literature has focused on government spending shocks, this new framework allows me to make a detailed analysis of both the budget and external consequences of tax cuts — an experiment which appears to be closer to the current policy debate on global imbalances. At the same time, the basic business cycle properties of the model (response to a productivity shock and second moments of the main variables) are not too dissimilar from the RBC benchmark and do not lead to unrealistic responses.

Assuming lump-sum taxes, the model predicts twin deficits conditional on tax cuts, while the model further predicts twin divergence (i.e. negative correlation) conditional on government expenditure shocks. Notably, these responses are qualitatively in line with those estimated by a structural VAR on U.S. data from 1973 to 2004 and with the recent empirical

literature on twin deficit in the U.S.

In addition, the model allows me to analyze the implications of financial liberalization as regards the sign and magnitude of the current account response to fiscal shocks. The motivation for this exercise is the observation that, after U.S. deregulated and liberalized financial markets at the beginning of the 1980s, the external trade imbalance of this country has grown quite steadily and, in recent times, dramatically. The results of the model suggest that the response of current account deficit to fiscal policy shocks is indeed larger in a deregulated economy.

The chapters of this thesis investigate and describe the propagation mechanism of fiscal policy shocks once different consumption behaviors are considered. A fruitful new research agenda takes shape, whose ultimate objective is the development of medium and large scale DSGE models better suited to fit the data. This will require an assessment of the relative importance of different groups of consumers through structural estimation. These models can potentially be applied to a number of problems. For instance, they could shed light on the role of asset prices fluctuations in open economy, depending on the nature of financial frictions and the severity of collateral constraints characterizing different financial systems.

BIBLIOGRAPHY

- [1] Bilbiie F. and R. Straub (2004) "Fiscal Policy, Business Cycles and Labor-Market Fluctuations", *MNB Working Paper n° 2004/6*

- [2] Blanchard, O. and R. Perotti (2002) "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*, Vol.117, 1329-1368.

- [3] Carroll, C. D. (1994) "How Does Future Income Affect Current Consumption?" *Quarterly Journal of Economics*, CIX, 111-48

- [4] Carroll, C.D. and L.H. Summers "Consumption Growth Parallels Income Growth: Some New Evidence", in B. Douglas Bernheim and J. B. Shoven, eds, *National Savings and Economic Performance* (Chicago: Chicago University Press, pp. 503-43.

- [5] Fatas A. and I Mihov (2003) "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence", *mimeo*, INSEAD

- [6] Gali, J., J.D. Lopez-Salido and J. Valles (2005) "Understanding the Effects of Government Spending on Consumption", *Journal of the European Economic Association*, mimeo.

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

- [8] Mankiw, N.G. (2000), "The Savers-Spenders Theory of Fiscal Policy", *Discussion Paper n.1888*, HIER.

- [9] Taylor, J.B. (2000) "Reassessing Discretionary Fiscal Policy", *The Journal of Economic Perspectives*, vol. 14 n.2 21-36

Part II

Chapters

CHAPTER 1

BUFFER STOCK SAVINGS, CONSUMPTION AND GOVERNMENT SPENDING SHOCKS

1.1 Introduction

In recent years fiscal policy has been the subject of a large body of research: a new set of VAR evidence produced by the works of Blanchard and Perotti (2002), Fatas and Mihov (2001 and 2003) and Mountford and Uhlig (2001) has called for a coherent and microfounded theoretical framework able to interpret and explain the dynamic effects of fiscal policy shocks.

In this respect, the predictions of standard RBC and New-Keynesian models cannot be easily reconciled with some of the VAR findings: in particular the nonnegative response of private consumption to a government expenditure shock constitutes a "puzzle" to which it is hard to give an explanation in a dynamic context: both the RBC and New-Keynesian models, indeed imply that the increase in the present discounted value of taxes needed to finance the increase in government spending generates a negative wealth effect which pushes households to reduce consumption and leisure. This should trigger a negative correlation between private consumption and employment while the data relative to the U.S. case display a positive correlation¹.

This paper builds on the structural framework of Gali, Lopez-Salido and Vallés (2006), to investigate how the consumption response to fiscal shocks changes when households heterogeneity is fit into an otherwise standard New-Keynesian model. Following Mankiw (2000) the mass of consumers is split in two groups: the first, called *Ricardians*, are standard infinite-horizon consumers, who have access to the private asset markets and so get the profits from the intermediate, monopolistic competitive firms. The second group of agents, called *Buffer Stock* agents, is populated by individuals who mimic the Buffer-Stock consumption behavior as it is described in Carroll (1997, 2001): their rate of growth of consumption is a negative function of cash-on-hand (the sum of labor income and inherited bonds). The conditions describing these agents' behavior are not derived from an explicit maximization procedure but

¹Blanchard and Perotti (2002), Fatas and Mihov (2001, 2003) and Gali, Lopez-Salido and Vallés (2005) all find that private consumption rises after an increase in government expenditure. Mountford and Uhlig (2001) establishes a flat response of consumption: all these works are related to US data.

Perotti (2004) estimate a VAR on seven OECD countries and finds that the positive consumption response is typical only of the US case.

are rather an approximation of the main features generated by Carroll in his paper through simulation. This mechanism departs from a fully microfounded approach but it is nevertheless a useful way to introduce this kind of consumption behavior preserving tractability. Moreover, this assumption is less binding than the assumption underlying rule-of-thumb consumers in Gali, Lopez-Salido and Vallés (2006) (henceforth GLV), which posits that the agents can neither borrow nor save. Furthermore, to generate a positive consumption response to fiscal shocks, GLV has to presuppose a demand-determined labor market structure (called *Unionized* labor markets).

The interaction between sticky prices and the behavior of Buffer-Stock agents manages to generate a positive consumption response after a government expenditure shock. As long as the present discounted value of cash-on-hand changes is positive, the consumption response is positive as well. The presence of sticky prices is also crucial. The reason is that demand drives output up to such an extent that the increase in labor demand prevails over labor supply: real wages rise, translating into an increase in labor income, and this in turn increases current consumption while reducing expected consumption growth. For this mechanism to generate our desired result, however, the government expenditure shock cannot be too persistent, and the degree of price stickiness must be above some threshold.

Compared with GLV and Bilbiie and Straub (2004) this model generates a positive consumption response with a smaller rise in real wages, more in line with the contained increase conveyed by data. Furthermore, Buffer-Stock agents increase their savings after the shock: while this fact reduces the impact multiplier of the consumption response it is certainly closer to reality than what is implied by the rule-of-thumb approach.

While the impact response of consumption is in line with the VAR evidence, this model cannot generate enough persistence (GLV, for instance, estimate that the consumption response reaches its peak after 2,5 years). The model's response falls monotonically after the positive impact response and becomes negative after 1,5 years. Another weakness of this approach is the fragility of the positive consumption response for different values of shocks' persistence: when it reaches values close to 1, the negative wealth effect prevails over the positive response of Buffer-Stock agents and drags aggregate consumption down. The model generates a positive response for values that are in lines with the evidences provided by Finn (1998)².

This paper contributes to the growing body of research pioneered by Mankiw (2000), who emphasizes the need to introduce different kinds of consumption behavior to explain

²There is no agreement in the literature on the exact value of this parameter: Kollmann (1998) contends that government expenditure follows a random walk while Coenen and Straub (2004) find that government expenditure is highly persistent but still stationary.

1.2. EMPIRICAL EVIDENCE ON THE EFFECTS OF GOVERNMENT EXPENDITURE SHOCKS³

some important findings related to consumption and fiscal policy issues³. Indeed, in recent years many papers have applied this framework to macroeconomic issues: Bilbiie and Straub (2004) studies the effects of government spending shock in a model with rule-of-thumb consumers and walrasian labor markets; Coenen and Straub (2004) estimate a similar model with Bayesian methods, finding that the role of rule-of-thumb agents is only marginally: this conclusion cannot be applied to this model though, because it assumes a different consumption behavior for Non-Ricardian agents. Erceg, Guerrieri and Gust (2005) and Bussière, Fratzscher and Mueller (2005) apply this framework to the analysis of fiscal policy shocks in open economy, concluding that fiscal policy does not affect current account dynamics in a significant way⁴.

This framework have also been applied to monetary policy analysis: Gali, Lopez-Salido and Vallés (2003) study the determinacy properties of this model; Bilbiie (2005) continues this analysis, showing that a passive monetary policy rule might lead to equilibrium uniqueness, in contrast with the current literature with homogeneous agents; this conclusion leads to a revision of the judgement of the pre-Volker monetary policy management.

The structure of the paper is as follows: in the next section we will briefly present the main empirical evidence provided by the literature on government expenditure shocks. Section 3 presents the model and section 4 presents the equilibrium conditions, whereas Section 5 presents the log-linearized equilibrium system and section 6 describes the intergroup transfer and the basic mechanism of the model. The dynamics of the model is illustrated in Section 7 before the conclusion in Section 8.

1.2 Empirical Evidence on the effects of government expenditure shocks

Blanchard and Perotti (2002) and Fatas and Mihov (2001) both measure the effect of positive shocks to government spending: in a manner consistent with both the RBC and the Keynesian predictions, they found that a positive shock on government spending triggers a positive response on output, with the fiscal multiplier being greater than one in Fatas and Mihov (2001) and close to one in Blanchard and Perotti (2002). However, they also found a large positive effect of government spending on consumption, in stark contrast with the predictions of the standard RBC and New-Keynesian model. A partial confirmation of these

³Mankiw (2000) maintains that the two-groups framework (that he called the *Savers-Spenders framework*) can help to explain several facts relative to consumption: *a*) the lack of consumption smoothing at the individual level; *b*) the fact that many people have a net worth close to zero; *c*) that bequests are an important factor in wealth accumulation. Mankiw (2000) explicitly suggests the introduction of Buffer-Stock consumption behavior along the standard optimizing one.

⁴Callegari (2006) shows that fiscal policy is important for current account dynamics when collateral constraints are introduced in a framework very similar to this one with two groups of consumers.

results comes from Mountford and Uhlig (2002) who, using a different methodology for the identification of government shock, found that such a shock does not reduce consumption.

Gali, Lopez-Salido and Valles (2005) using the same identification methodology than Blanchard and Perotti (2002) and Fatas and Mihov (2001), but using different datasets, find that consumption rises on impact and remains above zero for more than four years. Moreover, their measure of the fiscal multiplier on output is of 0.7 in the first year and of 1.3 after eight quarters, close to what was estimated by Blanchard and Perotti (2002). As for the effects on the labor market, GLV and Fatas and Mihov (2003) find that following an increase in government spending both the amount of labor hired and the real wage increase (with the latter being around 0.3 and 0.6 percent on impact), thus suggesting a shift of the labor demand curve along the labor supply. In particular GLV finds that the path of consumption follows fairly closely that of disposable income, suggesting a failure, in some ways, of consumption smoothing.

Perotti(2004) performs a similar analysis in five OECD countries comparing the response to a fiscal policy shock in two subsamples, the pre-1980 and the post-1980 period. He found that the response of consumption and output changes considerably in the two periods: in the first, fiscal policy seems to be more effective, with a more accentuated response of output and consumption; in the second subsample the response of output is smaller and the one of consumption close to zero or even negative.

1.3 The Model

The economy is populated by a continuum of infinitely-lived households of mass one with two different types of agents: *Ricardian* consumers, of mass $(1 - \lambda)$, who are standard optimizing agent who maximizes their utility function over an infinite time horizon; *Buffer-Stock* consumers, of mass λ , who display a negative relationship between expected consumption growth and cash-on-hand, the amount of cash available for consumption

The first group of consumer receives the labor income, owns the intermediate firms receiving the relative profits and holds government bonds, whereas the second group is constituted of consumers who rely only on labor income and on the interest rates received on government bonds.

The production side of the economy is composed by a final and intermediate sector: this sector produces a continuum of goods in a monopolistic competitive environment, which are then assembled by the final good sector in a unique good, sold in a perfectly competitive market. Prices are sticky in the sense of Calvo(1983) and Yun(1996).

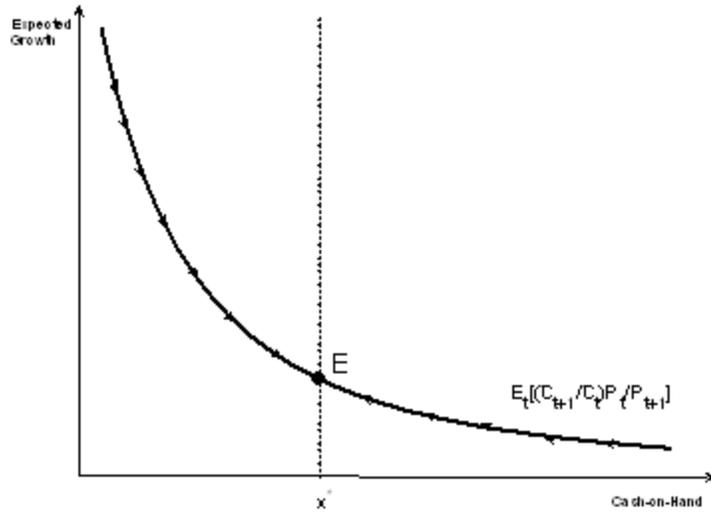


Figure 1.1: Simulation results on Buffer-Stock consumption behavior - Negative relationship between expected consumption growth and current cash-on-hand (Source: Carroll, 2001).

1.3.1 Preferences

The preference of Ricardian consumers are as follows:

$$\max_{\{\hat{B}_t\}_{t=0}^{\infty}, \{\hat{C}_t\}_{t=0}^{\infty}, \{\hat{N}_t\}_{t=0}^{\infty}} U(\hat{C}, \hat{N}) = E_t \sum_{t=0}^{\infty} \hat{\beta}^t \left[\ln(\hat{C}_t) + \hat{\chi} \frac{(1 - \hat{N}_t)^{1-\hat{\varphi}}}{1 - \hat{\varphi}} \right] \quad (1.1)$$

where $\hat{\beta}$ is the utility time discount factor of Ricardian agents, \hat{C} is the amount of the final goods consumed and \hat{N}_t are the hours supplied.

In the Buffer-Stock model of Carroll(1997), consumers are characterized by impatience, precautionary savings motives and a strictly positive probability of zero labor income. In order to avoid the event of zero consumption, they hold a positive level of wealth (the target level, point E in 1.1) which is used to buffer against adverse shocks. Carroll(1997) does not manage to solve the model analytically, so it simulates it numerically; Carroll(2001) proves some of the results obtained through simulation.

Figure 1.1, built on the simulation results of Carroll(1997), shows the negative correlation between expected consumption growth (y-axis) and the level of cash-on-hand (x-axis), which is defined as

$$P_t \tilde{X}_t \equiv W_t \tilde{N}_t + \tilde{B}_{t-1} - P_t L_t$$

where P_t is the general price index, \tilde{N}_t is the amount of labour supplied by Buffer-Stock agents, \tilde{B}_{t-1} is the nominal stock of government bonds inherited from the previous period and L_t is the amount of lump-sum taxes paid to the government. Buffer-Stock consumers have a stable cash-on-hand target (denoted by x^* in the graph). The presence of income uncertainty, the borrowing constraint and of the zero-income event pushes agents to save so to avoid that consumption falls towards zero (precautionary savings)⁵; relative impatience, on the contrary, pushes agents to borrow from the future to finance current consumption. At x^* these two forces balance each other in a stable equilibrium: if cash-on-hand rises, impatience prevails, consumption rises (and expected consumption falls) so that cash-on-hand gets back to x^* . The opposite holds when cash-on-hand falls⁶.

1.3.2 Technology

There are two sectors in this economy: the final and intermediate good sector. The first sector is characterized by perfectly competitive markets, whereas the second is composed by monopolistically competitive firms and sticky prices.

The final good sector aggregates all the intermediate goods, defined over a continuum between 0 and 1.

$$Y_t = \left(\int_0^1 Y(z)^{\frac{\epsilon-1}{\epsilon}} dz \right)^{\frac{\epsilon}{\epsilon-1}}$$

where $\epsilon > 1$ is the elasticity of substitution between intermediate goods.

The demand of the intermediate goods is

$$Y_t^d(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon} Y_t \quad (1.2)$$

the price index is defined by the zero-profit condition and by the cost minimization procedure⁷

$$P_t = \left(\int_0^1 P_t(s)^{1-\epsilon} ds \right)^{\frac{1}{1-\epsilon}}$$

The intermediate good is produced using labor according to the following linear production function

$$Y_t^s(z) = N_t$$

⁵The marginal utility of consumption has to go to infinity as consumption falls toward zero to generate the Buffer Stock savings behavior. This is a condition satisfied by the standard power utility function.

⁶This mechanism implies also a negative relation between the expected variance of consumption and cash-on-hand. The presence of the borrowing constraint and the zero-income event implies that for low values of cash-on-hand the consumption function approaches the 45 degree line, so that consumption and cash-on-hand almost move one-by-one. As cash-on-hand rises, the influence of the zero income event and of the borrowing constraint fades away, and consumption smoothes out, thus implying a lower volatility.

⁷This index is defined as the minimum expenditure needed to produce one unit of Y_t .

which implies that the real marginal costs correspond to the real wage.

We suppose that firms adjust their prices infrequently, and the opportunity to adjust follows a Bernoulli distribution, accordingly to the Calvo set up. Let θ be the probability of keeping prices constant and $(1-\theta)$ the probability of changing prices, the profit maximization problem can then be defined as

$$\begin{aligned} & \max_{\{P_t(z)\}_{t=0}^{\infty}} E_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} Y_t(z) [P_t(z) - P_t MC_t] \\ \text{s.t. } Y_t(z) &= \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon} Y_t \end{aligned}$$

where

$$Q_{t,t+k} = \hat{\beta}^k \frac{\hat{C}_t}{\hat{C}_{t+k}} \frac{P_t}{P_{t+k}}$$

is the stochastic discount factor of Ricardian agents, the owners of intermediate firms.

The first order condition of this problem is

$$E_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} Y_t(z) \left[P_t^*(z) - \frac{\epsilon}{\epsilon - 1} MC_{t+k} P_{t+k} \right] = 0$$

and the price level is given by

$$P_t = \left[\theta P_{t-1}^{1-\epsilon} + (1-\theta) P_t^*(z)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}$$

where $P_t^*(z)$ is the optimal price for the firm z .

1.3.3 Monetary Policy

Monetary policy is determined through an interest rate rule of the form

$$R_t = \bar{r} (\pi_t)^{1+r_\pi}$$

where r_π determines the interest rate response of monetary authorities to an increase in inflation and \bar{r} is the steady state nominal interest rate. As discussed in the section on determinacy, conversely to what was found in Galí *et al.* (2003), here the Taylor principle holds for a very wide range of parameter values, and fails to hold only when the share of Buffer-Stock consumers gets close to one.

1.3.4 Fiscal Policy

Fiscal Policy enters the model through the flow budget constraint of the government that can be defined as

$$P_t G_t + B_{t-1} = P_t L_t + \frac{B_t}{1 + r_t} \quad (1.3)$$

Consistent with GLV, the aggregate amount of lump sum taxes imposed on the two groups of households depends on government expenditure and on the quantity of debt issued in the previous period, and follows the two rules

$$l_t = \phi_b(b_{t-1}) + \phi_g g_t \quad (1.4)$$

where $b_{t-1} \equiv \frac{B_{t-1}/P_{t-1} - (B/P)}{Y}$, $l_t \equiv \frac{L_t - L}{Y}$, $g_t \equiv \frac{G_t - G}{Y}$.

Government expenditure evolves exogenously according to the equation

$$g_t = \rho_g g_{t-1} + \varepsilon_t \quad (1.5)$$

where $\rho_g < 1$ in order to guarantee a stationary process for government expenditure.

The possibility for the Buffer stock consumers to buy government debt makes the way the financing of the shock is shared among groups crucial for the final results. This is because in this framework the two groups can (and actually will) buy different quantities of government debt, so there can be an endogenous redistribution of wealth across groups that can affect substantially the dynamics of the economy⁸.

Following GLV, steady state taxes in steady are set so to equalize the consumption of the two agents, by redistributing the profits of intermediate firms. This assumption does not affect the dynamics of the model and is made only to make the log-linear model simpler.

⁸Standard optimization made by the Ricardian agents leads to the equality in (1.6) and to the following transversality condition, that rules out Ponzi schemes

$$\lim_{k \rightarrow \infty} E_t [\beta^k U_c(\hat{C}_k, \cdot) \hat{B}_k] \leq 0$$

A condition parallel to this one is imposed by the government on the aggregate amount of debt

$$\lim_{k \rightarrow \infty} E_t Q_{0,k} B_K \geq 0$$

In the standard model with homogenous agents, these two conditions would have guaranteed that at infinity the amount of discounted government bonds were zero (together, they would have implied equality in both the conditions).

Even if it is not explicitly modelled, the optimization procedure that leads to equation (1.9) implies a transversality condition parallel to the condition holding for Ricardian consumers.

1.3.5 Consumers' Problem

Ricardian agents maximize their utility function subject to the following flow budget constraint

$$P_t \hat{C}_t + \frac{\hat{B}_t}{1 + r_t} = W_t \hat{N}_t + \hat{B}_{t-1} + P_t \hat{D}_t - P_t L_t \quad (1.6)$$

where \hat{B}_t is the amount of government bonds held by Ricardian agents, \hat{D}_t is the profits of the intermediate firms and L_t indicates the amount of taxes paid to the government.

The resulting first-order conditions are

$$1 = \hat{\beta} R_t E_t \left\{ \frac{\hat{C}_t}{\hat{C}_{t+1}} \frac{P_t}{P_{t+1}} \right\} \quad (1.7)$$

$$\hat{\chi} (1 - \hat{N}_t)^{-\hat{\varphi}} = \left(\frac{W_t}{P_t} \frac{1}{\hat{C}_t} \right) \quad (1.8)$$

The first equation is the Euler condition determining the dynamic path of Ricardians' consumption. The second is the intratemporal condition between consumption and labor.

Expected consumption growth of Buffer-Stock agents is negatively related to the level of cash-on-hand, consistently with the simulation results of Carroll (1997, figure 1.1). According with the simulation results, consumption tracks current income much more than in the classical Ricardian case: in our framework this element can then be used to explain the positive response of consumption after a government shock when this increases labor income, as it is the case in every model with sticky prices.

Buffer-Stock consumers' budget constraint is

$$P_t \tilde{X}_t = P_t \tilde{C}_t + \frac{\tilde{B}_t}{1 + r_t}$$

The behavior of these agents can then be summarized by two equations: the first equation is this modified Euler equation, aimed at replicating the negative correlation between expected consumption growth and cash-on-hand

$$E_t \{ \Delta \tilde{c}_{t+1} \} = (r_t - E_t \{ \pi_{t+1} \}) - \kappa \tilde{x}_t \quad (1.9)$$

where \tilde{c}_t is the log-deviation of Buffer-Stock consumption from its steady state level, r_t is the nominal interest rate, π_t is inflation and \tilde{x}_t is the cash-on-hand, again in log-deviations form⁹. κ is a coefficient measuring the importance of Buffer-Stock behavior: assuming $\kappa = 0$

⁹Condition (1.9) can be formally derived through a second-order approximation of the Euler equation where the expected variance term is in turn a negative function of cash-on-hand (see previous footnote). This approach, however, is not followed here, to preserve the simplicity and transparency of the model.

Buffer Stock agents become standard optimizing consumers, and by varying κ it is possible to study the real influence of their behavior as is intended in this paper.

The group's supply of labor behaves according to a standard intratemporal condition, expressed in log-linear form as

$$\psi \tilde{n}_t = w_t - \tilde{c}_t \quad (1.10)$$

where $\tilde{\psi}$ is the inverse of the elasticity of labor supply of Buffer stock agents. When $\psi = 0$ consumption is totally isolated from wealth effect and Ricardian equivalence holds, even when $\lambda \neq 0$. In case of an infinite Frisch elasticity, labour supply in both groups adjusts as to accommodate the increase in demand coming from the public sector.

1.4 Equilibrium Conditions

In this model there are a continuum of markets: the market for the final good, for the intermediate goods, for labor and for government bonds.

The clearing and aggregation conditions are

$$\begin{aligned} Y_t &= C_t + G_t \\ C_t &= \lambda \tilde{C}_t + (1 - \lambda) \hat{C}_t \\ N_t &= \lambda \tilde{N}_t + (1 - \lambda) \hat{N}_t \\ Y_t^s(z) &= Y_t^d(z) \quad \forall z \in [0, 1] \\ B_t &= \lambda \tilde{B}_t + (1 - \lambda) \hat{B}_t \end{aligned}$$

the last equation implying that the government satisfy all the demand of bonds from both groups of consumers.

1.5 Log- Linearized Equilibrium System

The equilibrium conditions turn to be non linear, and the system cannot be solved analytically. Following Campbell(1994) the model is log-linearized around the zero inflation steady state. A detailed discussion of the steady state can be found in the appendix.

In the following equation, for a variable Z_t , $z_t = \frac{Z_t - Z^{SS}}{Z^{SS}}$, where the deviation is measured with respect to the steady state values. Here the value of government bonds in the steady state is zero, an assumption which makes the analysis easier and is neutral from the point of view of the final result. The log-linearization of the Euler equation, the intratemporal

condition and of the budget constraint of the Ricardian consumers is

$$\hat{c}_t - E_t \{\hat{c}_{t+1}\} + r_t - E_t \{\pi_{t+1}\} = 0 \quad (1.11a)$$

$$\hat{c}_t - (w_t - \psi \hat{n}_t) = 0 \quad (1.11b)$$

$$\gamma_c \hat{c}_t + \beta \hat{b}_t = \frac{1}{1 + \mu} \left[\hat{n}_t + w_t \left(1 - \frac{1}{1 - \lambda} \right) \right] + \frac{1}{1 - \lambda} \left(\frac{\mu}{1 + \mu} \right) y_t + \hat{b}_{t-1} - l_t$$

where ψ is the Frisch elasticity of labor supply, which is assumed to be equal across groups; the level of steady state labour supply is again equal across groups and set to $1/3$. The steady-state mark-up is denoted by $1 + \mu$.

The Buffer Stock relevant equations are those described in section 3.2, together with the log-linear budget constraint

$$E_t \{\Delta \tilde{c}_{t+1}\} = (r_t - E_t \{\pi_{t+1}\}) - \kappa \tilde{x}_t \quad (1.12a)$$

$$\gamma_c \tilde{c}_t + \beta \tilde{b}_t = \frac{1}{1 + \mu} (\tilde{n}_t + w_t) + \tilde{b}_{t-1} - l_t \quad (1.12b)$$

$$\tilde{c}_t = w_t - \psi \tilde{n}_t \quad (1.12c)$$

The government budget constraint and the tax rule are as follows

$$g_t + \lambda \tilde{b}_{t-1} + (1 - \lambda) \hat{b}_{t-1} = l_t + \beta \left(\lambda \tilde{b}_t + (1 - \lambda) \hat{b}_t \right) \quad (1.13)$$

and

$$l_t = \phi_b \left(\lambda \tilde{b}_{t-1} + (1 - \lambda) \hat{b}_{t-1} \right) + \phi_g g_t \quad (1.14a)$$

By consolidating the two equations describing fiscal policy we obtain the difference equation describing the evolution of debt. Let the aggregate amount of debt be defined as

$$b_t \equiv \lambda \tilde{b}_t + (1 - \lambda) \hat{b}_t$$

government bonds evolve according to

$$b_t = \frac{1 - \phi_b}{\beta} b_{t-1} + \frac{1 - \phi_g}{\beta} g_t$$

as it may be easily inferred, the path of $\{b\}_t^\infty$ depends only on $\{g\}_t^\infty$ and on the parameters of the tax rules. The path of government bonds is stable when

$$\frac{1 - \phi_b}{\beta} < 1$$

The log-linearized monetary policy condition is

$$r_t = (1 + r_\pi) \pi_t \quad (1.15)$$

For what concerns the firm sector, the log-linearization of the production function and of the profit maximization condition are

$$y_t = \lambda \tilde{n}_t + (1 - \lambda) \hat{n}_t \quad (1.16)$$

$$\pi_t = \beta E_t \{ \pi_{t+1} \} + \eta w_t \quad (1.17)$$

where $\eta = \frac{(1-\beta\theta)(1-\theta)}{\theta}$; equation (1.17) is the traditional New Keynesian Phillips curve. The last element of the dynamic system is the stochastic process for the government shock

$$g_t = \rho_g g_{t-1} + \varepsilon_t \quad (1.18)$$

1.6 Inspecting the Mechanism

1.6.1 Parametrization

The utility discount factor β is set to 0.99, so as to compare the generated impulse responses to quarterly data, as in most of the VAR works; the elasticity of substitution is set to 6, so that the steady state mark-up is 0.2. The steady state value of bonds held by both groups is set to zero. The wage elasticity of labor supply (Frisch elasticity) ψ is equal for both kinds of agents and set to 0.5: this value is consistent with the values obtained through calibration in macro studies (Rotemberg and Woodford (1997,1999))¹⁰.

Under the baseline parametrization, the persistence of the shock ρ_g is equal to 0.95, the degree of price stickiness θ is 0.75, and the Taylor coefficient in the monetary policy function $r_\pi = 0.2$. The elasticity of the expected growth rate of consumption with respect to Buffer-Stock cash-on-hand is set to $\kappa = 1$ but, in the following sections it will also be shown how the impulse responses vary when κ is between 0 and 1. The steady state ratio of government expenditure is 0.2, consistent with US data. We follow GLV calibration by setting the fiscal policy parameters ϕ_b and ϕ_g to 0.33 and 0.12; the persistence of the government expenditure process in the baseline specification is set to 0.95, while the share of Buffer Stock consumers λ is fixed at 0.5.

Furthermore, it is also assumed that in steady state taxes are used by the government to redistribute profits among agents, so that the steady state level of consumption is equal

¹⁰This value however, is not consistent with the values established in micro studies, even if these values have to be applied carefully in macroeconomic analysis like this one (see Browning, Hansen and Heckman (1999)).

among groups ($\hat{C} = \tilde{C}$): this assumption is made for sake of simplicity, and does not affect in any way the final result of the paper.

1.6.2 Steady State Transfers

In a similar fashion to GLV steady state transfers are used to equalize the value of steady state consumption, but contrary to Bilbie and Straub(2004) who presuppose fixed costs in production. Taxes in steady state are thus shared in the following way

$$\hat{L} = G + \frac{\hat{B}}{P}(1 - \beta) + \frac{\lambda}{1 - \lambda} \frac{\mu}{1 + \mu} Y \quad (1.19)$$

$$\tilde{L} = G + \frac{\tilde{B}}{P}(1 - \beta) - \frac{\mu}{1 + \mu} Y \quad (1.20)$$

The Buffer Stock consumers receive from the Ricardian agents a share of profits, so that they are actually subsidized in steady state ($T^{BS} < 0$). This assumption is not crucial for our result, it is made only to make the analysis easier.

1.6.3 Labor Market

Following a government expenditure shock we observe two different and opposite effects on labor market variables. On the one hand, a rise in g_t increases the present discounted value of current and future taxes for both groups; this absorption of resources from the government reduces leisure and consumption, so that the resulting increase in hours supplied generates a downward pressure on real wages. On the other hand, the increase in aggregate demand is accommodated by an increase in quantity, amplified by price stickiness, which is immediately translated in an increase in labor demand, that tends to increase wages.

Whether real wages respond positively or negatively to g_t and the magnitude of this response depends on which of these two effects eventually prevails. By aggregating the two labor supply equations we get the following relation

$$w_t = \psi n_t + \lambda \tilde{c}_t + (1 - \lambda) \hat{c}_t \quad (1.21)$$

To see how labor supply evolves we have to study how the introduction of Buffer-Stock consumers affects the labor supply curve. By iterating forward the BS Euler equation (1.9) we get this expression for c_t^{BS}

$$\tilde{c}_t = E_t \kappa \sum_{i=0}^{\infty} \tilde{x}_{t+i} - E_t \sum_{i=0}^{\infty} (r_{t+i} - \pi_{t+1+i}) \quad (1.22)$$

By substituting (1.22) and the forward solution of the Ricardian Euler equation in (1.21) we obtain

$$w_t = \psi n_t + \lambda \kappa E_t \sum_{i=0}^{\infty} \tilde{x}_{t+i} - E_t \sum_{i=0}^{\infty} (r_{t+i} - \pi_{t+1+i}) \quad (1.23)$$

So the element that changes the response of this economy with respect to a purely Ricardian one is the total present value response of Buffer Stock cash-on-hand: given the increase in labor supply and the low amount of taxes imposed initially, the present value of cash-on-hand tends to be positive during the first periods, reducing as time passes, because of the exclusion of the periods with high \tilde{x}_t . Consequently, the shift in labor supply tends to be less accentuated in the first periods and increases afterward. The labor-demand effect then prevails initially, so that real wages increase, but this effect tends to be less persistent than the government shock, because of the gradual increase in taxes.

The response of wages is also affected by the persistence of g_t (the more persistent the effect, the higher the present value of taxes, the lower the present value of \tilde{x}_t), by the responsiveness of r_t to π_t (it lowers the last term in (1.23)), and by the degree of price stickiness (it emphasizes the increase in labor demand).

1.7 Dynamics of the Model

Figure 1.2 shows the impulse responses for the baseline model: the impact response of Buffer Stock consumption is slightly above 0.2 followed by a U-shaped pattern which turns to negative values very quickly. This is due to the high persistence of the government shock that increases the present value of taxes. Cash-on-hand is positive in the first two years, falls rather quickly and then remains negative thereafter. Real wages increase by 40% of the increase in government spending, slightly more than in the $\lambda = 0$ case, but it falls almost immediately because of the rise in Buffer Stock labor supply triggered by the fall in cash-on-hand (which in turn increases the marginal utility of income).

The inflation and nominal interest rate responses fall much faster than in the $\lambda = 0$ case because of the quick fall in the real wages which, given the production function (1.16), represent also marginal costs.

Summarizing, the baseline parametrization generates an initial positive cash-on-hand flow for Buffer Stock agents which is however sufficient enough to offset the negative impact response of Ricardian agents. The aggregate consumption response is then basically zero on impact, turning immediately to negative values. This response, even if represents an improvement with respect to the $\lambda = 0$ case, is still unsatisfactory both for the impact response and for the pattern that follows.

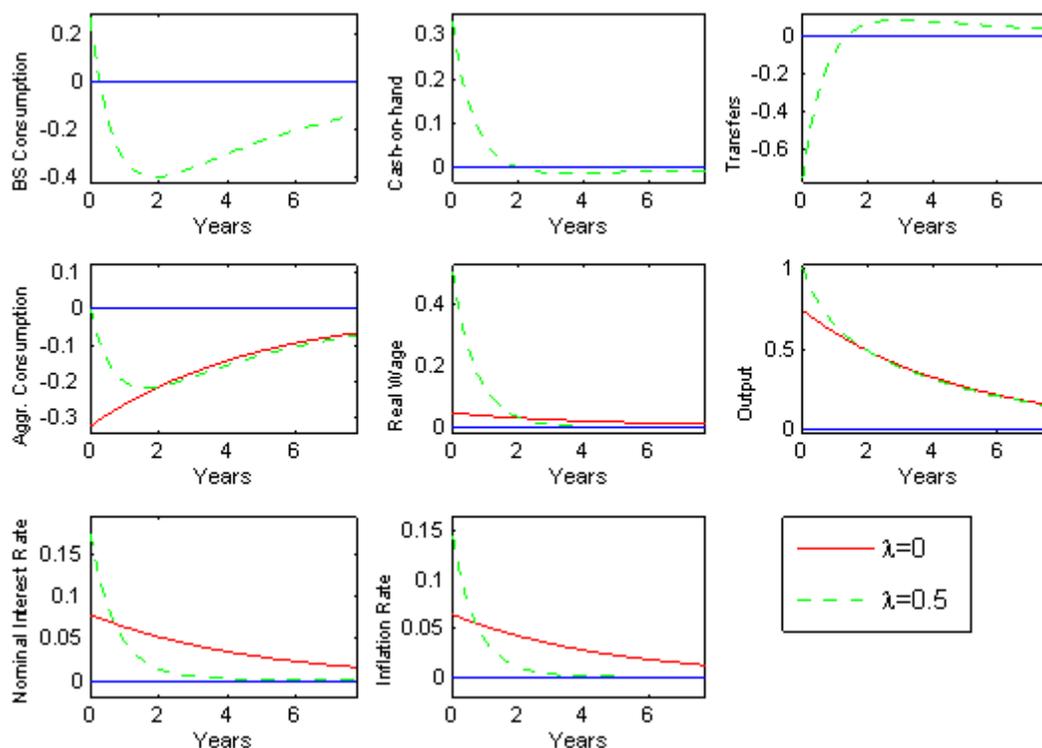


Figure 1.2: Impulse Responses to a Government Expenditure Shock - Baseline Model

Reducing the persistence of the government shock to $\rho_g = 0.8$, a value close to what was estimated by Finn (1998), reduces the negative wealth effect; combining this with an increase of price stickiness from 0.75 to 0.8 manages to generate an aggregate consumption response which is now clearly positive and remains so for 4 periods.

The increased price rigidity emphasizes the output response, thus increasing labor demand: as a consequence real wages increase more than in the baseline and $\lambda = 0$ model. However, as figure 1.3 shows, the rise in real wages needed to increase the consumption response is not as big as it is in Bilbiie and Straub (2004) and GLV and this is especially remarkable since the VAR evidence points towards a positive but contained response of real wages: in GLV a spending shock rises real wage of 0.1 percent, in front of a maximum increase of consumption of 0.3 percent; in GLV's model the order is reversed, with real wages increase double the increase in consumption.

The model implies reduced inflation and interest rate responses, due to the different determinants of Buffer Stock government bonds' demand. The influence of real interest changes on Buffer Stock agents through eq. (1.9) is smaller than for Ricardians because of

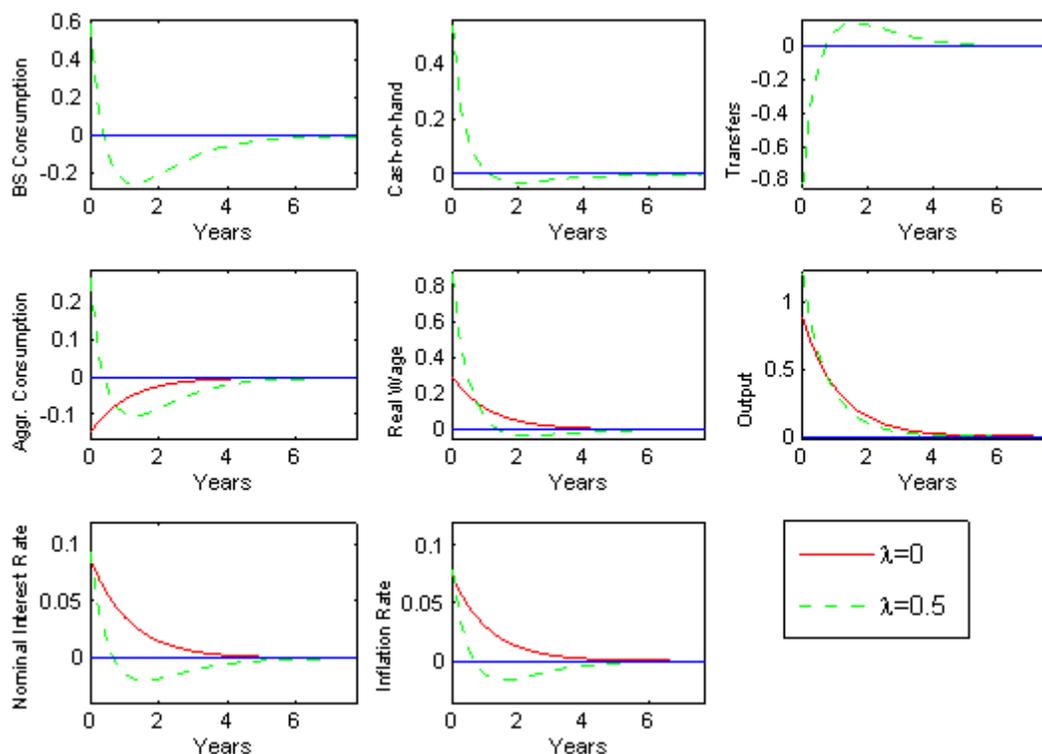


Figure 1.3: Impulse Responses to a Government Expenditure Shock - $\rho_g = 0.8$ and $\theta = 0.8$.

the cash-on-hand term which makes consumption more sensitive to current income than to intertemporal considerations. As a consequence, the interest rate change needed to accommodate the higher supply of government bonds is smaller than in the $\lambda = 0$ case¹¹.

s

The value of the parameter κ is crucial for the model's mechanism since it determines the extent to which Buffer Stock behavior matters. In Section 6.1 we identified the range of values for κ in which the solution path is determined and not cyclical (between 0 and 1). Figure 1.4 shows how the impulse responses of selected variables change when κ varies in the $[0, 1]$ interval. When $\kappa = 0$ the only difference between Ricardians and Buffer Stock agents is income, since only Ricardians receive profits. This case will be discussed in more details in the next section.

As κ rises over 0 though, the impact response of consumption rises, leaving that of cash-on-hand largely unaffected: a larger κ means that consumption follows cash-on-hand more

¹¹This is not a general rule however: if the demand of bonds by Buffer Stock agents would turn out to be very low, then the interest change would actually be higher than in the $\lambda = 0$ case.

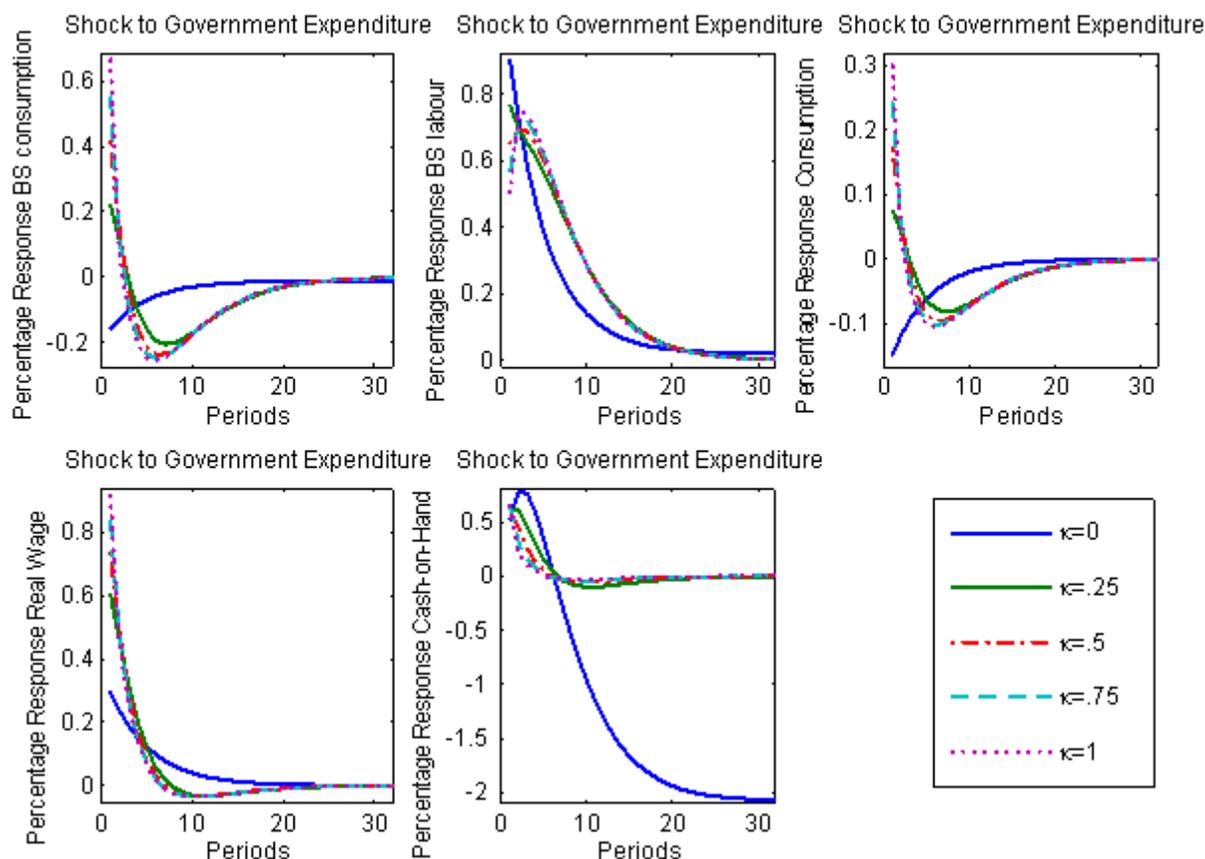


Figure 1.4: Impulse responses of selected variables as κ changes between 0 and 1 - $\rho_g = 0.8$ and $\theta = 0.8$

closely. This is in line with the evidence on individual consumption behavior identified in Carroll and Summer (1991), which concluded that at the individual level consumption tracks income fairly closely.

Figure 1.5 shows how a change in the fiscal policy rule affects the economy's responses: as ϕ_b and ϕ_g increase the consumption impact response and its persistence lowers. As is shown in the fifth panel, this is due to the increasing weight of taxes in Buffer Stock agents cash-on-hand. Labor income remains constant because the drop in Buffer Stock labor supply is matched by an increase in real wages. Since the higher increase in consumption leads to a bigger output response, a government which wants to maximize the output effect of an increase in government expenditure must spread the tax burden over time as much as possible.

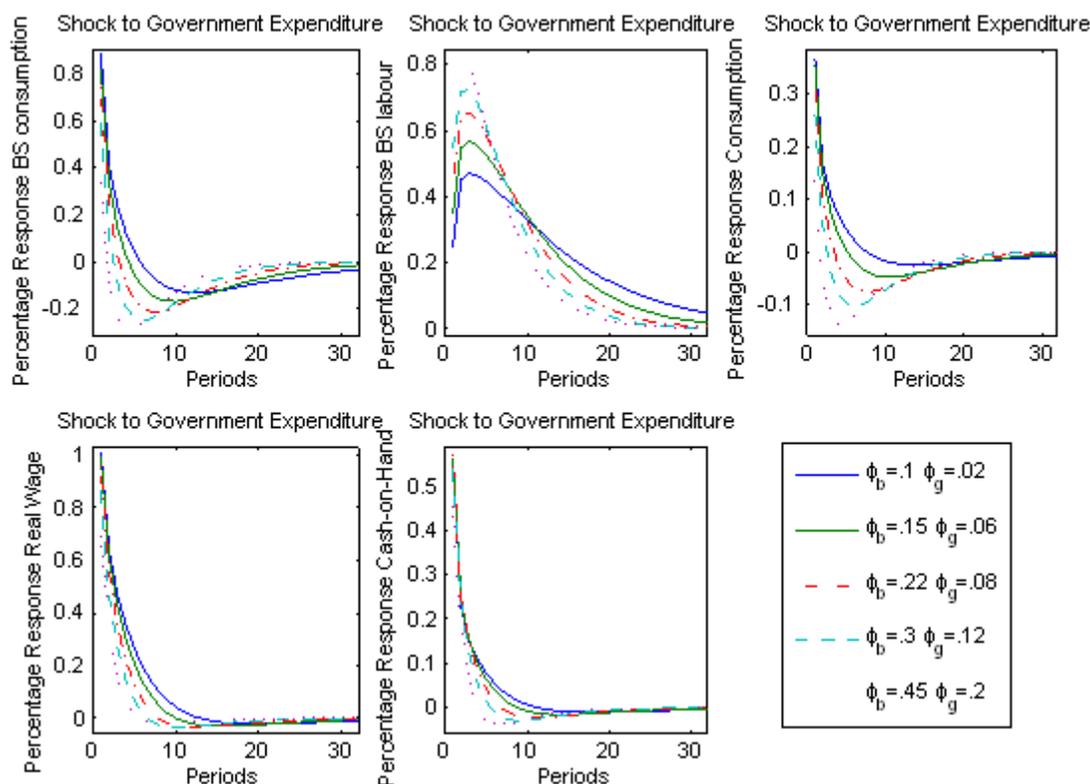


Figure 1.5: Impulse responses of selected variables with changing fiscal policy rule coefficients - $\rho_g = 0.8$ and $\theta = 0.8$.

This model, contrary to the rule-of-thumb model of Bilbiie and Straub (2004) and GLV does not show any relevant change in the consumption response as r_π rises: this is due to the fact that the positive consumption response is mainly driven by the introduction of cash-on-hand in the Buffer-Stock Euler equation and not by intertemporal substitution effects. The smaller increase in inflation shown in figure 1.3 makes the change in Ricardian consumption smaller than it is when $\lambda = 0$.

1.8 Conclusions

The objective of this paper is to explore the implications of Buffer Stock savings on macroeconomic dynamics after a government expenditure shock. Following recent literature, the mass of households in the model is divided into two groups. In the first we posit a negative relation between expected consumption and current cash-on-hand, motivated by

the simulation results in Carroll (1997). Consumption tracks income more closely, shaping the transmission mechanism of government expenditure shock. With sticky prices, fiscal shocks increase labor income *and* real wages, thus leading to a rise in private consumption — a stylized fact documented by many (by no means all) empirical studies tracking the impact of fiscal shocks in the US. With respect to the rule-of-thumb model of Galí, López-Salido and Vallés (2005) and Bilbiie and Straub (2004), the model in this chapter generates a positive consumption response associated with a plausible response of real wage. In addition, both kind of consumers save after the shock.

The introduction of Buffer-Stock consumers alone, however, is not enough to generate a positive response of consumption to fiscal shocks; this result can only be obtained through a combination of low persistence of shocks (the autoregressive coefficient must be around 0.8) and high degree of price stickiness. In this case, the cash-on-hand effect of Buffer Stock consumers prevails over the negative consumption response of standard Ricardian agents. The positive consumption response might be magnified by reducing the elasticity of taxes with respect to government expenditure and public bonds. A change in the way monetary policy is conducted, however, does not change significantly the economy's response.

A possible future extension of this model could be to take into account the possibility of distortionary taxes and to observe how it interacts with the Buffer Stock behavior as it is intended here. At the same time, it would be interesting to evaluate the empirical relevance of this behavior using structural estimation techniques, in a similar fashion to what Coenen and Straub (2004) have done for the rule-of-thumb model.

BIBLIOGRAPHY

- [1] Bilbiie F. and R. Straub (2004) "Fiscal Policy, Business Cycles and Labor-Market Fluctuations", *MNB Working Paper n° 2004/6*

- [2] Blanchard, O. and R. Perotti (2002) "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*, Vol.117, 1329-1368.

- [3] Browning, M., L.P. Hansen and J.J. Heckman (1999) "Micro Data and General Equilibrium Models" in J. B. Taylor and M. Woodford (eds.) *Handbook of Macroeconomics*, North-Holland

- [4] Callegari, G. (2006), "Financial Frictions and Household Debt: a New Perspective on the Twin Deficit Problem", *mimeo*, European University Institute.

- [5] Campbell, J.Y. (1994), "Inspecting the Mechanism: An Analytical Approach to the Stochastic Growth Model", *Journal of Monetary Economics*, Vol.33, 463-506.

- [6] Campbell, J. and Z. Hercowitz (2005), "The Role of Collateralized Household Debt in Macroeconomic Stabilization", *mimeo*, University of Chicago

- [7] Carroll, C. D., (1997) "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis", *Quarterly Journal of Economics*, Vol.62, 1-55.

- [8] ———, (2001), "Theoretical Foundations of Buffer Stock Saving", *mimeo*, Johns Hopkins University.

- [9] Carroll, C. D. and A. Samwick (1997), "The Nature of Precautionary Wealth," *Journal of Monetary Economics*, Vol. 40, 41-71.
- [10] Carroll, C.D. and L. H. Summers (1991), "Consumption Growth Parallels Income Growth: Some New Evidence", in B. Douglas Bernheim and John B. Shoven (eds) *National Saving and Economic Performance*, 305-343, Chicago University Press.
- [11] Fatas A. and I. Mihov.(2001), "Fiscal Policy and Business Cycles: An Empirical Investigation", *Moneda y Credito*.
- [12] Fatas A. and I Mihov (2003) "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence", *mimeo*, INSEAD
- [13] Finn M. G.(1998), "Cyclical Effects of Government's Employment and Goods Purchases," *International Economic Review*, Vol. 3, 635-57.
- [14] Gali, J., J.D. Lopez-Salido and J. Valles (2006) "Understanding the Effects of Government Spending on Consumption", *Journal of the European Economic Association*, forthcoming.
- [15] Kollmann, R. (1998) "US Trade Balance Dynamics: the Role of Fiscal Policy and Productivity Shocks and of Financial Market Linkages", *Journal of International Money and Finance*, 17, 637-669.
- [16] Iacoviello, M. (2005) "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", *American Economic Review*, V. 95 n.3, 739-764
- [17] Mankiw, N.G. (2000), "The Savers-Spenders Theory of Fiscal Policy", *Discussion Paper n.1888*, HIER.
- [18] Mountford, A. and H. Uhlig (2001), "What are the Effects of Fiscal Policy Shocks?", Discussion Paper 31, Tilburg University, Center for Economic Research.

[19] Smets, F. and R. Wouters, "Monetary Policy in an Estimated Stochastic Dynamic General Equilibrium Model of the Euro Area", forthcoming *Journal of Monetary Economics*.

[20] Uhlig, H. (1999) "A Toolkit for Analyzing Non-linear Dynamic Stochastic Models Easily", in R. Marimon and Andrew Scott, eds., *Computational methods for the study of dynamic economies*. Oxford: Oxford University Press, 30-61

1.A A Log-linearization of the Equilibrium Conditions

1.A.1 A.1 Steady State

From now on, variable without time subscripts will denote steady state values.

Since firms in the intermediate good are symmetric we have that

$$Y = Y(z) \quad \forall z \in [0, 1]$$

The resource constraint then becomes

$$\begin{aligned} Y &= C + G \\ 1 &= \gamma_c + \gamma_g \end{aligned} \tag{1.25}$$

where γ_c and γ_g are the share of aggregate private consumption and government expenditure on output.

From the solution of the cost minimization problem and of the profit maximization problem we establish that

$$\begin{aligned} \frac{W}{P} &= \frac{1}{1 + \mu} \frac{Y}{N} \\ \frac{D}{Y} &= \frac{\mu}{1 + \mu} \end{aligned}$$

where μ is the log of mark-up.

Switching to the consumer side, we now consider the consumption-output ratio for both groups. The Ricardian agents finance their consumption with labor income, profits minus the amount of lump-sum taxes. The consumption-output ratio for the Ricardian Consumers is thus equal to

$$\frac{\hat{C}}{Y} = \frac{1}{1 + \mu} + \frac{\mu}{1 + \mu} \frac{1}{1 - \lambda} - \frac{\hat{L}}{Y} \tag{1.26a}$$

Buffer Stock consumers finance their consumption with labor income, interest rate income earned on steady state government bonds minus lump-sum taxes. Consistently with

Gali *et al.* (2003) and Bilbiie and Straub (2004), Buffer Stock consumers do not participate in the redistribution of profits

$$\frac{\tilde{C}}{\tilde{Y}} = \frac{1}{1 + \mu} + \frac{1 - \beta}{\beta} \frac{\tilde{B}}{PY} - \frac{\tilde{L}}{\tilde{Y}} \quad (1.27a)$$

1.B B Determinacy Analysis

The conditions for determinacy are analyzed numerically, solving the model using Uhlig's Toolkit (Uhlig(1999)), and studying how the roots governing the process for the state variables change with the parameters of the model. The linearized dynamic discrete-time stochastic model, once solve, takes the following general reduced-form functional form

$$\begin{aligned} Y_t &= RH_{t-1} + S\varepsilon_t \\ H_t &= PH_{t-1} + Q\varepsilon_t \end{aligned}$$

where H_t is the vector of endogenous state variables (that in this case includes \tilde{b} and \hat{b}), Y_t is the vector of endogenous non-state variables and ε_t is the vector of endogenous shocks (in this case g_t). The determinacy properties of the system are studied by looking at the evolution of the roots of the P matrix, which regulates the evolution of the two state variables, \tilde{b} and \hat{b} .

This model conforms to the Taylor(1993) principle: when $r_\pi > 0$, the region in the parameter space leading to indeterminacy is small and confined to empirically implausible values¹². Figure 1.6 shows the combination of λ and θ for which the system is undetermined, with all the combinations lying in the regions $[0.84, 1]$ for λ and $[0.6, 1]$ for θ .

Figure 1.7 displays the determinacy of the system as a function of λ and of the inverse of the elasticity of labor supply with respect to wages when $\theta = 0.75$. This analysis has been done following Bilbiie and Straub(2004), who found that the Frisch elasticity of labor supply ψ is of crucial importance for the determinacy of the stochastic system. Even in this case, the region in which there may be indeterminacy is restricted to combinations in which λ is higher than 0.8.

With respect to the other models operating in the savers-spenders framework the determinacy properties of this model seems to be more in line with the standard New-Keynesian model: the Taylor principle holds independently of the values of the other parameters of the model.

¹²Campbell and Mankiw (1989) estimate the share of rule-of-thumb consumers in the economy is roughly 50%. Carroll (2000) conjectures that the share of impatient agents is 75% of the population. Note that relative impatient agents have a very similar consumption behavior to this one, as it is shown in Callegari (2006) in a model with impatient consumers and borrowing constraints.

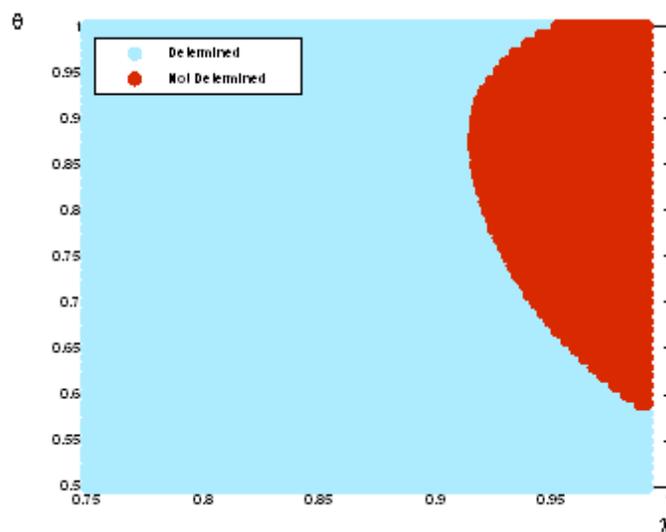


Figure 1.6: Determinacy Analysis - Combination of values of λ (x-axis) and θ (y-axis) for which the system solution path is determined.

Table 1 displays how the model's dynamic response changes as κ , the coefficient expressing the importance of cash-on-hand in the B-S Euler equation, rises above zero. The dynamic properties of the model are studied by looking how the two roots relative to the two state variables \tilde{b} and \hat{b} change with κ .

It is possible to identify four intervals: for $0 \leq \kappa < 1.05$ the system is determined and stable, with well-behaved dynamic response; both roots of the model lie in the $[0, 1]$ circle and have the same sign¹³. In this case the behavior of the model is comparable with the standard New-Keynesian model.

For values included in the interval $[1.05, 3.95[$ the absolute values of the two roots are still in the unit circle, ensuring the stability of the system, but their signs are now different, implying a cyclical dynamic pattern. This means that one of the two state variables (\tilde{b} or \hat{b}) tends to change sign at a short term horizon. Even if the dynamics are still stable, converging back to the steady state, this kind of behavior is not at all realistic, and so this interval cannot be considered in the parametrization.

¹³When $\kappa = 0$ the cash-on-hand term disappears from the modified Euler equation of Buffer Stock consumers, leaving an economy in which the only difference from a standard New-Keynesian one is the different sources of income accruing to the two groups. These income differences lead agents to use government bonds as inter-agent assets meant to facilitate consumption smoothing. For this reason, the economy is no longer stationary since the steady state group levels of government bonds are modified by the expenditure shock (Ricardians lend to Buffer-Stock agents). The system is however stable and the solution path is unique.

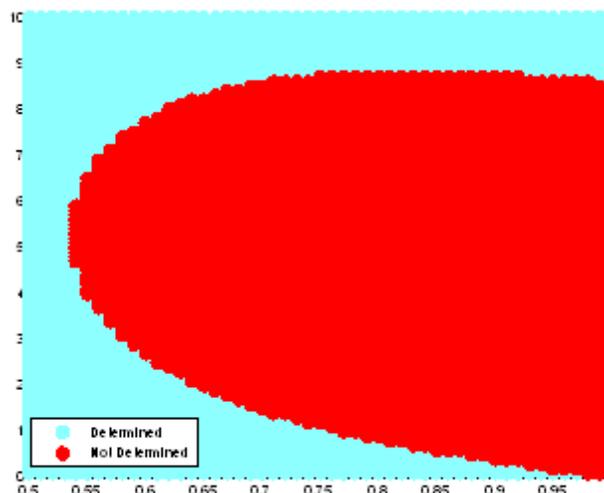


Figure 1.7: Determinacy Analysis - Combinations of λ (x-axis) and ψ (y-axis) for which the system is determined.

For the $[3.95, 4.1]$ this cyclical pattern is no more stable since the negative root is now bigger than one in absolute value: one of the state variables tends to oscillate with For values bigger than 4.1 the system is unstable but no longer cyclical, since both roots have the same, positive, sign (and one of them is bigger than one in absolute value). Both these two intervals cannot then be considered for the parametrization.

Table 1 - Dynamic Properties of the System

Values of κ	Roots (r_1 and r_2)	Equilibrium Dynamics
0	$r_1 \in [0, 1]$ and $r_2 = 1$	Unique solution, non-stationary S.S.
$]0, 1.05]$	$ r_1 $ and $ r_2 \in [0, 1]; \text{sign}[r_1] = \text{sign}[r_2]$	Unique stable solution
$]1.05, 3.95]$	$ r_1 $ and $ r_2 \in [0, 1]; \text{sign}[r_1] \neq \text{sign}[r_2]$	Unique stable solution cyclical responses
$]3.95, 4.1]$	$ r_1 \in [0, 1], r_2 \notin [0, 1], \text{sign}[r_1] \neq \text{sign}[r_2]$	Explosive non-unique sol. cyclical responses
> 4.1	$ r_1 \in [0, 1], r_2 \notin [0, 1], \text{sign}[r_1] = \text{sign}[r_2]$	Explosive non-unique sol. non-cyclical responses

The values of the other parameters are those of the baseline model laid down in section 7

The following graph shows how the two roots of the system vary as κ moves from 0 to 6.

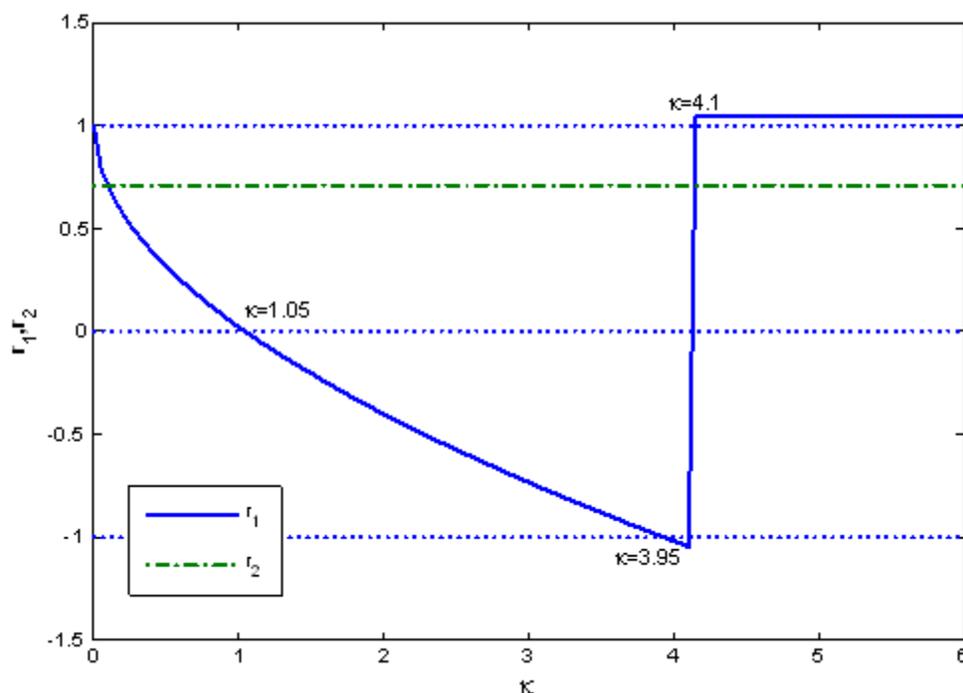


Figure 1.8: System's roots dynamics

While one of the two roots (that concerning \hat{b}_t) remains equal to 0.707 for every range of κ values, the other varies determining the kind of dynamics followed by the system.

At $\kappa = 0$ the root is equal to 1 so that the system is determined and stable, but the steady state is not stationary, since the shock produces a redistribution of wealth through government bonds, which are used as asset to transfer resources across groups. As κ rises above one, though, the increase in current consumption triggered by the increase in cash-on-hand introduces an endogenous mechanism of rebalancing which makes the steady state stationary. When $\kappa = 1.05$ the root goes below zero: this determines an oscillating solution which, as κ grows, becomes more and more accentuated; however, the system remains stable. As κ crosses the 3,95 threshold the root becomes bigger than one so that the path of \tilde{b}_t is not stable anymore. In the narrow interval of $]3.95, 4.1]$ the system is oscillatory and unstable. When $\kappa > 4.1$ the two roots regain the same sign, while one of them is still bigger than one: this determines non-oscillatory but explosive solution dynamics.

CHAPTER 2

GOVERNMENT EXPENDITURE, DURABLE GOODS AND RULE-OF-THUMB BEHAVIOR

2.1 Introduction

The standard RBC and New-Keynesian models predict a reduction in private consumption after an exogenous increase in government expenditure, because of the predominance of the negative wealth effect generated by the increase in the present discounted value of taxes¹. The non-negative response of consumption observed in many empirical analysis on fiscal policy (Blanchard and Perotti, 2002, Fatas and Mihov, 2003 and Galì, Lopez-Salido and Vallés, 2006) is a puzzle for these models, which has generated a fair amount of research in recent years. In particular, in order to reconcile theory with the evidence, a new class of models building on the New-Keynesian framework has recently been developed, in which the population of consumers is split in two groups of agents with a structurally different consumption behavior. The first group consists of standard agents who optimize their utility over an infinite-horizon, the second group consists of agents who blindly consume their income every period, without borrowing nor saving: these are usually identified as ‘*rule-of-thumb*’ consumers. With price rigidities and some assumption about labor market clearing, the positive income effect of spending shocks on the consumption of rule-of-thumb agents is so strong that it overcomes the negative wealth effect due to the higher taxes. This effect reverses the sign of the aggregate consumption response to the shock — see Galì, Lopez-Salido and Vallés (2006) and Bilbiie and Straub (2004).²

Introducing rule-of-thumb consumers improves the ability of the model to fit the empirical evidence on the consumption response to spending shock, as well as to account for other

¹Private consumption might respond positively in case of deficit-financed increase of government spending together with distortionary taxes on consumption: since agents expect higher taxes in the future, they have an incentive to substitute future with present consumption. This substitution effect may outweigh the wealth effect under some parametrizations. However, this result is very fragile, since for all the other alternatives financing scheme (lump-sum taxes, taxes on output etc.) the wealth effect always prevails.

²This result, however, crucially depends on some important assumptions: in Galì, Lopez-Salido and Vallés (2005) the labor is said to be *unionized*, that is the supply of labour is unique and common across groups: this guarantees that the labor supply of agents does not fall after the expenditure shock and that the wage response is positive, so as to amplify the income effect on rule-of-thumb agents. In Bilbiie and Straub (2004) there is no capital, and this is crucial to generate the necessary positive wage response that induces rule-of-thumb agents to increase consumption.

important facts. This paper checks the robustness of the positive consumption response generated by the rule-of-thumb model by introducing three additional features: durable goods and heterogeneity in time discount factors. The role of durable goods as collateral for borrowing is also checked.

In this framework the unwillingness to save by a group of agents is a consequence of these agents' preferences and utility maximizing behavior, while the inability to borrow is due to credit constraints, for which various justifications might be found both conceptually and empirically (see, for instance, Jappelli and Pagano, 1994).

Building on this model, the central claim of this paper is that, as soon as one introduces some alternative to ways to move resources intertemporally for otherwise constrained consumers - namely durable goods - the correlation of public and private consumption in response to fiscal shocks is no longer positive. The driving mechanism is centered on the fluctuations of the durable relative prices, which introduce an indirect, negative wealth effect which again drives down consumption.

We move from a specification with rule-of-thumb consumption behavior as in Gali, Lopez-Salido and Vallés (2006), to a specification with a durable sector, and eventually to a specification where individuals can borrow only to the extent that they own a stock of durables as a collateral. The economy is populated by two groups of agents, patient and impatient, which consume both durable and nondurable goods. While the former are in fixed endowment, the latter are differentiated, and produced by monopolistic competitive firms, subject to nominal rigidities — i.e. prices are sticky. The assumption of a fixed stock guarantees a variable durable goods price, but this assumption is not crucial for our mechanism to work, since the extent of price variations is independent to the value of the stock itself. This assumption is then made only to make the analysis simpler and the model more transparent.

The interest rate in steady state is set by patient agents so that impatient agents' preferred consumption path has a downward tendency; barring them from borrowing makes their consumption behavior as that of Gali *et al.* (2006) rule-of-thumb consumers. This suggests that the model in the paper can be used to analyze in detail how the aggregate and group-specific consumption response to shocks changes, moving from less to more general specifications

An important insight from this analysis is that, even if Impatient agents are totally unable to borrow or save, durable goods still provide them with a means to move resources intertemporally. The specification of durable goods is thus a crucial element³ driving the

³The importance of durable goods in the cycle has been underlined both theoretically and empirically (Mankiw, 1985 and Baxter, 1996)

model's results on consumption, as these goods are at the same time consumption goods and assets.⁴ Variations in their price affect households' net wealth, with first-order effects on private consumption. This is the main reason why, in the presence of durable goods, the response of private consumption to government spending shocks falling on nondurable goods becomes negative. The spending shock lowers the relative price of durables, thus translating into an indirect, additional negative wealth effect for households. This channel of fiscal transmission is strong enough to generate a negative response of private consumption even when durables are a very small fraction of private expenditure. The mechanism is robust to changes in the rate of intertemporal substitution and to different specifications of the labor market. Most important, relaxing the borrowing constraint does not help in changing the sign of the consumption response to fiscal shocks.

In light of the rapid diffusion of models including rule-of-thumb agents for fiscal policy analysis,⁵ this paper questions the robustness of the central claims by these contributions — regarding the ability of the rule-of-thumb models to match the empirical evidence. It also shows the need for a careful reconsideration of coherent microfoundations for rule-of-thumb consumption behavior.

The paper is structured as follows: section 2 presents the model with durable goods and borrowing constraint and section 3 describes its parametrization. Section 4 describes the dynamic response of this model to a government spending shock and compares it with the responses of a model without durables and inter-group borrowing. Section 5 inspects the transmission mechanism of the spending shock in the main specifications considered, while section 6 confronts the robustness of this paper's results to different specifications of the utility function and to different compositions of government expenditure. Finally, section 6 concludes.

2.2 The Model

This is a New Keynesian model with two groups of consumers and two goods, durable and non-durable. While the former are in fixed supply⁶ the latter are produced and sold by perfectly competitive firms which aggregate a continuum of intermediate goods. These goods are sold in a monopolistic competitive market where prices are sticky *à la* Calvo.

⁴As a matter of fact, in the literature on financial frictions what we called *durable goods* is usually referred to as *real estates* or *collateral assets*, to underline their role as assets rather than as consumption goods.

⁵See, among others, Coenen and Straub, (2004), Bilbiie, Meier and Mueller (2005), Bussière, Fratzscher and Mueller (2005) and Erceg Guerrieri and Gust (2005). Rule-of-thumb agents have also been introduced in the IMF macroeconomic model.

⁶Durable goods might be thought of as housing, real estates, generic assets in this framework: since the stock of these goods changes very slowly over time, assuming a fixed supply is not so far from reality.

The economy is populated by a continuum of agents of mass one divided in two sub-groups. The first, of measure $(1 - \lambda)$, is composed by agents who have full access to the asset and bond markets and own the intermediate sector firms, receiving the relative profits. They can freely buy bonds from the government or from the other group of agents. These consumers are called *Patient*.

The second group, of measure λ , is composed by consumers who are relatively impatient: their utility discount factor is smaller than that of Patient consumers, and so they give more weight to current rather than future utility; they are called *Impatient*. Their only means of moving resources intertemporally is to buy durable goods or to borrow from the Patient group through collateralized bonds. The amount of durables they hold serves two ends: it increases the agents' utility and can be used as a collateral to borrow from the Patient group.

The labor market in the baseline model is as in Gali, Lopez-Salido and Vallés (2006): hours supplied by each agent are determined by an economy-wide real wage schedule. They show that such a schedule can be thought as the outcome of unionized labor market, in which the union aims at maximizing the utility stream obtained by supplying labor⁷. The analysis of a Walrasian labor market in which every group has its autonomous labor supply will be included here, to check for the relevance of durable goods consumption in that context.

The subscript identifies the period in which a variable is set, independently on the period in which it is in place. K_{t-1} , for instance, represents the amount of capital set in period $t - 1$, even if it enters into the production function at time t .

To make investment non-trivial, an adjustment cost of capital is included in the analysis. The exposition below is made assuming a share of Impatient agents equal to one-half.

2.2.1 Preferences

The preferences of patient and impatient agents are expressed by the following utility functions:

$$E_0 \sum_{t=0}^{\infty} \hat{\beta} \left[\theta \ln \hat{H}_t + (1 - \theta) \ln \hat{C}_t + \hat{\chi} \frac{(1 - \hat{N}_t)^{1-\hat{\varphi}}}{1 - \hat{\varphi}} \right]$$

$$E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t \left[\theta \ln \tilde{H}_t + (1 - \theta) \ln \tilde{C}_t + \hat{\chi} \frac{(1 - \tilde{N}_t)^{1-\tilde{\varphi}}}{1 - \tilde{\varphi}} \right]$$

⁷The utility stream is obtained by subtracting from the utility obtained by the increase in income the disutility of labor. The utility stream of the two groups are then averaged and maximized.

where C_t is consumption of nondurable goods, H_t is the stock of durables in period, N_t is the labour supply and β is the time-discount factor. Letters denoted by a hat identifies variables related to Patient agents, whereas a tilde denotes impatient agents' variables, with $\hat{\beta} > \tilde{\beta}$.

The relative importance of housing in the utility functions is given by θ , and it is assumed to be equal across the two groups. The two parameters in the utility function, χ and φ , are different but parametrized in such a way that the two agents share the same labour supply in steady state (equal to one-third) and the same Frisch elasticity.

2.2.2 Production Sector

Nondurable goods are produced by a continuum of monopolistically competitive firms producing differentiated intermediate goods.

While labor is supplied by both groups, capital is owned only by Patient agents.

Every intermediate good is produced according to the following production function

$$Y_t(j) = K_{t-1}(j)^\alpha N_t(j)^{1-\alpha}$$

where K_{t-1} is the stock of capital rented out in $t-1$ and use it in period t .

The final good Y_t is produced by a perfectly competitive firm which aggregates all the intermediate goods using the Dixit-Stiglitz functional form.

$$Y_t = \left(\int_0^1 \left(Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} \right) dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where ε is the elasticity of substitution among intermediate goods.

The demand for every intermediate good is then

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon} Y_t$$

Cost minimization in the intermediate good sector gives the following condition for real wages and the rental rate of capital

$$\begin{aligned} \frac{W_t}{P_t} &= (1-\alpha) MC_t \frac{Y_t}{N_t} \\ \frac{R_t^K}{P_t} &= \alpha MC_t \frac{Y_t}{K_{t-1}} \end{aligned}$$

where

$$MC_t = \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \left(\frac{W_t}{P_t} \right)^\alpha \left(\frac{R_t^K}{P_t} \right)^{1-\alpha}$$

Firms adjust their prices infrequently, and the probability of being able to adjust the price in each period follows a Bernoulli distribution, accordingly to Calvo's (1983) set up. Let ι be the probability of keeping prices constant and $(1 - \iota)$ the probability of changing prices, the profit maximization problem can then be defined as

$$\begin{aligned} & \max_{\{P_t(z)\}_{t=0}^{\infty}} E_t \sum_{k=0}^{\infty} \iota^k \Lambda_{t,t+k} Y_t(z) [P_t(z) - P_t MC_t] \\ \text{s.t. } & Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\varepsilon} Y_t \end{aligned}$$

where

$$\Lambda_{t,t+k} = \beta^k \left[\frac{\hat{C}_t}{\hat{C}_{t+k}} \frac{P_t}{P_{t+k}} \right]$$

is the stochastic discount factor set by Patient consumers, the owners of the intermediate firms.

The first order condition of this problem is

$$E_t \sum_{k=0}^{\infty} \iota^k \Lambda_{t,t+k} Y_t(z) \left[P_t^*(z) - \frac{\varepsilon}{\varepsilon - 1} MC_{t+k} P_{t+k} \right] = 0$$

where the general price level is given by

$$P_t = [\iota P_{t-1}^{1-\varepsilon} - (1 - \iota) P_t^*(z)^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$$

where $P_t^*(z)$ is the optimal price for the firm z .

2.2.3 Monetary and Fiscal Policy

Monetary Policy follows the Taylor rule

$$R_t = (R_{t-1})^{r_R} (\pi_t^{1+r_\pi} (Y_t/Y)^{r_Y} \bar{r})^{1-r_R}$$

This way of formulating the monetary policy rule is extremely general: it includes the possibility that the central bank takes into account output differentials and interest rate inertia.

The government expenditure falls entirely on nondurable goods. It finances spending by taxes or by issuing debt. Thus the flow budget constraint of the government is

$$P_t G_t + B_{t-1}^g = L_t + R_t^{-1} B_t^g$$

A fiscal rule is imposed, so that taxes are a monotonic function of last year's bonds and current government expenditure.

$$l_t = \phi_b b_{t-1}^g + \phi_g g_t \quad (2.1)$$

where $l_t = \frac{L_t - L}{Y}$, $g_t = \frac{G_t - G}{Y}$ and $b_t^g = \frac{B_t^g / P_t - B^g / P}{Y}$. Variables without subscript denote steady-state values. As it will be shortly shown with the log-linear system, these two rules together with the flow budget constraint imply a unique dynamic path for government debt.

2.2.4 Asset Trading

When Impatient agents are allowed to borrow, the different way of discounting time is at the basis of the mechanism regulating asset trading: since the steady state interest rate is set by Patient agents, Impatient agents have a fundamental incentive to borrow and finance their current level of consumption.

The amount of savings of Patient agents, \tilde{B}_t , is used then to lend to the group of borrowers, \tilde{B}_t , and to finance the government deficit, B_t^g . The return from these two investments is the same and equal to R_t . Bonds are all expressed in nominal form: this may be justified on the ground that in developed countries only a very small percentage of bonds is indexed, as already noted by Iacoviello(2005).

The maximum amount of resources that Impatient agents can borrow is given by the following constraint

$$\tilde{B}_t \leq m E_t \left(P_{t+1}^D \tilde{H}_t / R_t \right)$$

where P_{t+1}^D is the price of durables at $t + 1$. This is the borrowing constraint as expressed in Iacoviello(2005), and corresponds to the collateral constraint of Kiyotaki and Moore (1997) when $m = 1$. Once a creditor lends money to another agents, she knows that ,in case of insolvency, she will be able to seize up to a certain share m of the stock of durables held by the borrower at time t evaluated at $t + 1$ prices.

The borrowing constraint expressed in real terms, is

$$\frac{\tilde{B}_t}{P_t} = m E_t \left(p_{t+1}^D \tilde{H}_t \pi_{t+1} / R_t \right)$$

where p_{t+1}^D is the relative durable/nondurable price.

Note that durables can also be thought as an asset whose return is the expected value at which it can be resold in the next period plus the amount of utility it generates.

2.2.5 Consumers' Problem

The budget constraint of Patient agents is

$$\begin{aligned} & \hat{C}_t + \hat{I}_t + p_t^D \Delta \hat{H}_t + R_t^{-1} \frac{\hat{B}_t}{P_t} \\ &= \frac{W_t}{P_t} \hat{N}_t + \frac{\hat{B}_{t-1}}{P_t} + \frac{R_t^K}{P_t} \hat{K}_{t-1} + \hat{D}_t - L_t \end{aligned}$$

where $\hat{B}_t = B_t^g + \tilde{B}_t$: B_t^g is government debt and \tilde{B}_t is debt held by Impatient agents. Investment is denoted by \hat{I}_t , q_t is the relative price of durables, \hat{D}_t is the amount of profits received by Patient agents, R_t^K is the rental price for installed capital, \hat{K}_{t-1} and δ_K are, respectively, the stock of capital rented by Patient agents in period t (set in $t-1$) and its depreciation rate. Disposable income is given by the product of hours \hat{N}_t times the real wage $\frac{W_t}{P_t}$ minus taxes, L_t .

The budget constraint of Impatient agents is

$$\tilde{C}_t + p_t^D \Delta \tilde{H}_t + \frac{\tilde{B}_{t-1}}{P_t} = \frac{W_t}{P_t} \tilde{N}_t + R_t^{-1} \frac{\tilde{B}_t}{P_t} - L_t$$

Since capital is owned only by Patient agents⁸ the capital evolution equation is equal both at the group and aggregate level

$$K_t = (1 - \delta_K) K_{t-1} + \phi \left(\frac{I_t}{K_{t-1}} \right) K_{t-1}$$

where δ_K is the capital depreciation rate.

$\phi(\cdot)$ describes the capital adjustment costs and has the following characteristics

$$\begin{aligned} \phi(\delta_K) &= \delta_K \\ \phi'(\delta_K) &= 1 \\ \phi'' &\leq 0 \\ \phi' &> 0 \end{aligned}$$

This guarantees that in a steady state the amount of capital is constant. These assumptions on the adjustment cost function ϕ imply that, for low levels of investment I_t , the costs are zero, with a non-differentiable point in correspondence of the investment/capital ratio value in which the costs hits the zero level. Given the assumption above, this point lies in

⁸ Assuming that capital is owned only by Patient agents is coherent with them owning the intermediate firms. Assuming that capital is rented to firms by Impatients, however, would not change the qualitative results of this analysis.

the $[0, \delta_K]$ interval. However, this does not affect the basic mechanism of the paper, since the focus is on the steady state properties of the model and on small deviations from it.

Investment costs are introduced to smooth the fluctuation in investment and to make them more close to the VAR evidence of Blanchard and Perotti (2002) and Gali *et al.* (2006).

The first order conditions for Patient agents are

$$1 = \hat{\beta} R_t E_t \left[\frac{\hat{C}_t}{\hat{C}_{t+1}} \frac{P_t}{P_{t+1}} \right] \quad (2.2)$$

$$1 = \frac{\theta}{1 - \theta} \frac{\hat{C}_t}{p_t^D \hat{H}_t} + \beta E_t \left[\frac{\hat{C}_t}{\hat{C}_{t+1}} \frac{q_{t+1}}{q_t} \right] \quad (2.3)$$

$$\phi' \left(\frac{I_t}{K_{t-1}} \right) Q_t = 1 \quad (2.4)$$

$$Q_t = E_t \left\{ \beta \frac{\hat{C}_t}{\hat{C}_{t+1}} \left[\frac{R_{t+1}^K}{P_{t+1}} + Q_{t+1} \left(1 - \delta_K + \phi_{t+1} - \phi'_{t+1} \frac{\hat{I}_{t+1}}{\hat{K}_t} \right) \right] \right\} \quad (2.5)$$

where Q_t is the correspondent for individual investment of the Tobin's Q .

Equation (2.2), the Euler equation, determines the path of consumption and at the same time is the price kernel for bonds and sets the risk-free nominal interest rate.

Equation (2.3) is the durables intratemporal condition. It might also be thought in terms of asset pricing, where the current relative price of durables is given by the present discounted value of the current and future marginal rate of substitution between durables and non-durables, which represent the stream of utility generated by a unit of durable goods expressed in terms of non-durables.

The last two equations define the Tobin's Q and the investment dynamic evolution. The first equalizes the benefit of increasing investment by one unit, which is expressed by the marginal increase in capital times its shadow real value Q_t , to its cost, all expressed in terms of the nondurable good. The second condition defines the real shadow value of capital Q_t , which is equal to the present discounted value of the expected flows of revenues generated by the increase of one unit of capital.

Taking into account the borrowing constraint, the Lagrangian relative to the Impatient agents' optimization problem is

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t \left\{ \begin{array}{l} \theta \ln \tilde{H}_t + (1 - \theta) \ln \tilde{C}_t + \tilde{\chi} \frac{(1 - \tilde{N}_t)^{1 - \tilde{\varphi}}}{1 - \tilde{\varphi}} + \\ + \Psi_t \left(\frac{W_t}{P_t} \tilde{N}_t + R_t^{-1} \frac{\tilde{B}_t}{P_t} - L_t - \tilde{C}_t - p_t^D \Delta \tilde{H}_t - \frac{\tilde{B}_{t-1}}{P_t} \right) + \\ + \Xi_t \Psi_t \left[m E_t \left(p_{t+1}^D \tilde{H}_t \pi_{t+1} / R_t \right) - \frac{\tilde{B}_t}{P_t} \right] \end{array} \right\}$$

The first-order condition for bonds and the durable/non-durable flow condition are

$$1 = \tilde{\beta} R_t E_t \left\{ \frac{\tilde{C}_t}{\tilde{C}_{t+1}} \frac{P_t}{P_{t+1}} \right\} + R_t \Xi_t \quad (2.6)$$

$$1 = \frac{\theta}{1 - \theta} \frac{\tilde{C}_t}{p_t^D \tilde{H}_t} + E_t \left\{ \beta \frac{\tilde{C}_t}{\tilde{C}_{t+1}} \frac{q_{t+1}}{p_t^D} \right\} + \Xi_t m E_t \left[(p_{t+1}^D / p_t^D) \pi_{t+1} / R_t \right] \quad (2.7)$$

These two conditions jointly describe how the collateral constraint affects Impatient agents' consumption. The Lagrange multiplier Ξ_t measures both the utility value of increasing by one unit the stock of durables and the difference between the desired return from bonds (the one would hold if there had not been any constraint) and the current one, in terms of utility. The bigger the difference, the bigger the utility cost of the collateral constraint; this in turn implies a higher Ξ_t and a higher return from holding durables goods, as may be inferred from the third term in eq. (2.6).

The collateral constraint impact on the consumption of Impatient agents increases with the difference between future and current income, that is, when the difference in current and future marginal utility of consumption is bigger. On the contrary, in a situation in which current income is (temporarily) higher, the value of the Lagrange multiplier falls.

2.2.6 Modelling the Labor Market

Several studies (Fatas and Mihov, 2003, Bilbiie and Straub, 2004 and Gali, Lopez-Salido and Vallés, 2006) have stressed the importance of the labor market in a model that wants to solve the positive consumption puzzle: without a positive correlation between consumption, labor and real wage it is indeed hard to match the empirical evidences. Investigating the labor market and finding the appropriate modelling strategy is therefore crucial for an effective analysis of government spending shocks.

The first natural candidate for labor market modelling is the standard Walrasian market: every agent chooses labor supply, determined by the intratemporal first order condition. This way of modelling however, has proved to be largely unsuccessful in explaining the responses to a government spending shock⁹, especially the positive correlation between labor and consumption that many empirical works (Blanchard and Perotti (2002), Fatas and Mihov (2001,2003), Gali, Lopez-Salido and Vallés (2006)) have found in the case of United States.

Gali, Lopez-Salido and Vallés (2006) have proposed an alternative modelling strategy: they introduce a *real-wage schedule* in which the real wage is a function of aggregate con-

⁹Bilbiie and Straub (2004) manage to get a positive response of private consumption with Walrasian labour market: their result though, heavily depends on the fact that there is no capital in the model.

sumption and total labor. This relation determines the combination of real wage and labor which clears the market, where the latter is supplied by every agent in the same measure, independent of the group to which she belongs; individual labor supplies depend then on *aggregate* consumption rather than on each groups' consumption level. Since this may be proved to be the result of unionized labor markets, in the remaining of the paper this will be defined as the *unionized* labor market specification.

Since the positive consumption response with plausible values of λ (the share of Impatient consumers) is obtained only with a unionized labor market, our baseline model will include this specification. The dynamic response of the system to government expenditure shock will also be studied under the alternative version of a Walrasian labor market, as it is in Bilbiie and Straub (2004). The "labor aggregator" that Erceg, Guerrieri and Gust (2005) introduce leads to a labour market similar to the unionized market of Galí *et al.* (2006).

The functional form of the real wage schedule is

$$\frac{W_t}{P_t} = F(N_t, C_t)$$

where

$$\begin{aligned} N_t &= \lambda \tilde{N}_t + (1 - \lambda) \hat{N}_t \\ C_t &= \lambda \tilde{C}_t + (1 - \lambda) \hat{C}_t \\ I_t &= (1 - \lambda) \hat{I}_t \end{aligned}$$

Since labor is allocated uniformly across agents $\tilde{N}_t = \hat{N}_t = N_t$ ¹⁰.

In the alternative specification the supply of labor is determined by each individual group's labor supply schedule

$$\hat{\chi} (1 - \hat{N}_t)^{-\hat{\varphi}} = \frac{W_t}{P_t} \frac{1 - \theta}{\hat{C}_t} \quad (2.8)$$

$$\tilde{\chi} (1 - \tilde{N}_t)^{-\tilde{\varphi}} = \frac{W_t}{P_t} \frac{1 - \theta}{\tilde{C}_t} \quad (2.9)$$

2.2.7 Equilibrium

The economy is in equilibrium when all the first order conditions are satisfied, the following resource constraints hold

$$\begin{aligned} \lambda \tilde{C}_t + (1 - \lambda) \hat{C}_t + I_t &= Y_t \\ \lambda \tilde{H}_t + (1 - \lambda) \hat{H}_t &= H \end{aligned}$$

¹⁰As already noted by Galí *et al.* (2006), we must have $F(N_t, C_t) > C_t(1 - N_t)^{-\varphi}$, applied for both groups, for the agents to be always willing to supply the amount of labour demanded.

and the market of capital is in the following equilibrium

$$K_t = (1 - \lambda) \hat{K}_t$$

2.2.8 Linearized System

Here small-cap letters denote percentage deviation, γ_i^j is the steady-state ratio to output of variable i relative to group j . α is the elasticity of output with respect to capital and μ is the steady state mark-up.

The linearized FOCs for the group of Patient consumers are

$$E_t \Delta \tilde{c}_{t+1} = r_t - E_t \pi_{t+1} \quad (2.10)$$

$$\beta (E_t \Delta \hat{c}_{t+1} - E_t \Delta \bar{p}_{t+1}^D) = [1 - \beta] (\hat{c}_t - \bar{p}_t^D - \hat{h}_t) \quad (2.11)$$

$$q_t = \beta E_t q_{t+1} + [1 - \beta (1 - \delta_K)] [E_t [m c_{t+1} + y_{t+1} - k_t]] - (r_t - E_t \Delta \pi_{t+1}) \quad (2.12)$$

$$i_t - k_{t-1} = \eta q_t \quad (2.13)$$

$$k_t = \delta_K i_t + (1 - \delta_K) k_{t-1} \quad (2.14)$$

where η is the steady-state elasticity of the Tobin's Q_t with respect to investment and capital and \bar{p}_t^D is the percentage deviation of the relative price. The log-deviation of the Tobin's q is denoted by q_t . Equations (2.10), (2.11) and (2.12) are the first order conditions for bonds, durable consumption and investment. Equation (2.13) defines the Tobin's q in log-linear form and (2.14) is the capital evolution equation.

The linearized FOCs for the group of Impatient agents are

$$r_t + \left(1 - \frac{\gamma}{\beta}\right) \tilde{\Xi}_t - \frac{\gamma}{\beta} E_t \Delta \tilde{c}_{t+1} - \frac{\gamma}{\beta} E_t \pi_{t+1} = 0 \quad (2.15)$$

$$\tilde{\beta} (E_t \Delta \bar{p}_{t+1}^D - E_t \Delta \tilde{c}_{t+1}) + m \hat{\beta} (\hat{\beta} - \tilde{\beta}) (E_t \Delta \bar{p}_{t+1}^D + E_t \pi_{t+1} + \hat{\Xi}_t - r_t) = \quad (2.16)$$

$$= [1 - \tilde{\beta} - \hat{\beta} (\hat{\beta} - \tilde{\beta}) m] (\tilde{h}_t + \bar{p}_{t+1}^D - \tilde{c}_t) \quad (2.17)$$

$$\tilde{\gamma}_c \tilde{c}_t + (p^D \tilde{\gamma}_H) \Delta \tilde{h}_t + b_{t-1} - \gamma_{\frac{B}{P}} \pi_t =$$

$$= \left(\frac{1 - \alpha}{1 + \mu}\right) (w_t + \tilde{n}_t) - \beta \gamma_{\frac{B}{P}} r_t + \beta b_t - l_t \quad (2.18)$$

$$b_t = \beta m \tilde{\gamma}_h (E_t \bar{p}_t^D + \tilde{h}_t + E_t \pi_{t+1} - r_t)$$

Here $\tilde{\Xi}_t$ is the log-linear deviation of the Lagrange multiplier from its steady state value.

The FOCs for the firm sector are

$$\pi_t = \beta E_t \pi_{t+1} + \kappa m c_t \quad (2.19)$$

$$m c_t = w_t - (y_t - n_t) \quad (2.20)$$

$$y_t = \alpha k_{t-1} + (1 - \alpha) n_t$$

where

$$\kappa = \frac{(1 - \beta \iota)(1 - \iota)}{\iota}$$

$$n_t = \lambda \tilde{n}_t + (1 - \lambda) \hat{n}_t$$

The policy rules are

$$r_t = (1 - r_R) ((1 + r_\pi) \pi_t + r_Y y_{t-1}) + r_R r_{t-1} \quad (2.21)$$

$$l_t = \phi_b b_{t-1}^g + \phi_g g_t \quad (2.22)$$

Assuming that steady-state government bonds are zero, equilibrium is defined by

$$g_t + b_{t-1}^g = l_t + \beta b_t^g - \beta \gamma \frac{B}{P} r_t \quad (2.23)$$

$$\hat{\gamma}_h \hat{h}_t + \tilde{\gamma}_h \tilde{h}_t = 0 \quad (2.24)$$

$$y_t = \gamma_c c_t + \gamma_i i_t + g_t \quad (2.25)$$

The exogenous shock, government spending, follows an AR(1) process

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g \quad (2.26)$$

The AR(1) process for government spending together with the tax rule (2.1) determine a path for government debt which can be obtained by substituting the two rules in the government flow budget constraint

$$b_t^g = \left(\frac{1 - \phi_b}{\beta} \right) b_{t-1}^g + \left(\frac{1 - \phi_g}{\beta} \right) g_t$$

The wage schedule in the specification with unionized labor markets is given by the following equation

$$\psi n_t = w_t - c_t \quad (2.27)$$

where ψ is the wage elasticity of Patient agents' labor supply and c_t is aggregate consumption.

In the Walrasian version every group has its own labor supply, given by the equations

$$\psi \hat{n}_t = w_t - \hat{c}_t \quad (2.28)$$

$$\psi \hat{n}_t = w_t - \tilde{c}_t \quad (2.29)$$

In both specifications we have assumed that χ and φ adjust in such a way that the hours supplied in steady state and the wage elasticity ψ is equal among groups.

2.3 Parametrization of the Model

To compare our impulse response functions to those generated by quarterly data we set β to 0.99; the discount factor of Impatient agents, γ , is set slightly below this value to 0.98. This value is well in line with microeconomic evidence in Lawrence (1991), Carroll and Samwick (1997) and Cagetti (1999).

The rule-of-thumb model occurs when θ , the relative preference for durable goods, and m are set to zero. In the specification with durable goods the value of the borrowing constraint is set to 0 and θ to 0.1 consistent with that estimated by Iacoviello(2005). In the specification with a relaxed borrowing constraint, the parameter m is set to 0.89. The share of Impatient agents λ is set to 0.5, consistently to what is done in all the other works using rule-of-thumb consumers and with the estimate of Campbell and Mankiw (1989). The wage elasticity is assumed to be the same among groups and equal to 0.2: this value is consistent with the values obtained through calibration in macro studies (Rotemberg and Woodford (1997,1999) when $\alpha = 1/3$).

The monetary policy parameters are initially set so that the coefficient on output and on the past value of interest rate are zero, whereas $r_\pi = 0.2$, so that the Taylor principle is respected and the model is as simple as possible. For comprehensiveness, the dynamic response of the model with different monetary policy rule, like the one estimated in Iacoviello(2005) using a similar model, will also be studied.

The tax policy functions respond more aggressively to bonds than government expenditure, so to achieve a hump-shaped response of taxes and bonds to a spending shock; as a consequence ϕ_b is set to 0.3 and ϕ_g to 0.12, consistently with the calibrated values of Gali *et al.* (2006). The level of steady state government debt is set to 0.

Firms are assumed to adjust on average every 4 periods, so that the probability of not-adjusting the price ι is 0.75.

2.4 Equilibrium Dynamics

First we analyze the model with rule-of-thumb consumers (θ and m are equal to zero), then a demand for durable is generated by introducing these goods in the utility function ($\theta > 0$); finally we add the collateral constraint (m and $\theta > 0$).

The model with rule-of-thumb consumers and unionized labor market is as in Gali *et al.* (2006). Figure 2.1 shows the responses to a one per-cent shock to government spending: given sticky prices, some of the firms increase the quantity supplied so that labor demand and real wages increases; this triggers a rise in Impatient agents' disposable income so that their consumption move up. The rise in demand due to the government expenditure shock increases aggregate demand and aggregate employment which in turn increases consumption. This leads to a further increase in aggregate demand, initiating an amplifying process well described in Gali *et al.* (2006).

Figure 2.1 also shows the same response in a model with a Walrasian market and no durable goods: the positive responses of both real wage and aggregate consumption are no longer in place. These responses underline how crucial is the way labor market is modelled to generate the positive consumption response.

With unionized labor supply the quantity of labor demanded is set by firms, while the real wage is set by the unions through the real wage schedule, eq. (2.27). Furthermore, the quantity of hours supplied is equal for both kind of agents, and so it is independent from variations at the group's level: this feature affects especially Impatient's labor supply which is insulated from the effects of tax variations. On the contrary, with a Walrasian labor market structure an increase in L_t ¹¹ produces a negative wealth effect which increases the labor supply so much that the real wage response becomes negative¹². This latter effect is important because it substantially reduces the increase in Impatient's disposable income, so

¹¹Note that here it is not the present discounted value of taxes that matters for the labor supply decision but only the current value.

¹²In the rule-of-thumb specification and in absence of taxes ($L_t = 0$), so that the Impatients' budget constraint is reduced to $P_t \tilde{C}_t = W_t \tilde{N}_t$, their supply of labour is fixed and equal to the steady state value

$$\hat{N}_t \left(1 - \tilde{N}_t\right)^{-\varphi} = \frac{1}{\chi}$$

This is due to the fact that the substitution and income effects exactly offset each other for any change in real wages. Introducing taxes ($L_t > 0$) adds another factor influencing the supply of labour: in steady state it increases Impatients' labor supply, because of the negative wealth effect.

An increase in L_t then, reduces disposable income and increases the marginal utility of income: this leads Impatients to supply an higher quantity of labor.

With unionized labor markets, the equilibrium quantity of labor is determined at the aggregate level, so the negative influence of taxes is much smaller than with the Walrasian structure .

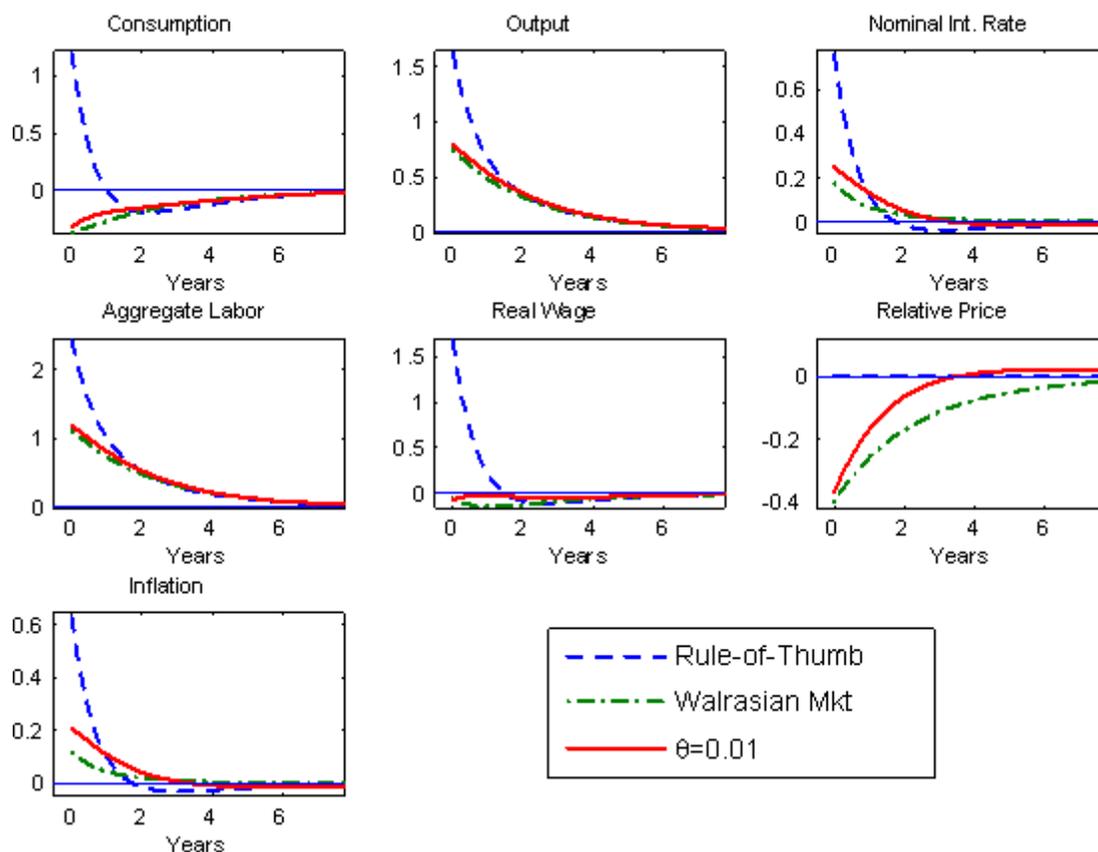


Figure 2.1: Impulse responses to a government expenditure shock in a model with rule-of-thumb consumers as in GLV, with Walrasian labour markets and with durable in the utility function ($\theta = 0.01$). In each case, $m = 0$.

that it cannot offset the consumption reduction of Patient agents. This is the reason behind the positive aggregate consumption response of Gali *et al.* (2006).

Does the result of Gali *et al.* (2006) resist the introduction of durables? The answer is clearly negative. As Figure 2.1 shows, as soon as θ rises over zero ($\theta = 0.01$) nondurable consumption response falls below zero. In this case the response of Impatient agents' consumption is negative even in the specification with unionized labor markets.

Still keeping the assumption of unionized labor markets and $\theta = 0.01$, Figure 2.2 shows that increasing m from 0 to 0.89 substantially increases the Impatient agents' demand for durables, so that their increased ability to borrow permits them to consume more. The increased Impatient agents' consumption manages to offset the negative response of Patient consumers, thus generating a positive aggregate response of consumption, even if quite small

in absolute value. The amount of debt held by Impatient agents is now the key element driving the aggregate consumption response, more than the dynamics of labour income: as a matter of fact, the path of the aggregate consumption response follows closely that of debt held by Impatient agents.

As displayed in figure 2.2, as θ rises from 0.01 to 0.1, the picture changes, with the multiplier given by the borrowing constraint falling rather than rising when m is increased to 0.89. The higher steady state stock of durable goods implied by a higher θ leads to a bigger negative wealth effect on both agents, which reverse the amplifying mechanism, leading actually to a contraction of the amount of debt available to Impatient agents.

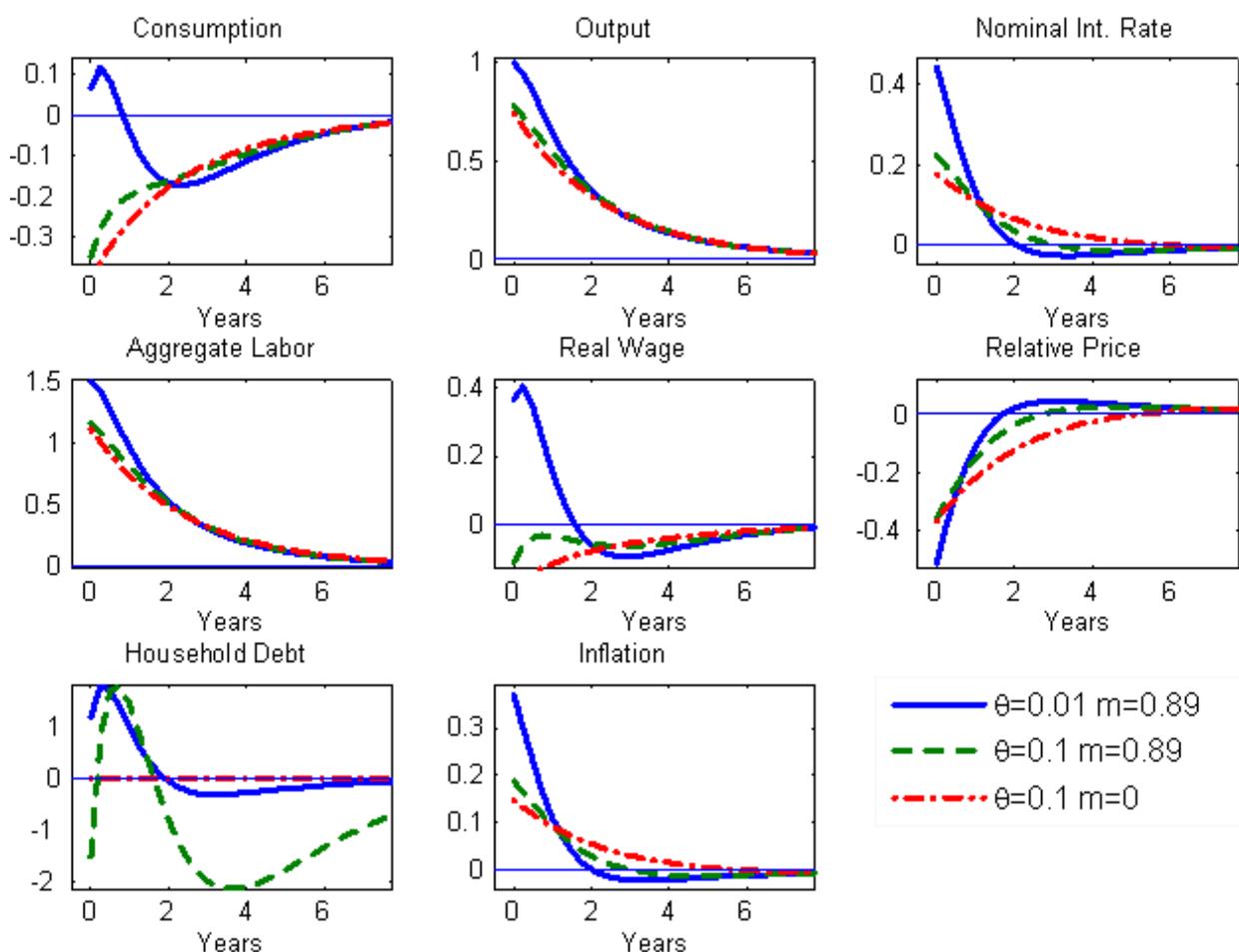


Figure 2.2: Impulse responses to a government expenditure shock when $m = 0.89$ for different weights of durable in the utility function ($\theta = 0.01$ or $\theta = 0.1$).

The positive or negative consumption response affects the magnitude of the output impact multiplier: it is higher than one (1.2) when aggregate consumption rises (figure 2.1), it is close to one when $\theta = 0.01$ and $m = 0.89$ and less than one (around 0.7) in those models which cannot reproduce the increase in consumption. The response is in line with what was found by Gali *et al.* (2006), while other empirical papers found values in line with those reproduced by the other specifications.

The response of investment is negative on impact, and changing the labor market structure affects substantially the following response pattern. With a Walrasian structure the low output response is never able to offset the negative influence given by the increase in the real interest rate. With unionized markets the nominal interest rate response becomes negative after 2 years and, at the same time, the marginal return to capital increase is bigger because of the higher output response. Therefore, after the initial negative response, investment becomes positive as soon as the nominal (and real) interest rate falls below the steady state value. This pattern is consistent with the US empirical evidences (Gali *et al.*, (2006), Corsetti and Mueller (2005)).

Inflation responds positively to an expenditure shock, because of the increase in demand. Obviously the magnitude of the inflation response (and of the real interest rate response) depends directly on the monetary policy responsiveness to changes in inflation (r_π), and on the sign of the consumption response: a positive sign implies a bigger increase in demand which is accommodated by a higher increase in the price level. This also explains the higher inflation impact response when $\theta = 0.01$ and $m = 0.89$: in this case the consumption response is still positive but smaller in absolute value.

2.5 Inspecting the Mechanism

Why does consumption drop so dramatically as soon as durable goods enter in the utility function? To understand the underlying mechanism one needs to analyze how the government expenditure shock together with the presence of durables interact with the nondurable consumption behavior of both groups.

The rise in government spending increases the present discounted value of taxes, thus diminishing households' wealth: this tends to reduce the consumption of all goods and of leisure. Since durables are in fixed supply and spending is assumed to fall entirely on nondurable goods, the relative price \bar{p}_t^D falls after the shock. This is the key element of the transmission mechanism, because in this economy durables are not only a component of consumption, but also contribute to the initial wealth of agents. In the case of Patient consumers this is shown in the equation below, obtained by substituting the durable-nondurable flow

condition and the Euler equation in the Patients' budget constraint and solving it forward

$$\begin{aligned} \left[\frac{\hat{\gamma}_c}{1-\beta} + \bar{p}^D \hat{\gamma}_h \right] \hat{c}_t &= a_{t-1} + \sum_{s=0}^{\infty} \hat{\beta}^s \left[\left(\frac{1-\alpha}{1+\mu} \right) (w_{t+s} + \hat{n}_{t+s}) - l_{t+s} \right] \\ &\quad - \left[\beta \left(\frac{\hat{\gamma}_c}{1-\hat{\beta}} - p^D \hat{\gamma}_h \right) + p^D \hat{\gamma}_h \right] \sum_{s=0}^{\infty} \hat{\beta}^s rr_{t+s} \end{aligned}$$

where

$$a_{t-1} = b_{t-1}^g + p^D \hat{\gamma}_h \left(\hat{h}_{t-1} + \bar{p}_t^D \right)$$

and rr_t is the real interest rate. The fall in \bar{p}_t^D lowers the value of the stock of durables held by Impatient agents: nondurable consumption of Patient agents falls more than in the rule-of-thumb model.

A similar effect also works with Impatient agents: since their ability to smooth consumption intertemporally is limited by the borrowing constraint, to observe the effect of a rise in durable/nondurable relative price it is enough to look at the flow budget constraint

$$(\tilde{\gamma}_c + p^D \tilde{\gamma}_h) \tilde{c}_t = -\frac{p^D \tilde{\gamma}_h \tilde{\beta}}{1-\tilde{\beta}} (E_t \Delta \bar{p}_{t+1}^D - E_t \Delta \tilde{c}_{t+1}) + p^D \tilde{\gamma}_h (\bar{p}_t^D + \tilde{h}_{t-1}) + \left(\frac{1-\alpha}{1+\mu} \right) (w_t - \tilde{n}_t) - l_t$$

The increase in labor supply (which is lower than in the Rule-of-Thumb model because now real wages fall) is indeed more than offset by the fall in initial wealth (the $p^D \tilde{\gamma}_h (\bar{p}_t^D + \tilde{h}_{t-1})$ term) due to the reduction in relative prices: this is exactly the *indirect* wealth effect.

As the impulse responses of figure ?? show, the indirect wealth effect is extremely important, since as soon as a demand for durable goods is generated ($\theta > 0$), aggregate consumption response falls immediately below zero. This is because the steady-state value of the stock of durables for both agents is high even for small values of θ

$$\frac{p^D \hat{H}}{Y} = \frac{\theta}{1-\theta} \frac{\hat{\gamma}_c}{1-\hat{\beta}} \quad (2.30)$$

and

$$\frac{p^D \tilde{H}}{Y} = \frac{\theta}{1-\theta} \frac{\tilde{\gamma}_c}{1-\tilde{\beta}} \quad (2.31)$$

where the values of $\hat{\gamma}_c$ and $\tilde{\gamma}_c$ are given in Appendix A¹³. These goods become particularly

¹³Note that the total value of the stock for each group qH is independent of the total stock of durables in the economy: this is a consequence of the Cobb-Douglas specification of the utility function. The results derived in this section however carry out also for alternative utility function: this will shown in the next section.

attractive for consumers because they can provide utility for all periods up until infinity¹⁴; agents buy a considerable amount of them so that a change in relative price reverses the consumption response of the rule-of-thumb model, showing the fragility of its main result. The reversal is independent of the labor market specification.

A relaxation of the borrowing constraint ($m > 0$, figure 2.2) affects the economy's response: aggregate consumption slightly rises when $\theta = 0.01$, but then falls again as θ gets to more realistic values.

Allowing for inter-group asset trading introduces a *financial multiplier* in the model: an increase in the stock of durables (either coming from an increase in \tilde{h}_t or \bar{p}_t^D) can be used as a collateral to borrow more funds from Patient agents which in turn will be used to finance additional units of durable and nondurable consumption. Therefore, whether the multiplier may increase or reduce consumption depends on how durables are shared among the two groups and on the dynamics of relative prices.

When $\theta = 0.01$ and $m = 0.89$ the path of consumption follows more closely cash-on-hand, allowing Impatient consumers to borrow and allowing them to consume more than in the $m = 0$ case. This translates into an increase in aggregate demand that leads to a higher demand of labor and a positive real wage response (while in the $m = 0$ case the real wage response was negative) which eventually leads to a further increase in demand. The multiplier on Impatient agents' consumption given by the unbinding of the borrowing constraint is enough to guarantee a positive consumption response.

Increasing agents' relative preference for durables ($\theta = 0.1$) changes the way the financial multiplier works: when m is brought to 0.89 the positive effect due to the increase in current cash-on-hand is offset by the indirect wealth effect which is now stronger because the value of Impatient agents' steady state stock of durables is bigger. At the same time Impatient consumers' consumption in steady state is smaller because of the higher interest payments: this reduces the weight of these agents in the overall aggregation. These two effects offset each others so that, eventually, the aggregate consumption response is negative because of the negative response of Patient agents. Appendix 2.C presents a more detailed analysis of how the multiplier works and how the stock of durable goods is shared among groups.

In conclusion adding durable goods and Impatient agents to the rule-of-thumb model shows that the positive consumption response is fragile to the introduction of durables, and allowing Impatient agents to borrow can generate a positive consumption response only for

¹⁴The low value of the marginal rate of substitution is a direct consequence of the zero depreciation rate which, in turn, is a consequence of the fixed supply assumption.

The values currently assumed for the depreciation rate range between 0 and 0.1: therefore, a relaxation of the fixed supply would not affect considerably the basic mechanism.

low values of θ .

2.6 Other Robustness Checks

In this section, we want to check whether the contraction of consumption when $\theta = 0.1$ and $m = 0.89$ is sensitive to alternative parameterization.

In the analysis above durable and non-durable consumption are aggregated by a Cobb-Douglas function: this implies that the elasticity of substitution between the two goods is equal to one. Fig.2.3 presents how the impact response of consumption changes when ρ , the elasticity of substitution varies between 0 and 1, that is between the Cobb-Douglas and linear case. Aggregate consumption response changes only slightly, with the response becoming more negative as ρ increases. As ρ approaches one the change in durable consumption becomes smaller and smaller coinciding with zero when $\rho = 1$: at this point the system then behaves as the standard rule-of-thumb model, apart from the fact that durables constitute part of the initial wealth. This is because as ρ converges towards one Impatient agents prefer to buy only non-durable goods to increase today's utility so that Patient agents hold almost all the stock of durables in steady state¹⁵. The fall in aggregate consumption even when $\rho = 1$ confirms the fact that it is the drop in \bar{p}_t^D which drives the response of consumption down, and not the way durables enter in the utility function.

Dropping the assumption of log-utility (in which the intertemporal elasticity of substitution is fixed to one) does not affect the response in a substantial form: as it is expected, reducing the elasticity of substitution makes Patient consumers less willing to substitute present with future consumption so that the impact response of consumption is smaller and its persistence bigger. The influence on Impatient consumers is milder: the only intertemporal decision is the purchase of durable consumption whose pattern, as shown before, affects only marginally the nondurable consumption response. As figure 2.4 shows, the changes in the economy's responses are mainly due to variations in Patient agent's consumption while little changes occur in Impatient agents' response. The response of durable consumption changes only slightly in absolute terms.

¹⁵This can be seen in the steady-state equation for the share of durable stock held by Borrowers

$$\tilde{H} = \left(\frac{\tilde{C} \Delta \gamma^{\frac{1}{\rho-1}} H}{\lambda \hat{C} + (1 - \lambda) \tilde{C} \Delta \gamma^{\frac{1}{\rho-1}}} \right)$$

note that as $\rho \rightarrow 1$ the term $\Delta \gamma^{\frac{1}{\rho-1}}$ converges to zero, and so does \tilde{H} .

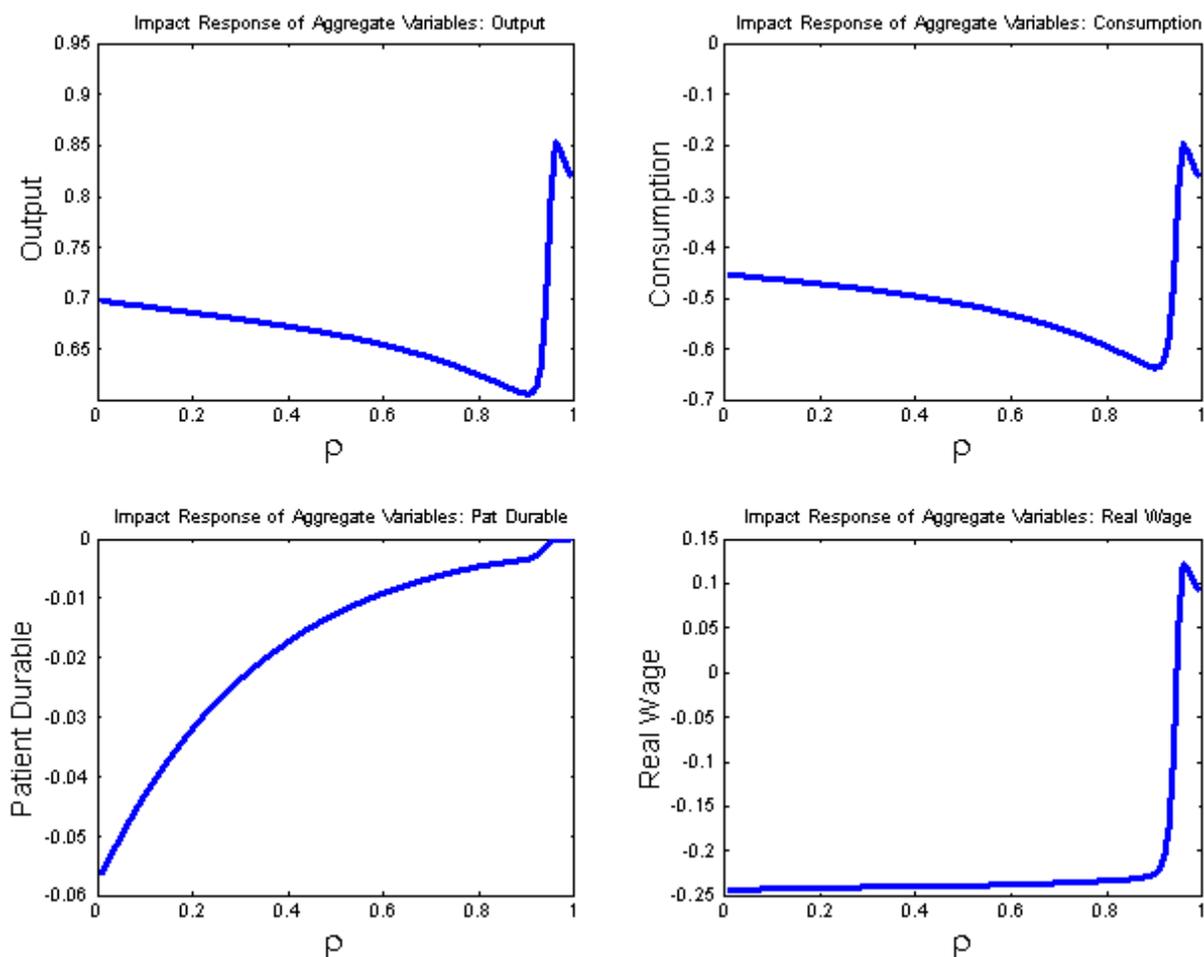


Figure 2.3: Impact responses to a government expenditure shock of selected variables varying ρ

Figure 2.5 shows the impulse response functions of a model with a more accommodative monetary policy ($r_\pi = 0.01$, $r_R = 0$, $r_Y = 0$) and with a monetary policy corresponding to the one estimated by Iacoviello (2005) ($r_\pi = 0.27$, $r_R = 0.73$, $r_Y = 0$).

The first panel, in which $r_\pi = .01$ shows a feature of this model found also in Bilbiie and Straub (2004) and Bilbiie, Meier and Mueller (2005). As the rise in the real interest rate becomes smaller the incentive of Patient agents to save more today falls so that the drop in the group's consumption is smaller and the reduction in aggregate consumption is more contained. Real wages increase because the rise in demand prevails over the rise in labor supply.

As suggested by Bilbiie, Mueller and Meier (2005) the change in the system dynamic responses when monetary policy is more passive may be a possible explanation for the

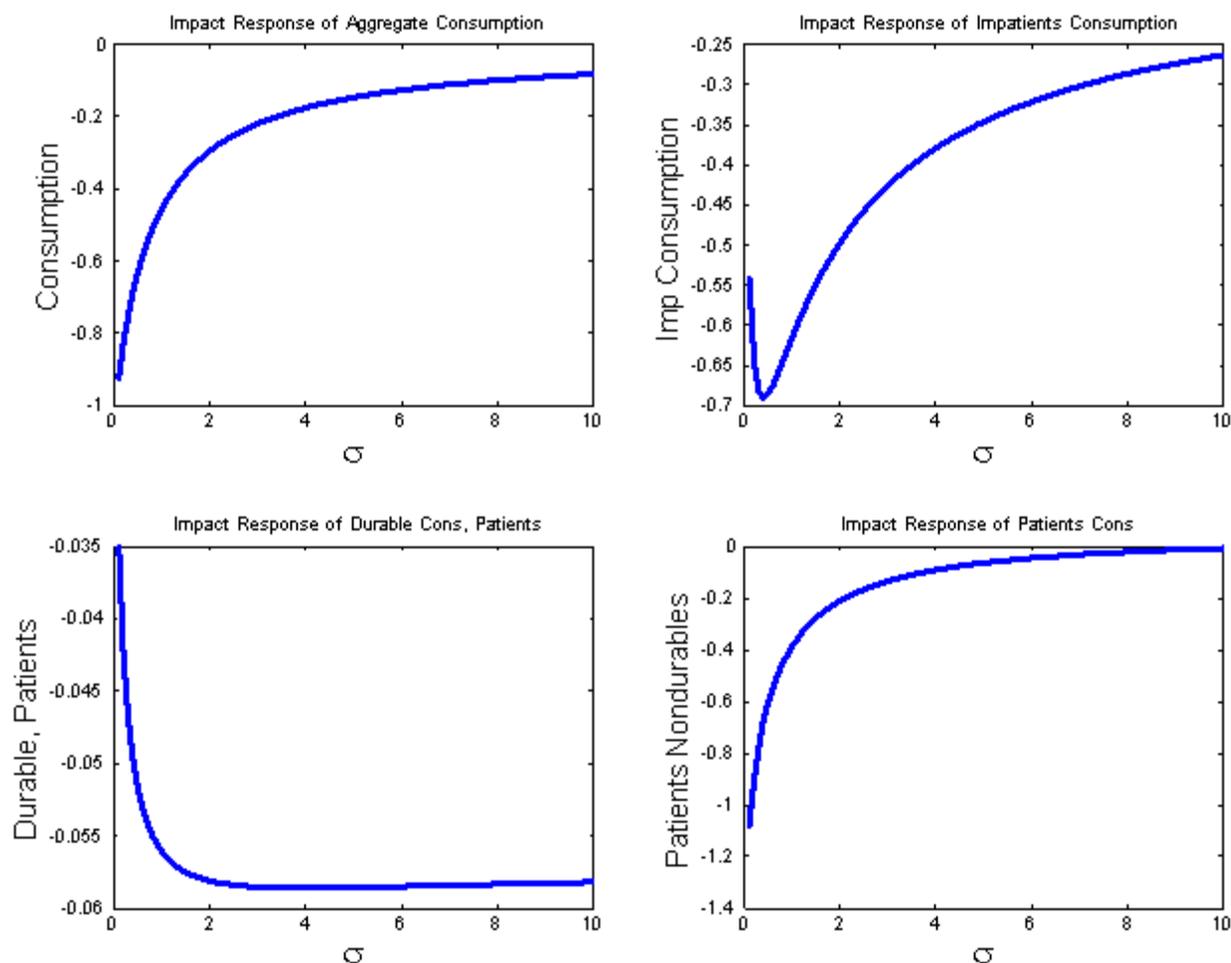


Figure 2.4: Impact responses of selected variables to a government expenditure shock as a function of σ .

evidences presented by Perotti (2005), who, analyzing the effects of fiscal policy in the US and in other OECD countries, found a structural break taking place approximately in 1982: indeed, after that year the magnitude of the positive consumption response observed in the US falls substantially, together with that of the other major macroeconomic variables¹⁶.

One of the proposed explanation is that before 1982 the more passive monetary policy contributed crucially to the more accentuated response of the economy to fiscal shocks, especially for those factors that concern consumption. With a more active monetary policy (higher r_π) private individuals save more in order to offset some of the effects of a fiscal

¹⁶Such a break has also been observed in other OECD countries, where the consumption response is slightly above zero in the pre-1982 sample and well below in the after-1982 sample.

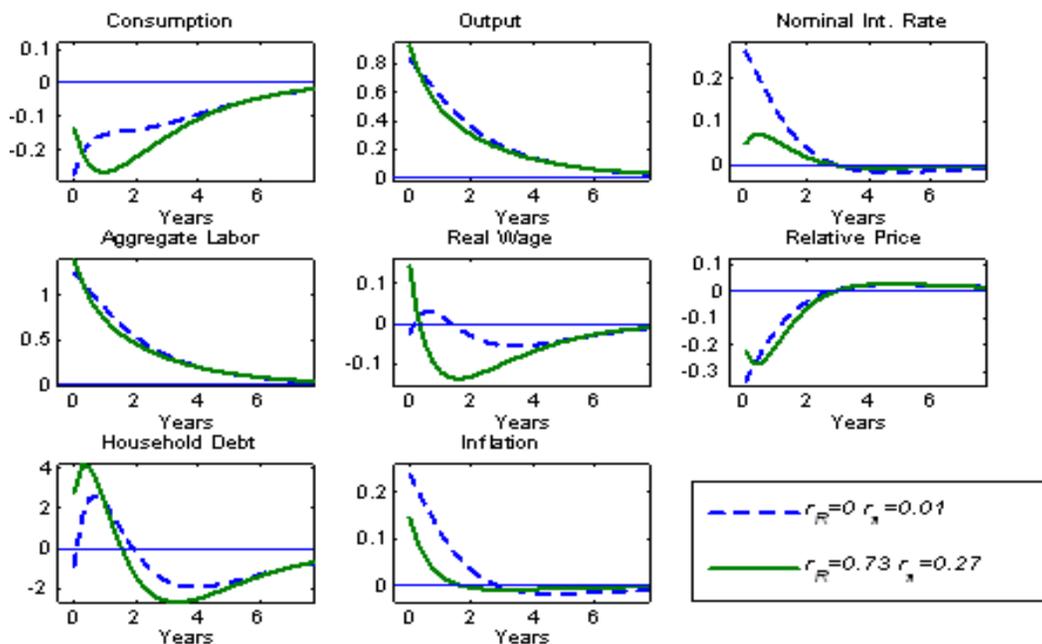


Figure 2.5: Impulse responses with different specifications of the monetary policy rule.

policy shock in the economy.

The monetary policy specification estimated by Iacoviello(2005) makes the interest rate response much smoother and hump-shaped: the path of consumption follows this pattern and then returns to zero, without modifying the main qualitative results of the model.

Because of the relevant role played by the price of durable goods in determining the economy's response, one might wonder what would be the effect of introducing a public component in the demand of durable goods. Let's then assume that government spending g_t falls on both durable and nondurable goods

$$g_t = g_t^f + g_t^{nd}$$

according to the following rule

$$g_t^f = \phi_d g_t$$

where g_t^f is the public expenditure on durable goods, corresponding to the change in the public stock of durables g_t^d

$$g_t^f = g_t^d - g_{t-1}^d$$

When $\phi_d = 0$ all the expenditure goes on nondurable goods, therefore returning to the basic specification.

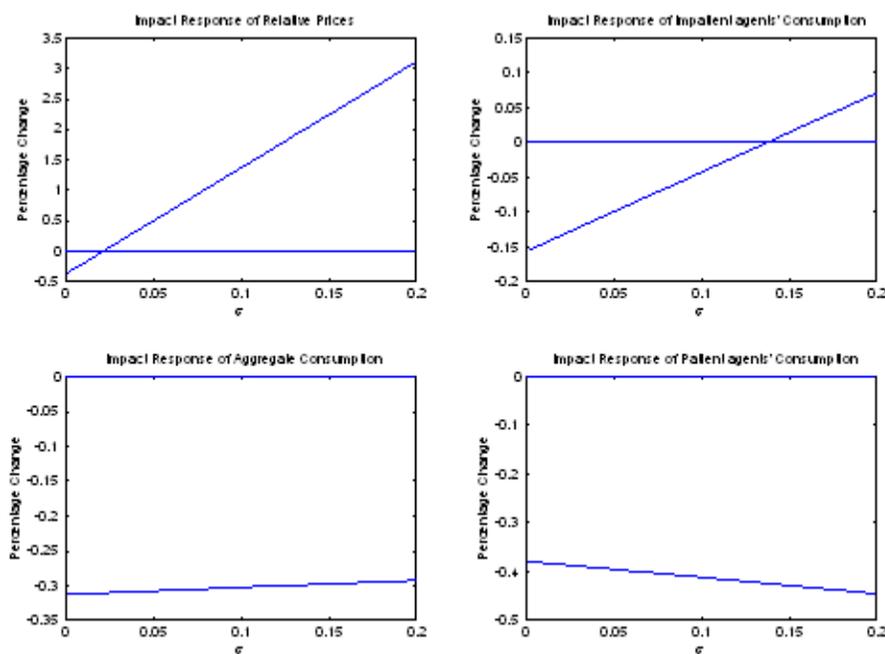


Figure 2.6: Impact response of selected variable as a function of the share of government expenditure falling on durable goods

Figure 2.6 shows how the impact responses of durable relative price and of aggregate and groups' consumption change as ϕ_d varies between 0 and 0.2¹⁷. While the sign of the impact response of relative price turns quickly to positive values, other general equilibrium effects prevent the consumption response to become positive (even if it slowly rises with ϕ_d).

In particular, the system is not stationary anymore once the government is allowed to buy durable goods: the amount purchased leads to a change in the distribution of this kind of goods between the private and the public sector, reducing the net wealth available to Impatient and Patient agents. Impatient agents, more sensitive to current variations in income, respond to the rise in p_t^D , while Patient agents take into account the reduction in wealth and actually reduces consumption as ϕ_d rises. As a consequence, aggregate consumption rises very slowly, without ever getting close to 0.

¹⁷Given the current definition of government expenditure (which includes also wages expenditure), the share of yearly public expenditure for durables is quite small: in the 1947-2006 sample it has exceeded 0.1 only in the 1950-1955 period, with an average value of 0.05. The 0.2 higher bound is then well above what is observed in the data, at least for the US case.

In steady state I assume that the share of durable goods held by the government is equal to $\phi_d \times \frac{G}{Y} \times \frac{qH}{Y}$.

2.7 Conclusion

The rule-of-thumb model is able to generate a positive response of consumption to a government spending shock consistently with US evidence on fiscal policy. In this paper, I show that this result is extremely fragile in a more general specification with durable goods and borrowing constraints. This is mainly due to what I call the *indirect wealth effect*: since durables also constitute part of households' initial wealth, the drop of the relative price of durables which takes place after the shock emerges as an additional wealth effect (other than the one generated by the increase in taxes) that reduces consumption.

Relaxing the borrowing constraint generates a positive consumption response only for a small relative preference for durable goods: when the parametrization approaches more realistic values, the consumption response again becomes less than zero: the financial multiplier generated by household debt lies behind the positive response of nondurable consumption when θ is small, but it does not alter it when $\theta > 0.1$. This negative result remains valid for any specification of the labor market, including the one presented by Gali, Lopez-Salido and Vallés (2006) of demand-determined labor market, and to the way durable and nondurable consumption goods are aggregated in the utility function. Allowing for different values of the intertemporal elasticity of substitution does not change the final result; the same conclusion is reached using different monetary and fiscal policy specifications. Finally, I also check the consumption response once a public component in the durable goods' demand is introduced in the system. While it substantially increases the durable/nondurable relative price, the government intervention also reduces the stock of durable available to the private sector, thus reducing their wealth. As a consequence, aggregate consumption rises very slowly, without reaching values close to zero.

Thus the rule-of-thumb model is not able to describe the effects of government spending once other means to transfer resources intertemporally (like durable goods) are introduced in the model: even a very small preference for durable goods in the utility function ($\theta = 0.01$) reverts the response of consumption to negative values.

Adding to this model a fully-fledged production sector constitutes a potential extension of this framework: the analysis of labor markets with and without sticky prices in the durable sector may provide alternative modelling strategies to the unionized markets proposed in Gali *et al.* (2006).

Another avenue of research which could be worth pursuing is the analysis of the spending shock when the government uses distortionary taxes: in this case the response of the economy may differ from this specification, changing considerably the role of Impatient agents in the transmission mechanism.

BIBLIOGRAPHY

- [1] Barsky, R. C.L. House and M. Kimball (2003) "Do Flexible Durable Goods Prices Undermine Sticky Price Models?", *mimeo*, University of Michigan

- [2] Bilbiie, F. (2005) "Limited Asset Market Participation, Monetary Policy and Inverted Keynesian Logic" *mimeo*, Nuffield College, Oxford U.

- [3] Bilbiie F. and R. Straub (2004) "Fiscal Policy, Business Cycles and Labor-Market Fluctuations", *MNB Working Paper n° 2004/6*

- [4] Bilbiie F., A. Meier and G. Mueller (2005), "What accounts for the change in US fiscal policy transmission?", *mimeo*, University of Frankfurt

- [5] Blanchard, O. and R. Perotti (2002) "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*, Vol.117, 1329-1368.

- [6] Browning, M., L.P. Hansen and J.J. Heckman (1999) "Micro Data and General Equilibrium Models" in J. B. Taylor and M. Woodford (eds.) *Handbook of Macroeconomics*, North-Holland

- [7] Bussière, M., Fratzscher M. and G. J. Mueller (2005) "Productivity Shocks, Budget Deficits and the Current Account", *ECB Working Paper*, 509

- [8] Campbell, J. and Z. Hercowitz (2005), "The Role of Collateralized Household Debt in Macroeconomic Stabilization", *mimeo*, University of Chicago

- [9] Campbell, J.Y. and G. Mankiw (1989), "Consumption, Income and Interest Rates: Reinterpreting the Time Series Evidences", in O.J. Blanchard and S. Fischer (eds.) *NBER Macroeconomics Annual 1989*, 185-216, MIT Press
- [10] Carroll, C. D., (1997) "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis", *Quarterly Journal of Economics*, Vol.62, 1-55.
- [11] Coenen, G. and R. Straub (2004) "Non-Ricardian Households and Fiscal Policy in an Estimated DSGE Model of the Euro Area", *mimeo*, ECB
- [12] Erceg C., L. Guerrieri and C. Gust (2005), "Expansionary Fiscal Shocks and the Trade Deficits", *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System
- [13] Fatas A. and I. Mihov.(2001), "Fiscal Policy and Business Cycles: An Empirical Investigation", *Moneda y Credito*.
- [14] Fatas A. and I Mihov (2003) "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence", *mimeo*, INSEAD
- [15] Gali, J., J.D. Lopez-Salido and J. Valles (2006) "Understanding the Effects of Government Spending on Consumption", *Journal of the European Economic Association*, forthcoming.
- [16] Iacoviello, M. (2005) "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", *American Economic Review*, V. 95 n.3, 739-764
- [17] Jappelli, T. and M. Pagano (1994) "Saving, Growth and Liquidity Constraints", *Quarterly Journal of Economics* 106, 83-109
- [18] Mankiw, N.G. (2000), "The Savers-Spenders Theory of Fiscal Policy", *Discussion Paper n.1888*, HIER.

- [19] Mendicino, C. (2005), "Credit Market and Macroeconomic Volatility", Stockholm School of Economics, *mimeo*
- [20] Mountford, A. and H. Uhlig (2001), "What are the Effects of Fiscal Policy Shocks?", Discussion Paper 31, Tilburg University, Center for Economic Research.
- [21] Perotti, R. (2004) "Estimating the Effects of Fiscal Policy in OECD Countries", *mimeo*, Università Bocconi
- [22] Rotemberg, J. and M. Woodford (1997) "An Optimization Econometric Framework for the Evaluation of Monetary Policy" in O.J. Blanchard and S. Fischer (eds.) *NBER Macroeconomics Annual 1997*, MIT Press
- [23] Rotemberg, J. and M. Woodford (1999) "Interest Rate Rules in an Estimated Sticky Price Model" in J. B. Taylor (ed.), *Monetary Policy Rules*, University of Chicago Press and NBER
- [24] Uhlig, H. (1999) "A Toolkit for Analyzing Non-linear Dynamic Stochastic Models Easily", in R. Marimon and Andrew Scott, eds., *Computational methods for the study of dynamic economies*. Oxford: Oxford University Press, 30-61

2.A Steady State

These values are derived assuming that $\tilde{\chi}$ and $\hat{\chi}$ are set such that $\tilde{N} = \hat{N} = N = 1/3$. These results are conditional on the steady state rule for taxes γ_T

$$\begin{aligned}\nu_A &= \delta_H + (1 - \beta) \hat{\beta} m \\ \nu_B &= \frac{1 - \theta}{\theta} \left(1 - \gamma(1 - \delta_H) - \hat{\beta}^2 \left(1 - \frac{\tilde{\beta}}{\hat{\beta}} \right) m \right) \\ \nu_2 &= \frac{1 - \alpha}{1 + \mu} - \gamma_T\end{aligned}$$

$$\begin{aligned}\frac{p^D \tilde{H}}{Y} &= \nu_2 \left(\frac{1}{\nu_A + \nu_B} \right) \\ \tilde{\gamma}_c &= \nu_2 \left(\frac{\nu_B}{\nu_A + \nu_B} \right) \\ \frac{B}{PY} &= \hat{\beta} m \frac{p^D \tilde{H}}{Y}\end{aligned}$$

$$\begin{aligned}\hat{\gamma}_c &= \left(\frac{1 - \gamma_g - \lambda \tilde{\gamma}_c}{1 - \lambda} \right) - \frac{\delta \alpha}{(1 - \lambda)(\rho + \delta_k)(1 + \mu)} \\ \nu_1 &= \left(\frac{\alpha}{(\rho + \delta_K)(1 + \mu)} \right)^{\frac{1}{1 - \alpha}} \\ \frac{K}{Y} &= \left(\frac{\alpha}{(\rho + \delta_K)(1 + \mu)} \right) N = (\nu_1)^{\frac{1 - \alpha}{\alpha}} \\ \frac{p^D \hat{H}}{Y} &= \frac{\theta}{1 - \theta} \frac{\hat{\gamma}_c}{1 - \hat{\beta}(1 - \delta_H)}\end{aligned}$$

2.B A more general utility function specification

The utility function in this general case, to be adapted to the specifications of the two groups is

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(C_t^*)^{1 - \sigma}}{1 - \sigma} + \chi^j \frac{(1 - N_t)^{1 - \varphi}}{1 - \varphi} \right\}$$

where

$$C_t^* = [\theta^{1 - \rho} H_t^\rho + (1 - \theta)^{1 - \rho} C_t^\rho]^{\frac{1}{\rho}} \quad (2.32)$$

The FOCs of Patient agents are

$$\begin{aligned}\hat{\Psi}_t &= (1 - \theta)^{1 - \rho} \left(\hat{C}_t^* \right)^{1 - \rho - \sigma} \left(\hat{C}_t^* \right)^{1 - \rho} \\ 1 &= \frac{\hat{\Psi}_{t+1} \bar{p}_{t+1}^D}{\hat{\Psi}_t \bar{p}_t^D} \left[\left(\frac{\hat{C}_t^*}{\hat{C}_{t+1}^*} \right)^{1 - \rho - \sigma} \left(\frac{\theta}{1 - \theta} \frac{\hat{C}_{t+1}^*}{\hat{H}_t} \right)^{1 - \rho} \frac{1}{\bar{p}_{t+1}^D} + \hat{\beta}(1 - \delta_H) \right] \\ 1 &= \hat{\beta} R_t E_t \left\{ \left(\frac{\hat{C}_{t+1}^*}{\hat{C}_t^*} \right)^{1 - \rho - \sigma} \left(\frac{\hat{C}_t^*}{\hat{C}_{t+1}^*} \right)^{1 - \rho} \frac{P_t}{P_{t+1}} \right\} \\ Q_t &= \hat{\beta} \frac{\hat{\Psi}_{t+1}}{\hat{\Psi}_t} \left\{ \frac{R_{t+1}^K}{P_{t+1}} + Q_{t+1} \left[(1 - \delta_K) + \phi_{t+1} - \phi'_{t+1} \frac{\hat{I}_{t+1}}{K_t} \right] \right\}\end{aligned}$$

The FOCs of Impatient agents are

$$\begin{aligned}\tilde{\Psi}_t &= (1 - \theta)^{1-\rho} \left(\tilde{C}_t^*\right)^{1-\rho-\sigma} \left(\hat{C}_t^*\right)^{1-\rho} \\ 1 &= \tilde{\beta} R_t E_t \left\{ \frac{\tilde{\Psi}_{t+1} P_{t+1}}{\tilde{\Psi}_t P_t} \right\} + R_t \Xi_t \\ 1 &= \frac{\tilde{\Psi}_{t+1} \bar{p}_{t+1}^D}{\tilde{\Psi}_t \bar{p}_t^D} \left[\left(\frac{\tilde{C}_t^*}{\tilde{C}_{t+1}^*} \right)^{1-\rho-\sigma} \left(\frac{\theta}{1-\theta} \frac{\tilde{C}_{t+1}^*}{H_t^*} \right)^{1-\rho} \frac{1}{\bar{p}_{t+1}^D} + \tilde{\beta} (1 - \delta_H) \right] + m \Xi_t E_t \left(\frac{\bar{p}_{t+1}^D}{\bar{p}_t^D} \pi_{t+1} R_t^{-1} \right) \\ \frac{B_t}{P_t} &= m E_t \left(\bar{p}_{t+1}^D \pi_{t+1} \tilde{H}_t R_t^{-1} \right) \\ \tilde{C}_t^* + \bar{p}_t^D \left(\tilde{H}_t - (1 - \delta_H) \tilde{H}_{t-1} \right) + \frac{B_{t-1}}{P_t} &= \frac{W_t}{P_t} \tilde{N}_t + R_t^{-1} \frac{B_t}{P_t} - L_t\end{aligned}$$

and ρ is a function of the elasticity of substitution. When $\rho = 0$ we have the Cobb-Douglas aggregation, when $\rho = 1$ the consumption aggregator is linear in durable and non durable goods, so that there is complete substitutability among them. σ is the inverse of the intertemporal elasticity of substitution; when $\sigma = 1$ we are in the log-utility case.

The general specification, to be adapted to the notation of the two groups is

$$(C^*)^\rho C_t^* = \theta^{1-\rho} H^\rho h_t + (1 - \theta)^{1-\rho} (C)^\rho c_t$$

where

$$(C^*)^\rho = \theta^{1-\rho} H^\rho + (1 - \theta)^{1-\rho} C^\rho$$

or, in terms of output ratio

$$\left(\frac{C^*}{Y} \right)^\rho = \theta^{1-\rho} (\gamma_h)^\rho + (1 - \theta)^{1-\rho} (\gamma_c)^\rho$$

This equation holds for both groups.

2.C Expenditure Sharing

This section analyze how durables are shared among groups and the basic mechanism behind the financial multiplier implied by the collateral constraint.

We first present how the cost of holding durables change for the two groups of consumers after the government expenditure shock. In the case of Patient Agents, this can be shown by substituting (2.10) in (2.11) so that we get

$$\hat{c}_t - \hat{h}_t = \frac{1}{1 - \tilde{\beta}} \left[\bar{p}_t^D - \hat{\beta} E_t (\bar{p}_{t+1}^D - r r_t) \right]$$

where $rr_t = r_t - E_t\pi_{t+1}$ is the real interest rate. The right-hand-side of this equation is the Patients' *user cost* of holding durables in terms of nondurables: the price paid today to buy the durable good is subtracted $\beta (\bar{p}_{t+1}^D - rr_t)$ from \bar{p}_t^D , the present discounted value of the revenue one can get by selling the durable next period minus rr_t , the opportunity cost of holding durables. The coefficient $1/(1 - \hat{\beta})$ measures the elasticity of the marginal rate of substitution with respect to the relative price.

After the spending shock firms allowed to increase prices will do so: the real interest rate then increases because of the active monetary policy.

The rise in the opportunity cost due to the increase in rr_t increases the user cost, but this change is almost completely offset by the expected increase in the relative price, so that eventually the Patient user cost remains constant, as shown by the sixth panel of figure 12.

For the group of Impatient agents the correspondent equation is obtained combining (2.16) and (2.15)

$$\left(\tilde{c}_t - \tilde{h}_t\right) = \frac{1}{\left[1 - \tilde{\beta} - \hat{\beta}m\left(\hat{\beta} - \tilde{\beta}\right)\right]} \left\{ \bar{p}_t^D - \tilde{\beta} (\bar{p}_{t+1}^D - rr_t) - \left(\hat{\beta} - \tilde{\beta}\right) \left[\left(r_t + \tilde{\Xi}_t\right) + \hat{\beta}m\left(p_{t+1}^D - rr_t + \tilde{\Xi}_t\right) \right] \right\} \quad (2.33)$$

where the term before the curly brackets measures the elasticity of the marginal rate of substitution of Impatient agents with respect to current relative price.

The first two elements indicate the same components of the user cost described previously, while the third term measures utility gain of using durables as collateral. In turn this last term can be decomposed in two subcomponents, identified by the two terms in the square brackets. From equation (2.15) we see that

$$\left(\hat{\beta} - \tilde{\beta}\right) \left(\tilde{\Xi}_t + r_t\right) = \tilde{\beta} (r\tilde{r}_t - rr_t) \quad (2.34)$$

where

$$r\tilde{r}_t \equiv E_t\Delta\tilde{c}_{t+1}$$

is what we call the *implicit* real interest rate, that is the real interest rate that would prevail in an economy populated only by Impatient consumers in which individuals are not borrowing constrained.

This Lagrange multiplier $\tilde{\Xi}_t$ of eq. (2.34) measures the deviation between the desired path of consumption of Impatient agents (determined by $r\tilde{r}_t$) and the actual one. This deviation is due to the borrowing constraint together with the fact that the real interest rate is set by Patient agents: so if current income is lower than the future one $\tilde{\Xi}_t$ rises, since Impatient agents are more motivated to borrow than they are in steady state: the constraint is therefore more binding.

The second term in the square brackets in (2.33) shows how the Impatient agents' user cost is affected by the expected value of the collateral and by the marginal utility of debt. When $m > 0$, whether Impatient agents increase or reduce their holdings of durable goods depends on three factors:

- The difference in the way the two groups of consumer value future returns: given that $\tilde{\beta} < \hat{\beta}$ Impatient consumers prefer to buy fewer durables since they are more interested in consuming today rather than tomorrow; if, for instance, only this factor would be in place a change in $\{\bar{p}_s^D\}_{s=t}^\infty$ and $\{rr_s\}_{s=0}^\infty$ implied a transfer of durables from Impatient to Patient consumers.
- The difference between the two opportunity costs of holding durables, rr_t and $r\tilde{r}_t$: as an example, if Impatient nondurable consumption grows less rapidly than \hat{c}_t , then holding durables provide a bigger stream to Impatient agents than to Patient ones. In other words, if $r\tilde{r}_t$ is lower than rr_t the Impatient agents' opportunity cost of durable falls with respect to the one of Patient agents and \tilde{h}_t rises.
- The expected utility stream Impatient agents may obtain by increasing collateralized debt: when future income is expected to be higher than current one (high $\tilde{\Xi}_t$) or when the future value of the stock of durable is expected to go up the marginal utility of borrowing rises, lowering the user cost of durables and increasing its demand.

Figures 12 and 13 show how the determinant of the two groups' user cost changes after a government shock when $\theta = 0.1$ and $\theta = 0.01$.

In the first case the user cost of Patient agents is almost flat: this is because the expected increase in the relative prices is matched by the increase in the opportunity cost. The user cost of durables for Impatient agents follows a hump-shaped pattern, almost always above zero. Most of the movement in the Impatient agents user cost is due to the change in the constraint multiplier $\tilde{\Xi}_t$, in turn determined by the path of disposable income. The path of rr_t and $r\tilde{r}_t$ is almost equal so that the opportunity cost is the same for both groups.

Impatient consumers then expect income to fall so that the constraint is less binding (low $\tilde{\Xi}_t$) which makes durables less attractive for them so that the marginal utility of debt is now smaller than in steady state: this element then prevails increasing the Impatient agents user cost and depressing their demand for durables. In this case then the multiplier tends to reduce rather than increase consumption.

When θ is smaller the response of Impatient durable demand is different, as shown in figure 13. In this case the wealth effect due to the reduction in the value of the stock of

durables is contained because the steady state stock is smaller as shown in eqs. (28) and (29). The path of consumption then follows much more closely than before the path of disposable income so that $r\tilde{r}_t$ follows a cyclical pattern as well: its value however is much smaller than rr_t and the opportunity cost of holding durables is then smaller for Impatient than for Patient agents. This leads \tilde{h}_t to rise, at least initially. However, after 8 periods, this relation reverses, and durables return to Patient consumers. The multiplier then tends to increase consumption in the first periods: however the rise in Impatient nondurable consumption is not enough to increase the aggregate level.

CHAPTER 3

FINANCIAL FRICTIONS AND HOUSEHOLD DEBT: A NEW PERSPECTIVE ON TWIN DEFICITS

3.1 Introduction

What are the effects of fiscal policy shocks on the current account? On the one hand, central banks and public authorities, especially in Europe, seem to take almost for granted a positive correlation between public and current account deficit; on the other hand, there is very little consensus in the academic literature on the effects of these shocks, both from an empirical and theoretical point of view.

This paper aims at filling this gap at least partially, by providing an empirical analysis of the effects of tax and expenditure shocks on the current account and by reconsidering the international transmission of fiscal policy. The empirical analysis shows how important is to analyze tax and expenditure shocks separately, rather than looking at deficit or government shocks only, as it was the case of Kim and Roubini (2004) and Corsetti and Mueller (2006). The evidence shows that rise in expenditure and tax cuts are deficit financed, with opposite effects on the trade balance: while an increase in government spending improves the trade balance (twin *divergence*, since the trade and fiscal budget balances move in different directions), a reduction in taxes worsens it (twin *deficit*). Our exercise is similar to the one of Monacelli and Perotti (2006): our results are in line with theirs, even if we use a different set of endogenous variables. Comparing the two works, in our estimate the response to a government expenditure shock, is more markedly positive.

The empirical evidence cannot be easily reconciled with the prediction of the standard RBC model: in this paper, we show that an explicit consideration of the role of household debt and of financial frictions in the international transmission of fiscal shocks can rationalize the two different responses of the trade balance to tax and government expenditure shocks.

Drawing on Iacoviello (2005) and Campbell and Hercowitz (2005, 2006) we introduce heterogeneity among households. We model two groups of consumers, each identified by their rate of time preferences: the group of Patient agents have a high discount factor, while that of Impatient agents have a low discount factor. In equilibrium, the former group sets the steady state interest rate, and lend funds to the latter, whose unwillingness to save results from

optimizing behavior¹; Impatient agents, however, are constrained in their ability to borrow by a collateral constraint. Due to its tractability, this framework is particularly attractive as it allows us to focus sharply on the way financial frictions shape the macroeconomic transmission of fiscal shocks in an open economy, thus providing a substantial and new contribution to the literature on twin deficit.²

The 'twin deficit' result after a tax shock is novel and most interesting in the framework of a DSGE model, as standard Neoclassical or New Keynesian models are unable to generate it.³ The intuition behind it is straightforward: a tax cut induce a positive effects on the wealth of impatient agents, who then work less and consume more — thus reducing private saving and therefore contributing to a current account deficit. The external deficit increases on impact, then goes back to zero following a hump-shaped pattern.

The non-negative result after a government expenditure shock is mainly given by the reduced ability to borrow of Impatient agents which compounds with the increase in the present discounted value of taxes. The fall in private demand reduces the price of collateral reducing even further private consumption. In this way, the fall in domestic demand is bigger than the increase in government expenditure, triggering then a trade balance surplus.

This model also permits a focused analysis of the effects of financial markets' structural reforms: we show that the deregulation process that has taken place in the U.S. since the 1980s has raised the impact of tax shocks on the external position of a country. We identify the financial liberalization with an unbinding of the borrowing constraint as in Campbell and Hercowitz (2005) and Mendicino (2005). Our results suggest that the deregulation process initiated in 1982 by the Garn-St. Germain and Monetary Policy acts may have contributed to increase the response of current account deficit to shocks, in particular by affecting the transmission mechanism of tax cuts.

One features of our analysis is worth stressing: most of the recent literature⁴ has tack-

¹This specification is much more realistic and internally consistent than the one taking into account rule-of-thumb agents along standard optimizing consumers as in Gali, Lopez-Salido and Vallès (2006). In this specification agents are unable nor to save or borrow, and this as a consequence of a purely exogenous specification of their consumption behavior. While the division in two groups and the relative heterogeneity in terms of time discount factor is still somehow arbitrary, our model contemplate only optimizing agents and does not restrict their optimizing horizon.

²For a discussion of financial frictions in the market for household debt in closed economy see Callegari (2005).

³Generating twin deficit by debt financed tax cuts is not trivial since standard models tend to generate *twin divergence* rather than twin deficit: RBC models with distortionary taxes like Baxter (1995), Baxter and Crucini (1995) and Kollmann (1998) find that tax cuts generate current account surpluses: the increase in labour supply which follows the shock increases output, and this prevails on the rise in consumption and investment expenditure. Adding sticky prices does not affect the picture considerably: the income effect would be bigger because of the higher increase in real wages, but it would not be enough to compensate the increase in output.

⁴Kim and Roubini (2004), Cavallo (2005) and Corsetti and Mueller (2006).

led the twin deficits by looking at the effects either of government expenditure shocks or of generic deficit shocks (independently on its underlying causes). Conversely, this paper analyzes twin deficits resulting from either government spending increases or tax cuts. However, the main focus is on tax cuts, given their relevance in generating the fiscal deficits of the 80s and of the 2000s.

A number of papers have recently introduced some form of consumer heterogeneity in general equilibrium model, thus breaking the Ricardian Equivalence: following Gali, Lopez-Salido and Vallès (2005) Bussière, Fratzscher and Mueller (2005) introduce rule-of-thumb consumers, i.e. agents who blindly consume all their income, in an otherwise standard small open economy, coherently with the intertemporal approach to the current account. They conclude for a small role of the fiscal deficit in current account determination, but they do not take into account the possibility of borrowing in deriving their testable implications.

The role of household debt in the transmission mechanism of policy shocks is at the centre of a fast-growing literature started by Kiyotaki and Moore (1997) and continued on its business cycle implications by Iacoviello (2004, 2005) and Campbell and Hercowitz (2005, 2006); taking into account the mortgage markets and collateral constraints, they explained several features of the business cycle, such as the importance of housing in private consumption, home-bias in international borrowing and the fall in output variability occurred from the 80s onwards. Calza, Monacelli and Stracca (2006) analyze the role of different institutional characteristics of mortgage markets, showing that the degree of development of the mortgage markets is a key factor in the transmission mechanism of monetary policy shocks. Monacelli (2006) shows that the presence of collateral constraint can explain the comovement of durable and nondurable prices.

By simulating their model with rule-of-thumb behavior using actual data, Erceg, Guerrieri and Gust (2005)⁵ generate twin deficit results similar to our ones: to get to this result, however, they need to introduce rigidities both in the labour and in the good markets, while our model only relies on the presence of financial frictions in the market for household debt.

Kim and Roubini (2004) assess the empirical relevance of the twin deficit hypothesis, finding a negative correlation between fiscal and current account deficit (twin divergence). Corsetti and Mueller (2006) find that twin deficit effects of spending shocks in the US are small and crucially depends on the persistence of the shocks and on the extent of both home bias in consumption and investment adjustment costs. Cavallo (2005) studies the effects that disaggregated components of government expenditure have on the current account,

⁵Apart from nominal rigidities, which are included in the Erceg *et al.* model, the rule-of-thumb specification is nested in our model.

concluding that the impact of wage expenditure is considerably smaller than the one on final goods.

The remaining of the paper is structured as follows. Section 2 presents the empirical evidence and section 3 describes the theoretical model, while section 4 presents its parametrization. Section 5 analyzes the implication of the model for the Twin Deficit hypothesis. Section 6 presents the analysis of financial liberalization. Finally section 7 concludes.

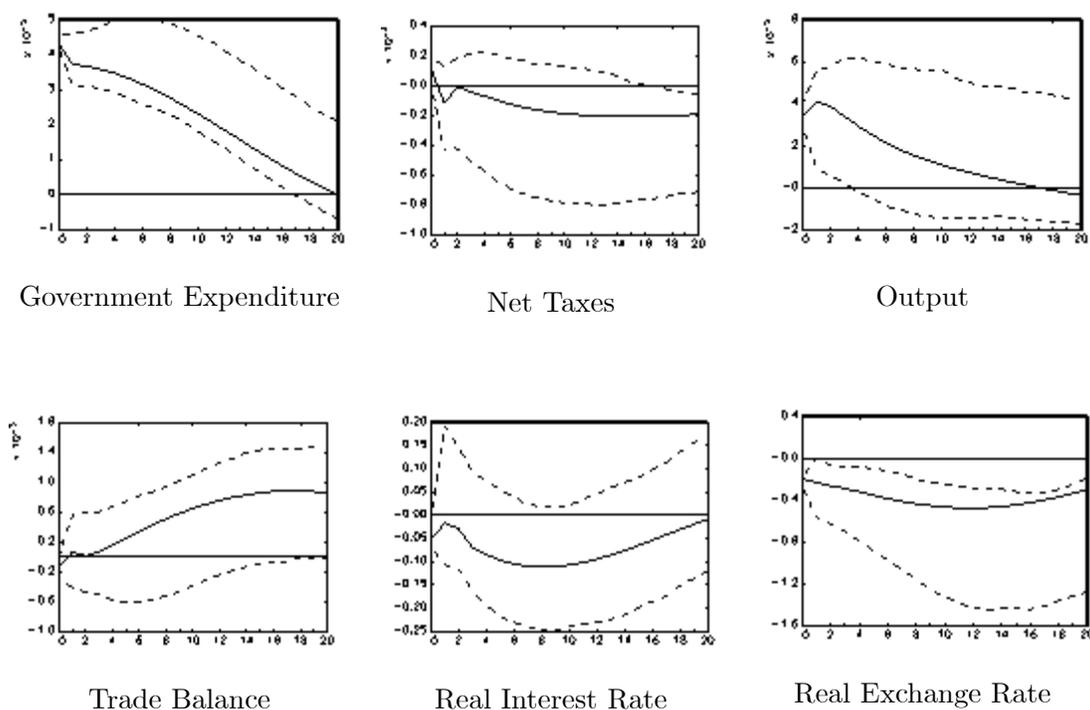


Figure 3.1: VAR Evidence to a Government Expenditure Shock

3.2 VAR Evidence

3.2.1 Baseline Specification

The empirical literature on fiscal policy has grown rapidly in the last years. Clarida and Prendergast (1999) use the VAR technique to estimate how the effects of a spending shocks vary with different level of pre-shocks public deficits. Kim and Roubini (2004), use a structural VAR framework to analyze fiscal deficit shocks, concluding in favor of twin *divergence* rather than twin deficit. Mueller (2006) use a structural VAR to study the

effects of government expenditure shocks on the trade balance, and develop a model able to explain some of the observed evidences; Corsetti and Mueller (2005) perform a similar analysis concluding that whether there is twin deficit or divergence depends on the degree of home bias, the extent of investment costs and the persistence of the government expenditure shock.

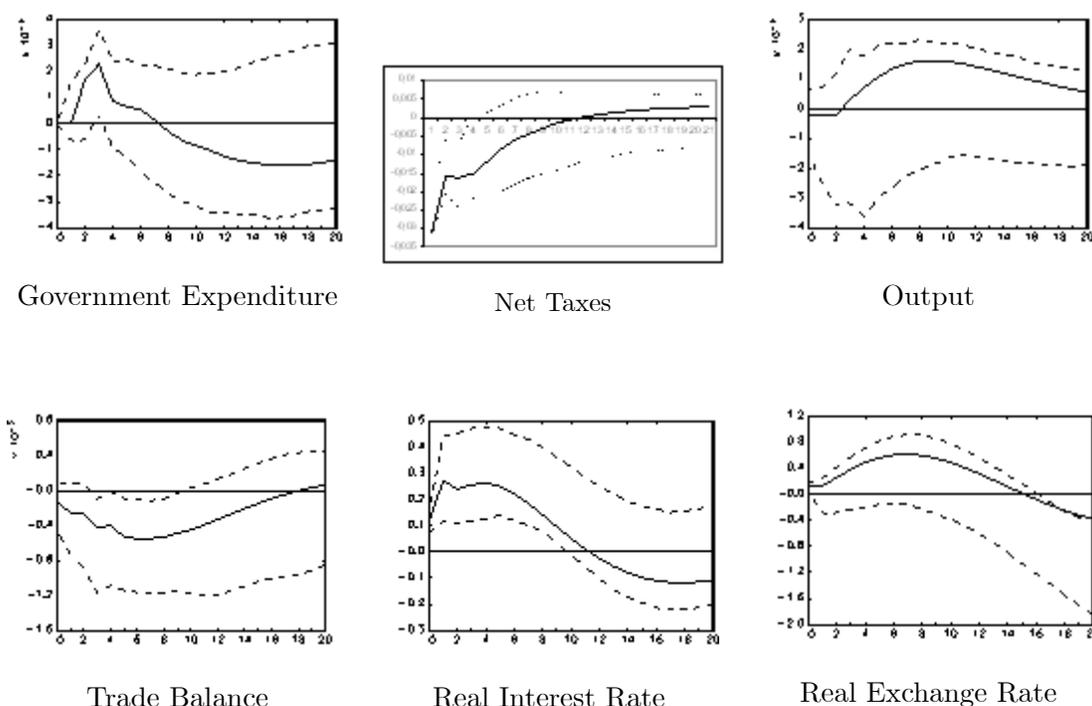


Figure 3.2: VAR Evidence to a Tax Cut

This analysis is performed by estimating a structural VAR on US data for the 1973-2004 period, focusing on the individual effects of expenditure and tax shocks rather than looking at generic deficit shocks (as, for instance, in Kim and Roubini, 2004) or a limitation on government expenditure shocks only (Mueller, 2006 and Corsetti and Mueller, 2006). Our analysis is comparable to Monacelli and Perotti (2006), who study the effects of government shocks and tax cuts on the US, Australia, Canada and UK: they use a different methodology to compute the real series (using the GDP deflator instead of the sectorial deflator), finding a different response of the trade balance to a government expenditure shock: however, we think that the use of a sectorial GDP is the correct choice if we want to compare our responses to those generated by a model in which there is no explicit consideration of a public sector

production sector and wages are paid only by the private sector. This claim follows from the fact that, by using a sectoral deflator we are able to identify structural changes in the amount of goods and services consumed by the government, while by using the GDP deflator you also take into account increases in wages which do not translate into a bigger use of labor services.

Together with real expenditure and net taxes we also include real output to control for the automatic effects of output on the fiscal variables. The measure used here to represent the external stance of the US is the trade balance, because of its higher reliability in comparison with other variables as, for instance, the current account⁶. In the estimation, we also need to include some variable that can account for the international price adjustment and for variations in the opportunity cost of savings, and so we include the real exchange rate and the real interest rate⁷.

The identification scheme is as in Blanchard and Perotti (2002), in which calculated elasticities are used to net out the automatic response of taxes to change in GDP. Net taxes respond with an elasticity of 1.85 (Giorno, 2002) to changes in GDP, while government expenditure is not affected within a quarter. For what concerns the other variables a recursive scheme is imposed, with GDP first, trade balance second followed by the real interest rate and the real exchange rate.

Figure 3.1 shows the effects of a government expenditure shock: the shock is persistent and generates a budget deficit, since the response of net taxes is basically zero. Output jumps up on impact and then goes back to zero more rapidly than the shock itself. The response of the real interest rate is negative in the point estimate, but not significant overall. This response indicates that the way financial markets response cannot be only related to the behavior of public debt, whose increase should lead to a surge in the real interest rate.

In line with the evidence of Monacelli and Perotti (2006) and Corsetti and Mueller (2006), the response of the real exchange rate is positive, thus pointing to a real *depreciation*: this is not easy to be reconciled with the increase in domestic demand coming from the government, which should lead to a real *appreciation* of the currency. This puzzling response can and must be the objective of future research, but is not taken into account here, where the focus is on the role of household debt and financial frictions in the framework of an RBC

⁶As noted in Gourinchas and Rey (2005) and Lane and Milesi-Ferretti (2001, 2006) the current account measure as it is published by the BEA does not take into account the valuation effects given by movements in asset prices and exchange rates, as long as quarterly data are concerned.

⁷Data on government expenditure, GDP and net taxes are taken from the NIPA database. Real government expenditure is the computed by deflating the nominal series with the sectoral database, while net taxes are total revenues minus subsidies and transfers. Real GDP is obtained using the GDP deflator. The real interest rate is obtained by subtracting the the quarterly GDP deflator inflation rate from three-month treasury bill rate. The real exchange rate is taken from the IFS database.

model. Monacelli and Perotti (2006) however, propose a new model with non-separable utility functions which can account, at least quantitatively, for this response.

Figure 3.2 shows the impulse responses to a tax cut: the response of government spending is zero on impact and remains above the zero line for almost ten periods, indicating that after the tax shock we have a period of budget deficits. The response of net taxes is not at all persistent, but this does not mean that the *shock* is not persistent: *ceteris paribus* government expenditure, an increase in taxes reduces the amount of outstanding debt reducing also interest payments and with them the amount of resources needed by the government. The positive response of output is persistent, while the trade balance response is negative, thus supporting the twin deficit hypothesis.

The response of the real interest rate is in line with an increased demand of resources in the market: however, as the response of the RIR to a government expenditure shock indicates, the increase in the public debt to finance the deficit cannot be considered the only reason behind the surge in the RIR. The response of the real exchange rate is positive, in line with the increased demand for home goods, as it is confirmed by the increase in output.

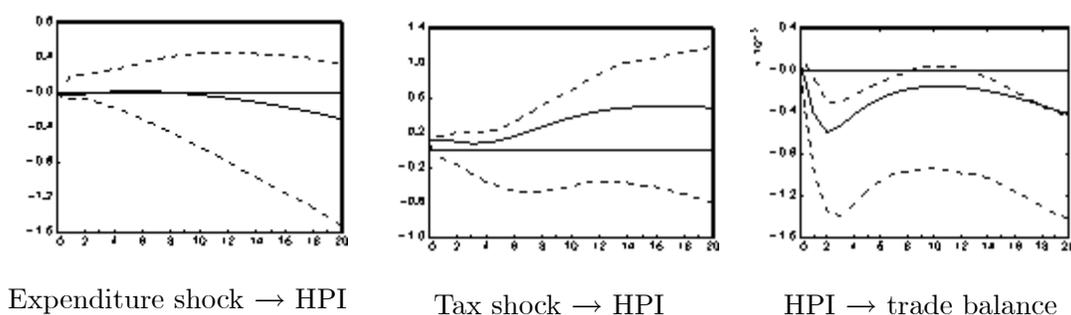


Figure 3.3: VAR Evidence on Twin Deficit and Housing Prices

To check for the response of collateral's prices, we have also estimated a 7 variables VAR which also included housing prices⁸. The first two panels of Figure 3.3 show how the fiscal shocks affect the relative price q_t , while the third describes how a shock to the relative price affect the trade balance. While the responses to the spending and tax shock are not significant, a positive shock to the housing price index generates a negative response of the trade balance: this evidence can be explained by the role of housing as a collateral.

⁸In the VAR, housing prices (see the appendix for details) was introduced fourth in the order, after the gross domestic product and before the trade balance, the real interest rate and the real exchange rate.

3.2.2 Robustness Checks

To check for the robustness of the main results on the trade balance we modify the baseline specification along two dimensions: first we allow for a quadratic trend in addition to a linear trend, to capture possible non-linearities in the responses, then we estimate a specification with "nominal" variables as in Mueller (2006), with inflation, nominal interest and nominal exchange rate along with real output, real government spending and real net taxes. Figure 3.4 shows the impulse responses with these two different specifications and compare them with the baseline model with a linear trend; the dotted line identify the 95% Efron percentile confidence interval obtained with this last model.

The qualitative patterns of the results are preserved in all versions; the only significant difference concerns the response of the trade balance to a tax cut after 10 period in the nominal specification which, however, do not affect the negative impact response.

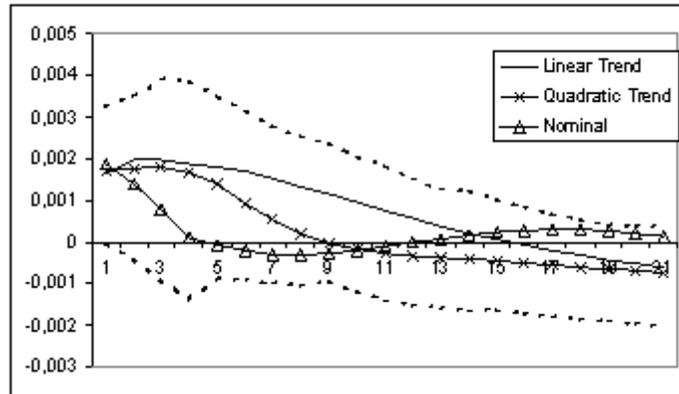
3.3 The Model

We study a Non-Ricardian open economy model with two symmetric countries, Home and Foreign, and durable and nondurable goods. Durables are nontradable and are in fixed supply; nondurable goods are produced using capital and labor and are traded across countries.

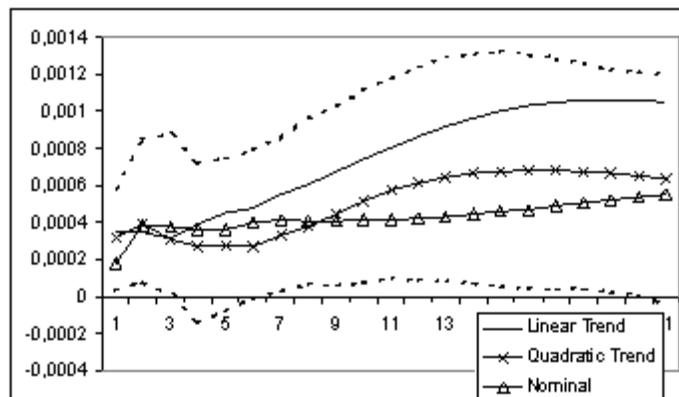
In each country there is a continuum of agents of mass one divided in two sub-groups. The first, of measure $(1 - \lambda)$, is composed of agents owning the capital stock and renting it to firms together with their labor, buy bonds from the government and from the other group of agents and trade assets internationally. These consumers are called Patient.

The second group, of measure λ , is composed of consumers who are relatively impatient: their discount factor is smaller than the one of Patient consumers, and so they give more weight to current rather than future utility; they are called Impatient. They supply labor to the firms and have access only to the internal asset market. They can move resources intertemporally by buying durable goods or by borrowing from Patient consumers through collateralized bonds. The amount of durables they hold serves two scopes: it yields utility services and can be used as collateral.

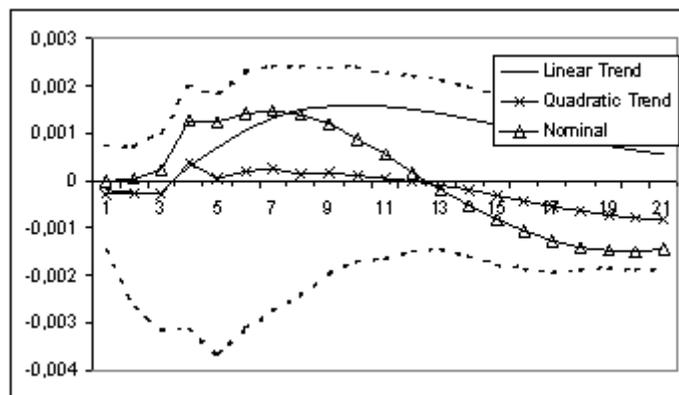
The rationale behind the introduction of the collateral constraint is based on two considerations: on the one hand the imperfect enforceability of contracts, whereby lenders cannot force borrowers to repay their debt. Concerning the first consideration, in case of default the lenders are able to recover only the amount of assets (real or financial) held by the borrowers, net of liquidation costs: for this reason they will not lend more than this amount



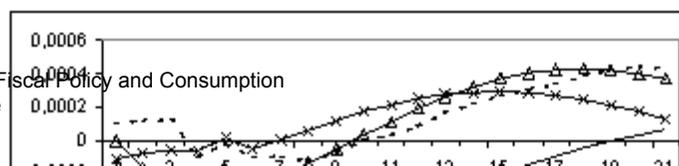
Government Shock - Output



Government Shock - Trade Balance



Tax Shock - Output



to the borrowers. In relation to the second consideration, since the interest rate in steady state is set by Patient agents, the preferred path of Impatient households consumption is downward sloping, so that they prefer to borrow in order to finance current consumption; without a borrowing constraint, the economy would converge to a limit in which Impatient agents' consumption would be zero because their amount of debt would be infinite. The difference in households' discount factors makes the borrowing constraint binding only on Impatient agents, while this is never the case for the patient ones⁹.

Agents maximize their utility in every period choosing the amount of nondurable and the flow of durable services they want to consume, their labor supply, the amount of bonds they want to lend/borrow and how much they want to invest in the production sector: investment is done using nondurable goods.

The production sector combines the amount of labor supplied with capital to produce the nondurable good, sold in a perfectly competitive market. The amount produced can then be consumed at home or abroad: trade entails no cost for the exporter.

The government imposes taxes and issues bonds to finance its spending on nondurable goods. Government expenditure and taxes are subject to exogenous shocks, while the deficit is determined by a fiscal rule. The subscript denotes the period in which a variable is set: K_{t-1} , for instance, represents the amount of capital set in period $t - 1$, even if it enters into the production function at time t .

3.3.1 Preferences

Preferences of Patient and Impatient agents are similar to those set out in the second chapter, with a hat denoting Patient agents and a tilde denoting Impatient agents.

$$\hat{V} = E_t \sum_{s=0}^{\infty} \hat{\beta}^s \left\{ \theta \ln \hat{H}_t + (1 - \theta) \ln \hat{C}_t + \hat{\chi} \frac{(1 - \hat{N}_t)^{1-\hat{\varphi}}}{1 - \hat{\varphi}} \right\} \quad (3.1)$$

$$\tilde{V} = E_t \sum_{s=0}^{\infty} \tilde{\beta}^s \left\{ \theta \ln \tilde{H}_t + (1 - \theta) \ln \tilde{C}_t + \tilde{\chi} \frac{(1 - \tilde{N}_t)^{1-\tilde{\varphi}}}{1 - \tilde{\varphi}} \right\} \quad (3.2)$$

where C_t and H_t are nondurable and durable consumption and N_t is the amount of labor supplied. θ is the parameter regulating the relative preference for durable goods and χ and φ determine, respectively, the importance and elasticity of the disutility of labour in the utility function.

⁹Note that the borrowing constraint is relative only to asset traded between households inside a country. There are no collateralized international assets.

As in the previous chapter, the time-discount factors are different across groups, with $\tilde{\beta} < \hat{\beta}$.

3.3.2 Production Sector

While durable goods are assumed to be in fixed supply, nondurable goods are produced by firms combining capital and labor and sold in a competitive market.

The production function is

$$Y_t = A_t K_{t-1}^\alpha N_t^{1-\alpha}$$

Consistently with the cost minimization process, the conditions regulating the demand for labor and capital are

$$\begin{aligned} W_t &= (1 - \alpha) \frac{Y_t}{N_t} \\ R_t^K &= \alpha \frac{Y_t}{K_{t-1}} \end{aligned}$$

3.3.3 Government Sector

The government imposes lump-sum taxes L_t , distortionary taxes τ_t and sell bonds B_t^G to finance government spending G_t . The flow budget constraint is

$$G_t + R_{t-1} (1 - \lambda) B_{t-1}^G = L_t + (1 - \lambda) B_t^G \quad (3.3)$$

The government spending process is exogenous to the system and given by an AR(1) data generation process

$$G_t = \rho_g G_{t-1} + (1 - \rho_g) G + \varepsilon_t^g$$

where ε_t^g is an i.i.d. white noise shock

The budget deficit can be defined as

$$d_t \equiv g_t - l_t$$

where $d_t = \frac{D_t}{Y}$, $g_t = \frac{G_t - G_{SS}}{Y}$, $l_t = \frac{L_t - L}{Y}$, $y_t = \frac{Y_t - Y}{Y}$ and τ is the steady state distortionary tax rate; letters without subscript denote steady state values variables.

The path of the government deficit depends on the outstanding amount of government bonds and on government expenditure: we assume the following deficit rule

$$d_t = (1 - \phi_g) g_t - \phi_b b_t + \varepsilon_t^T \quad (3.4)$$

where ε_t^T is an exogenous shock to taxes. This shock is assumed to be given by an autoregressive process

$$\varepsilon_t^T = \rho_\tau \varepsilon_{t-1}^T + u_t$$

This shock operates only on taxes, since it occurs only when government expenditure is maintained fixed. In the paper, we will analyze a specification with only lump-sum taxes and another with only distortionary taxes.

During the analysis we will consider both kinds of financing scheme, either based on distortionary taxation or on lump-sum taxes. In the case of permanent shock to distortionary taxes lump-sum transfers are assumed to adjust as to guarantee the intertemporal solvability of the government.

3.3.4 Household Problem

Patient agents' budget constraint is

$$\begin{aligned} \hat{C}_t + \hat{I}_t + p_t^D \Delta \hat{H}_t + B_t + B_t^H + B_t^G + \psi \frac{(B_t - B^{SS})^2}{2} = \\ W_t \hat{N}_t + R_t^K \hat{K}_{t-1} + R_t B_{t-1} + R_t^H B_t^H + R_t^H B_t^G - L_t \end{aligned}$$

where \hat{I}_t is investment and p_t^D is the durable/nondurable relative price. Labor income is the product between real wage, W_t and labor, \hat{N}_t , R_{t-1} is the interest rate set in period $t-1$ on bonds purchased in period $t-1$. R_t^K is the rental price paid by firms on the amount of capital K_{t-1} and L_t are the lump-sum taxes paid to the government.

These agents can invest their income on additional bonds holding, where B_t is the bond traded across countries, B_t^H is the amount of resources lent to the group of Impatient agents and B_t^G are the government bonds purchased. The last term on the left-hand side measures the adjustment costs of international bonds, given by the difference between the current and the steady state value, whose relevance is measured by ψ . Because of these costs, the domestic interest rate R_t^H is different from the international one, R_t . The reason why there are deviation costs only for international bonds may be justified on the ground that to change the stock of any kind of bonds households must get a whole set of informations, whose acquisition is costly. These costs might be generated by several factors as, for instance, the difference in the legal system of the two countries or by the need to rely on financial intermediaries to obtain these informations. However, since there are no explicitly modeled financial intermediaries, these costs are lost.

The introduction of deviation costs are neutral to the final result, and instrumental to achieve the stability of the final system after a temporary shock, see Schmitt-Grohe and

Uribe (2003). On the contrary, they are ineffective to ensure stationarity after permanent shocks.

The budget constraint of Impatient agents is

$$\tilde{C}_t + p_t^D \Delta \tilde{H}_t + R_{t-1}^H B_{t-1}^H = W_t \tilde{N}_t + B_t^H - L_t \quad (3.5)$$

Since the interest rate is set by Patient agents and $\tilde{\beta} < \hat{\beta}$, the preferred consumption path of Impatient agents will be downward sloping: these households will prefer to borrow to finance today's consumption, reducing that of the future. With time additive preferences even a small difference between $\tilde{\beta}$ and $\hat{\beta}$ causes the consumption of Impatient agents to converge to zero and their debt holding to infinite, as already pointed out in Lucas and Stokey (1984). Following the recent literature started by Iacoviello (2005a, 2005b) and Campbell and Hercowitz (2005) we impose that in case of default of the borrower the lender can liquidate the stock of durables held by the Impatient household and keep the revenues. This implies the following constraint on the amount of resources that can be borrowed by Impatient agents

$$B_t^H \leq m E_t \left\{ p_{t+1}^D \tilde{H}_t / R_t^H \right\} \quad (3.6)$$

This implies that the maximum amount that can be borrowed is equal to the expected value at time $t + 1$ of the stock of durables, discounted back at period t . This amount is further reduced by the assumed presence of liquidation costs, which make the multiplicative m term to be less than 1. Of course, when $m = 0$ Impatient households cannot borrow, and behave as rule-of-thumb agents. This borrowing constraint can be thought of as the device that lenders use to guarantee themselves against default in an environment characterized by imperfect enforceability. The imperfect enforceability problem becomes extreme in case of international debt, since for foreign lenders it may be particularly costly to get information on the amount of collateral held by the borrower and to seize the liquidated value in case of default. In this context, foreign Patient agents are not willing to engage in asset trading with domestic Impatient agents (and vice-versa)¹⁰.

As a consequence of the introduction of this constraint, durable goods play a double role in this economy, providing utility to consumers and serving as a pledgeable asset¹¹.

¹⁰Here we push to an extreme one of the Iacoviello and Minetti (2003) assumptions, which implies quadratic costs of liquidation in case of international Patient/Impatient asset trading and linear costs with internal asset trading. This implies that the expected loss in case of default when lending internationally increases with the value of the credit much quicker than when lending internally. In this model foreign patient lenders face transaction costs that are so high that they are only willing to trade internationally with other patient agents.

¹¹As shown by Carroll(1997), Impatient agents with borrowing constraints, when facing shocks to labor income tend to save a portion of their income when the shock is positive: this amount of precautionary wealth is then used as a buffer in case of bad events, to avoid the event of zero consumption.

Capital evolves as follows

$$K_t = (1 - \delta_K) K_{t-1} + \phi \left(\frac{I_t}{K_{t-1}} \right) K_{t-1}$$

and since only Patient agents hold capital, this relation holds both at the group and aggregate level.

The evolution of capital is subject to investment costs identified by the function $\phi \left(\frac{I}{K} \right)$; these convex costs are modelled so as to guarantee a constant level of capital in steady state such that

$$\begin{aligned} \phi(\delta_K) &= \delta_K \\ \phi'(\delta_K) &= 1 \\ \phi(\cdot) &> 0 \\ \phi'(\cdot) &> 0 \\ \phi''(\cdot) &\leq 0 \end{aligned}$$

These assumptions on the adjustment cost function ϕ imply that, for low levels of investment I_t , the costs are zero, with a non-differentiable point in correspondence of the investment/capital ratio value in which the costs hits the zero level. Given the assumption above, this point lies in the $[0, \delta_K]$ interval. However, this does not affect the basic mechanism of the paper, since the focus is on the steady state properties of the model and on small deviations from it. The permanent shocks under analysis are not so big to determine a fall in the investment/capital ratio adjustment function so to reach the non differentiable point.

As pointed out by Baxter(1995), with a single good produced in each of the two countries, capital owners have a strong incentive to shift the location of their capital in response to persistent movements in productivity. So the investment adjustment costs are introduced to eliminate excessive fluctuation in investment.

Combining the FOCs for bonds and nondurable consumption of Patient agents one obtains the two Euler condition for international and domestic bonds

$$1 = \hat{\beta} R_t E_t \left\{ \frac{\hat{C}_t}{\hat{C}_{t+1}} \right\} - \psi(B_t - B^{SS}) \quad (3.7)$$

A series of positive events may make the agents hold an amount of wealth such that the constraint (3.6) is not binding anymore. However, as shown in Iacoviello(2005) by simulation, if we assume small enough shocks to labor income, agents behave *as if* the constraint is always binding. This then permits to assume equality in (3.6) and to log-linearize the system.

$$1 = \hat{\beta} R_t^H E_t \left\{ \frac{\hat{C}_t}{\hat{C}_{t+1}} \right\} \quad (3.8)$$

The Euler equation of Impatient agents is

$$1 = \tilde{\beta} R_t^H E_t \left\{ \frac{\tilde{C}_t}{\tilde{C}_{t+1}} \right\} + \Xi_t \quad (3.9)$$

where Ξ_t is the Lagrange multiplier on the borrowing constraint and measures the value of relaxing the borrowing constraint (3.6), expressed in terms of nondurable good.

The durable/nondurable flow conditions of the two agents are given by

$$\frac{\theta}{1-\theta} \frac{\hat{C}_t}{\hat{H}_t} = p_t^D - \hat{\beta} E_t \left\{ \frac{\hat{C}_t}{\hat{C}_{t+1}} p_{t+1}^D \right\} \quad (3.10)$$

$$\frac{\theta}{1-\theta} \frac{\tilde{C}_t}{\tilde{H}_t} = p_t^D - E_t \left\{ \tilde{\beta} \frac{\tilde{C}_t}{\tilde{C}_{t+1}} p_{t+1}^D + \Xi_t m(q_{t+1} R_t^{-1}) \right\} \quad (3.11)$$

Equation (3.10) determines the marginal rate of substitution between durable and non-durable goods, given by durable good's real user cost p_t^D and by the discounted value of the expected returns from selling durables in the next period. Compared to (3.10), in equation (3.11) the user cost for Impatient agents is lowered by the additional flow of bonds obtained by increasing the stock of durables, whose weight is given by the borrowing constraint multiplier.

The investment dynamics are given by the interaction of the following two conditions

$$Q_t = \frac{1}{\phi' \left(\frac{I_t}{K_{t-1}} \right)} \quad (3.12)$$

$$Q_t = E_t \left\{ \hat{\beta} \frac{\hat{C}_t}{\hat{C}_{t+1}} \left[R_{t+1}^K + Q_{t+1} \left(1 - \delta_K + \phi_{t+1} - \phi'_{t+1} \frac{I_{t+1}}{K_t} \right) \right] \right\} \quad (3.13)$$

These conditions jointly determine investment and the value of Q_t , the present discounted value of the expected stream of utility that may come from an additional unit of capital. The first equalizes the benefit of increasing investment by one unit, which is expressed by the marginal increase in capital times its shadow real value Q_t , to its cost, all expressed in terms of the nondurable good. The second condition defines the real shadow value of capital Q_t , which is equal to the present discounted value of the expected flows of revenues generated by the increase of one unit of capital.

The first order intratemporal condition regulating the labour supply of Patient and Impatient agents are

$$\hat{\chi} \left(1 - \hat{N}_t\right)^{-\hat{\varphi}} = W_t \frac{1 - \theta}{\hat{C}_t} \quad (3.14)$$

$$\tilde{\chi} \left(1 - \tilde{N}_t\right)^{-\tilde{\varphi}} = W_t \frac{1 - \theta}{\tilde{C}_t} \quad (3.15)$$

Corresponding equations and conditions holds for the foreign country, where variables are indicated with a star and where the internal interest rate is R_t^F and the internal asset B_t^F .

3.3.5 Equilibrium Conditions

Equilibrium is achieved when the FOCs of the two groups are met and markets clear.

The nondurable and durable goods market clearing conditions are

$$\begin{aligned} G_t + G_t^* + C_t + C_t^* + I_t + I_t^* &= Y_t + Y_t^* \\ \lambda \tilde{H}_t + (1 - \lambda) \hat{H}_t &= H \\ \lambda \tilde{H}_t^* + (1 - \lambda) \hat{H}_t^* &= H^* \end{aligned}$$

Note that assuming a logarithmic utility specification together with a Cobb-Douglas aggregation between durables and nondurables guarantees that the quantity of durable goods circulating in the system does not affect the dynamics of the system. This is because the intertemporal elasticity of substitution is equal to the intratemporal elasticity between durable and nondurable so that any steady-state change in demand due to a variation in the aggregate stock of durables is matched by a corresponding change in the relative price, keeping $p^D H$ constant.

Equilibrium in the factor market is achieved when

$$\begin{aligned} N_t &= \lambda \tilde{N}_t + (1 - \lambda) \hat{N}_t \\ K_t &= (1 - \lambda) \hat{K}_t \end{aligned}$$

The government sector is in equilibrium when the flow budget constraint (3.3) holds with equality and the interest rate adjusts so that the demand for bonds is equal to its offer. The evolution of the external sector is analyzed by looking at the trade balance¹² from the point

¹²As pointed out in Kollmann(1998), measuring the trade balance is relatively easy and less arbitrary than the current account: the value of the latter depends heavily on the criteria followed to evaluate each different kind of asset. For this reason, we use the trade balance as an index of the external stance of a country.

of view of the home country, which is defined as

$$TB_t = Y_t - C_t - G_t - I_t$$

The system is log-linearized and then solved using Uhlig (1999)'s toolkit.

3.3.6 Inspecting the Mechanism

The introduction of household debt and financial frictions changes the internal propagation mechanism of the model with respect to the standard RBC model. To see how, we focus on the determinants of Impatient agents' consumption behavior by analyzing the equation for nondurable consumption, obtained by combining the log-linearized form of equations (3.5), (3.6), (3.11) and (3.9)¹³

$$\tilde{c}_t = \kappa_1 \left\{ \frac{p^D \tilde{H}}{Y} \left[\tilde{p}_t^D + \kappa_2 oc_t + \kappa_3 \tilde{\Xi}_t \right] + dw_t \right\} \quad (3.16)$$

where

$$oc_t \equiv r_t - E_t \Delta q_{t+1}$$

is the opportunity cost of holding durables and

$$dw_t = (1 - \alpha)(w_t + \tilde{n}_t) - \tilde{l}_t - \frac{1}{\beta} b_{t-1}^H + \frac{p^D \tilde{H}}{Y} \tilde{h}_{t-1} \quad (3.17)$$

is the amount of cash-on-hand available to Impatient agents¹⁴. The coefficient κ_1 , the elasticity of nondurable consumption with respect to cash-on-hand, is less than one since a share of cash-on-hand is used to buy new durable goods, limiting the fluctuations of nondurable consumption and labor supply.

¹³The log-linear equations are described in Appendix B.

¹⁴The values of the coefficients are

$$\begin{aligned} \kappa_1 &= \frac{1}{\frac{\tilde{C}}{Y} + \frac{p^D \tilde{H}}{Y} (1 - \hat{\beta}m)} \\ \kappa_2 &= \frac{(1 - \hat{\beta}m) (\hat{\beta} - \tilde{\beta}) (1 - m)}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} \\ \kappa_3 &= \frac{\tilde{\beta} (1 - m)}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} \end{aligned}$$

Details of the derivations are available under request.

The terms in the square brackets describe how Impatient agents value nondurable goods relative to durable goods. The Lagrange multiplier measures how binding the borrowing constraint is: a fall in current income relative to the future one makes Impatient agents more willing to borrow from future income to finance current consumption and the borrowing constraint becomes more binding. A similar effect is generated by a current or future increase of the marginal rate of substitution between durable and nondurable goods.

The opportunity cost oc_t measures the cost of holding durable goods expressed in terms of bonds' return r_t . The variations in $\tilde{\Xi}_t$ and of dw_t prevail over the variations in the opportunity costs so that Impatient agents consumption and labor supply vary sensibly with current and future income changes¹⁵.

Appendix D shows the behavior of the model after temporary and permanent productivity shocks and the results of its simulation.

3.4 Parametrization

The discount factor of patient agent is set to 0.99, so to compare the results with quarterly data; the discount factor of impatient consumers is set to 0.98. This value is well in line with microeconomic evidences as in Lawrence (1991), Carroll and Samwick (1997) and Cagetti (1999).

The importance of durables in the utility function is measured by θ which is set to 0.1 so that the ratio of private debt to output is equal to 0.6, the average value for the period 1970-2000. λ , the share of impatient agents is set to 0.5, consistently with the estimate of Campbell and Mankiw (1989) and with the values considered by Gali, Lopez-Salido and Vallès (2005) for the rule-of-thumb behavior¹⁶.

$\tilde{\varphi}$ and $\hat{\varphi}$ are assumed to be equal, and $\tilde{\chi}$ and $\hat{\chi}$ are calibrated such that the labour supply is equal across groups and set to 1/3. The wage elasticity of labour supply (inverse Frisch elasticity) σ is equal for both kinds of agents¹⁷ and is set to 0.3: this value is consistent with the values obtained through calibration in macro studies (Rotemberg and Woodford (1997,1999)) when $\alpha = 1/3$.

Setting $\alpha = 1/3$ is roughly consistent with the observed income shares. The depreciation

¹⁵In a previous extended version of this paper we studied the business cycle properties of the model analyzing the economy's response to productivity shocks, and simulating to model.

The economy responses are well in line with the empirical evidence on productivity shocks related to the RBC literature. The second moments of the model, while well in line with the previous literature, cannot solve the quantity puzzle as emphasized by Backus, Kehoe and Kydland (1994).

¹⁶Note that the Rule-of-Thumb specification is nested in this model and can be recovered by setting θ and $m = 0$.

¹⁷For the exact definition of this value look to appendix A.

rate of capital δ_K is set to 0.025. Following King and Watson (1996) we calibrate η , the elasticity of investment with respect to Q , to 1. The coefficient of the international bonds adjustment costs ψ is set to 0.01.

We analyze the effects of tax and government expenditure shock to the home country, where ρ_g and ρ_τ are both equal to 0.9. Both values are in line with the estimates of Blanchard and Perotti (2002) for the tax cuts and with Galí, López-Salido and Valles (2006) for the government expenditure process. The test used to generate these estimates are not very powerful when confronted with the null hypothesis of a unit-root: Kollmann (1998), for instance, conclude that total factor productivity, government expenditure and public revenues are non-stationary processes. For these reasons, an analysis of permanent shocks to government expenditure will also be included.

The policy parameters of the fiscal rules in the baseline model are equal across groups and countries, with $\phi_b = 0.3$ and $\phi_g = 0.12$, in accordance with the calibrated values of Galí, López-Salido and Valles (2006) and the observed hump-shaped response of government debt to a spending shock. The steady state value ratio of government expenditure to GDP is 0.2, corresponding to the average level of expenditure in the last 30 years.

Another variable of interest is the share m of durable that can be used as a collateral, set to 0.89, in line with the values estimated by Campbell and Hercowitz (2004) and Iacoviello (2005) for the post-1982 period.

Finally, we assume that in steady state the outstanding amounts of international bond B_t and government bonds B_t^g and B_t^{g*} are zero.

3.5 Fiscal Policy and the Trade Balance

3.5.1 Tax Cuts

Tax cuts are often used as a fiscal policy instrument for their direct and quick effects on households' income. Indeed, the Reagan administration in the 80s and the Bush government in the last years have focused their fiscal policy on tax reduction as a stimulus for the economy. A detailed assessment of twin deficits in the US cannot abstract from a deep and complete analysis of the transmission mechanism of tax cuts in a general equilibrium setting.

This model can generate a negative trade balance result after a tax cut: this result is particularly remarkable because it displays a positive correlation between fiscal and trade balance deficit (twin deficit) after a tax cut, a feature that standard optimizing model are not able to replicate. It is also important because it shows that tax cuts might be at the heart of the twin deficits episodes of the 1980s and 2000s, once the dynamics of private debt are

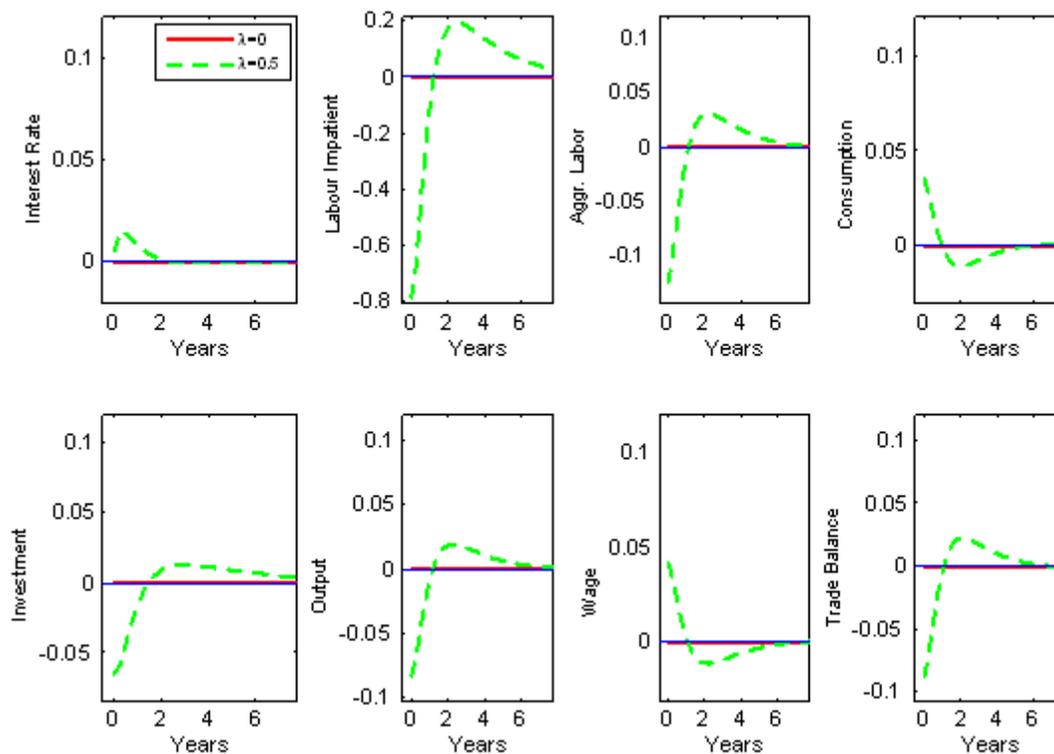


Figure 3.5: Temporary shock to lump-sum taxes.

explicitly taken into account. Such a result seems then to reconcile economic analysis with the view that fiscal deficit are a major determinants of external deficits. This result however, is not in contradiction with Ferguson (2005) which conclude that the increase in private savings offset the fall in public savings, thus reducing the impact of fiscal deficit increases on the external stance of a country. This paper shows the validity of this mechanism for the non-constrained agents, displaying that, at the same time, the presence of constrained agents generates a new channel of transmission which sets again fiscal deficits at the centre of the stage for trade balance determination.

After a temporary shock to lump-sum taxes, all the dynamics are driven by the responses of Impatient agents, since in the $\lambda = 0$ case Ricardian Equivalence would hold.

After the shock (figure 3.5), Impatient agents benefit of a rise in available cash-on-hand dw_t , which is used to increase borrowing and buy more durable goods. On impact then, and for few periods thereafter, the marginal utility of income falls so that they work less and consume more. These variations, however, are quite short-lived because the amount of debt that has to be repaid each period reduces quickly the amount of cash-on-hand available.

The higher level of consumption, together with the fall in labour supply both contribute to widen the gap between internal demand and supply, so that the home country registers a deficit in the trade balance. The negative response of the trade balance is due to the presence of the borrowing constraint: allowing impatient agents to borrow introduces an amplification mechanism that makes the quantitative response in line with the empirical evidences shown in section 3.2.

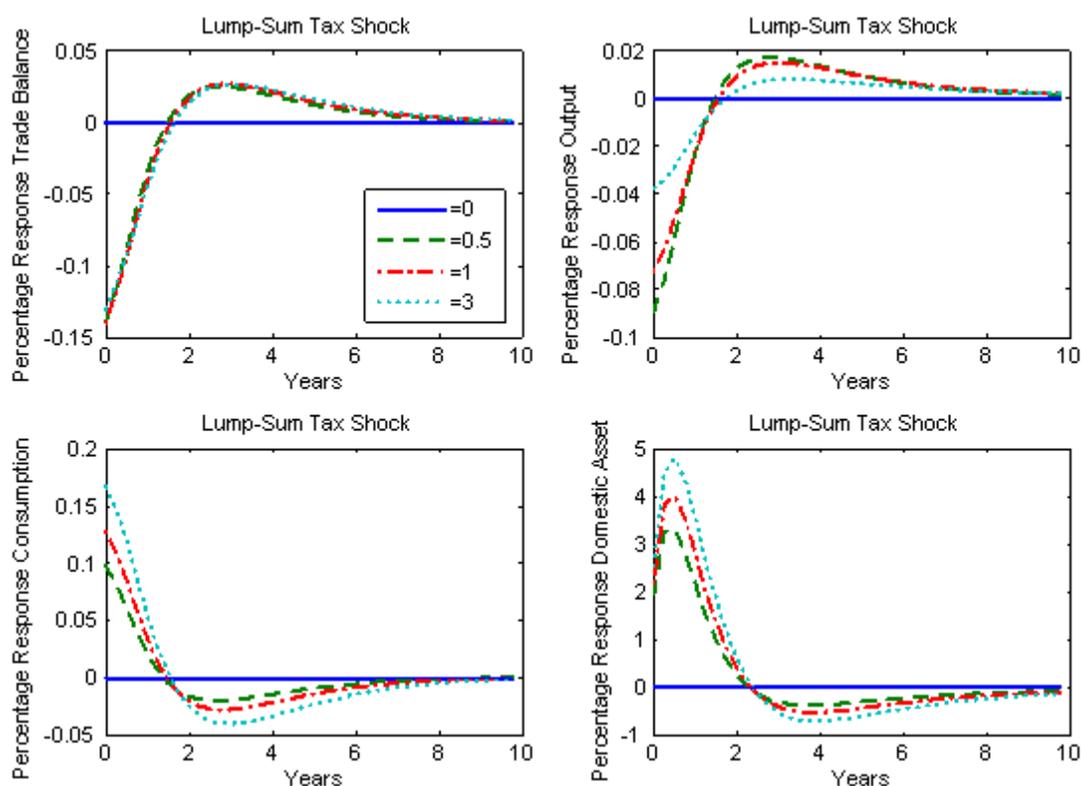


Figure 3.6: Impulse responses of selected variables to a tax cut shock when the elasticity of labour supply φ is varied between 0 and 3.

Is this result robust to changes in the parameters' values? Given the centrality of labor dynamics, it is interesting to check how the trade balance response changes when varying the inverse elasticity of labour supply φ . The first panel of figure 3.6 shows that the trade balance response is virtually unchanged as φ varies from 0 (labour enters linearly in the utility function) to 3 passing through 0.5 (the value assumed here) and 1 (logarithmic disutility of labour). As φ grows, the higher output response given by the increased labour supply is matched by an increase in consumption, which then maintains the trade balance constant.

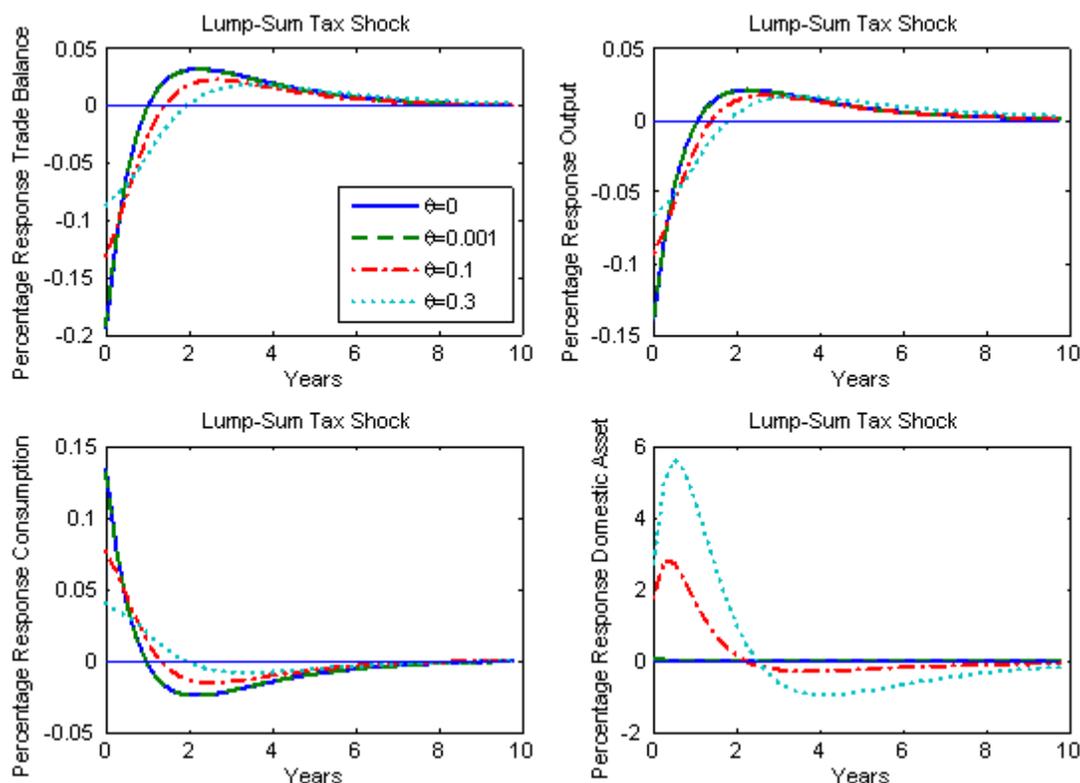


Figure 3.7: Impulse responses of selected variables to a tax cut shock when θ is risen from 0 to .3.

The reason of this compensation lies again in the multiplier mechanism: with a bigger labour supply the amount of labor income rises, so that agents can increase the stock of durable goods and thus borrow more. The bigger amount of resources available leads agents to consume more. This two-step mechanism is confirmed by the increase in domestic asset trading, as shown by the fourth panel in figure 3.6.

The trade balance response changes its magnitude, but not its sign, when the relative preference for H_t as a durable good, θ is risen from 0 (Impatient agents become rule-of-thumb consumers) to 0.3. The trade balance deficit shrinks because as θ rises the share of expenditure devoted to consumption is smaller; the higher amount of collateral available mitigates the shift of resources towards durable goods, so that these changes does not manage to generate an external surplus.

As figure 3.5 shows, however, the negative response of output to a tax cut is not in line with the VAR evidence underlined in section 1: as suggested by Perotti (2004), the response of output to a tax cut might actually change if the sample is reduced by shifting

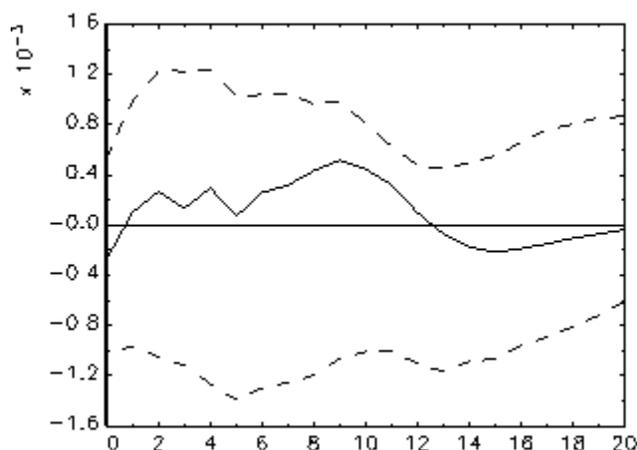


Figure 3.8: Response of real GDP to a tax cut - 1982-2004 sample

the starting date to the first quarter of 1982. As figure 3.8 shows, the response of output is still non significant and much closer to the zero line than in the whole 1973-2005 sample. Also the response of the real interest rate is in line with the VAR evidence, showing a small but positive change, mainly due to the increase in the demand for domestic bonds from Impatient agents.

Summarizing, the trade balance deficit response to a temporary lump-sum tax shock is a robust result which casts a new light on the way fiscal policy affects the external stance of a country. In section 6 we will analyze how an unbinding of the collateral constraint (a fall in m) affects the trade balance response.

3.5.2 Government Spending Shock

The responses to a government expenditure shock generate twin deficit in the case of temporary shocks and twin divergence after a permanent shock. The presence of Impatient agents, however, rises the trade balance response after a temporary shock to values very close to zero. The driving force here is the negative wealth effect generated by the increase in the present discounted value of taxes, necessary to finance the shock.

After a permanent shock, the increase in private savings generated by the wealth effect is enough to offset the increase in public demand, at least on impact (see fig. 3.9): the trade balance rises but falls quickly to negative values. The main mechanism behind the positive impact response of the trade balance is that the wealth effect hits Impatient agents harder,

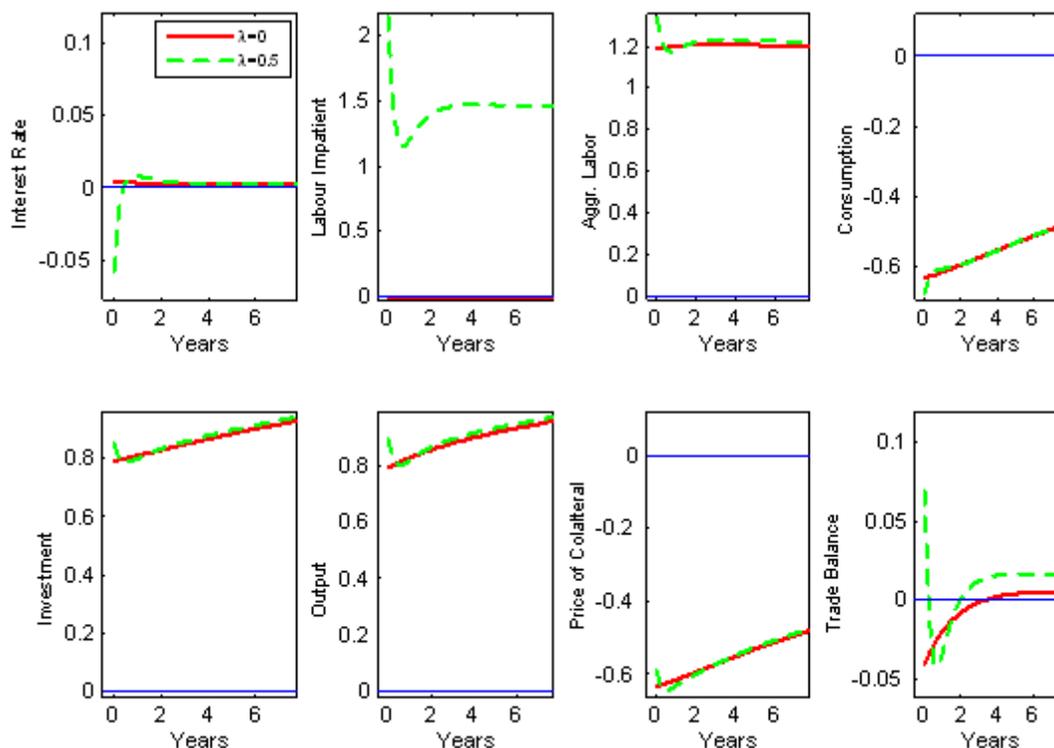


Figure 3.9: Permanent shock to government expenditure.

since it generates a downward shift in the durable/nondurable relative price, which reduces the value of the collateral and tightens their borrowing constraint.

Since the collateral constraint becomes more binding, private consumption of Impatient agents falls, thus contributing to a reduction in domestic demand. The smaller amount of resources borrowed increases the marginal utility of income, and labour supply rises: the increase in domestic production is crucial to offset the increase in public demand. This indirect negative effect due to the fall in the relative price of durables is described in more detail in Callegari (2006) analyzing fiscal policy in closed economy in presence of financial frictions.

However, the positive response of the trade balance to a government shock is not robust to changes in the persistency of the process: reducing ρ_g to 0.9 (figure 3.10) makes the response negative and the impact response is smaller in absolute value than that of the standard RBC model (from 0.2 to 0.15). The reduction in the price of collateral is now smaller than after a permanent shock, thus reducing the impact of the *indirect* wealth effect described above, due to the tightening of the collateral constraint.

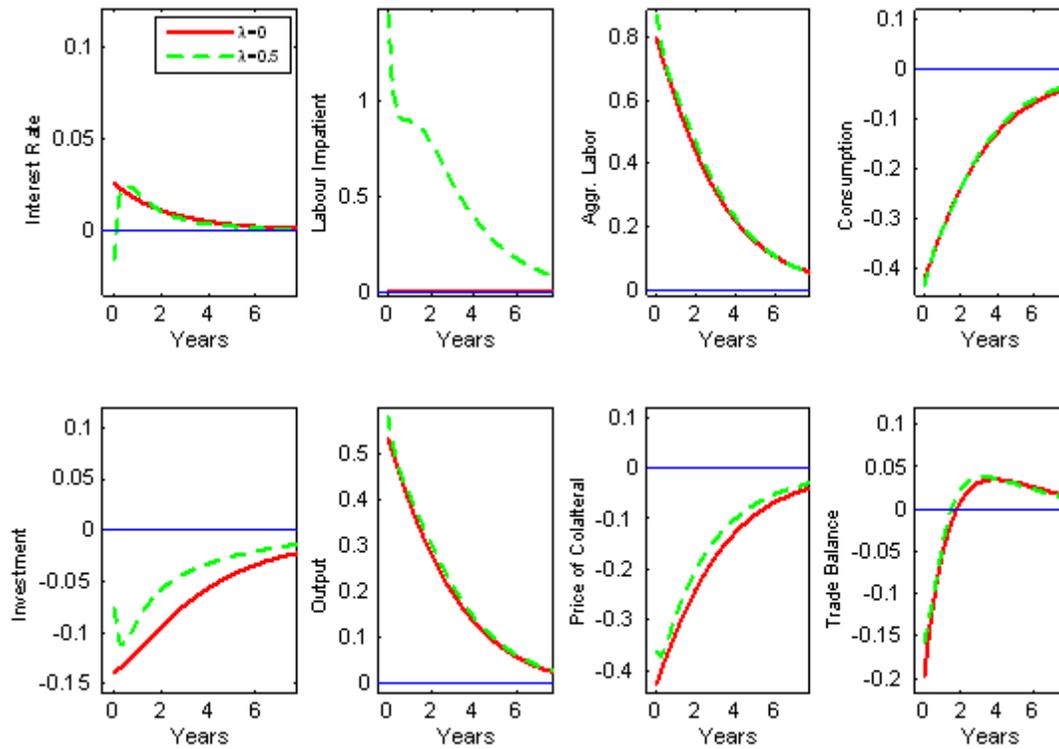


Figure 3.10: Temporary shock to government expenditure

The response of the interest rate is qualitatively in line with the VAR evidence, which points to a negative but not significant change: the response generated by the model is negative after a permanent shock and slightly positive after a temporary shock. This correspondence, robust to all the different specifications of government expenditure and tax shocks, underlines an important result of this paper: the role played by private debt and by the endogenous movements in collateral's price are crucial to understand the effects of deficit shocks in the financial markets, and show how the interaction between government and households' debt demand may explain bonds' prices movements better than the interaction between government and firms' demand for funds, as it is the case, for instance, in Kraay and Ventura (2005); this justifies an analysis of twin deficit centered on private debt (and of the frictions in its market) for the explanation of the transmission mechanism of fiscal policy shocks in open economy.

In synthesis, introducing financial frictions makes the behavior of the economy much more in line with the VAR evidence described in section 2: the response of the trade balance is always bigger than in the standard RBC model, and becomes positive when the G_t process follows a random walk.

The qualitative features of the impulse responses cannot be generated by a standard RBC model: by looking at the previous figures, the trade balance response is always negative after an expenditure shock and, because of Ricardian equivalence, null after a tax cut¹⁸.

3.6 The Effects of Financial Liberalization

The m term in the borrowing constraint can be interpreted as the down-payment occurring in a leveraged purchase of durable goods. Following Campbell and Hercowitz (2005) and Mendicino (2005), this coefficient can also be interpreted as a proxy for the degree of financial liberalization of the system viewed as an exogenous reduction in the equity requirement on households. Alternatively, the liberalization may be interpreted also as an increased reliance on market mechanism to evaluate households' ability to repay back the loans, leading eventually to smaller liquidation costs.

Consistently with this view, the effect of financial liberalization reforms undertaken by the U.S. after 1982¹⁹ may be evaluated by analyzing the economy's responses when m is varied. In line with Iacoviello (2005) we can think of $m = 0.5$ as the parameter relative to the pre-liberalization economy, and to $m = 0.89$ as that relative to the post-liberalization

¹⁸Adding distortionary taxes to the model, a temporary tax cut leads to positive response of the trade balance, in stark contrast with the VAR evidence.

¹⁹See Campbell and Hercowitz (2005) for comprehensive summary of the evolution of U.S. credit markets since the beginning of the 20th century.

economy.

Figure 3.11 shows the responses generated by a lump-sum tax cut shock when m varies from 0 to 0.89. The first panel of the figures shows that increasing m from 0 to 0.5 lowers the trade balance impact response of about 50%, from -0.04 to -0.06 . However, increasing m from 0.5 to 0.9, (a variation in line with the effect of the liberalization process) reduces the trade balance response by a much bigger factor, taking the trade balance impact response to -0.14 . This means that in a pre-liberalization economy economy ($m = 0.5$) 6% of the tax cut is transmitted to the trade balance deficit on impact, which represents less than half of what we observe after the same tax cut when $m = 0.89$.

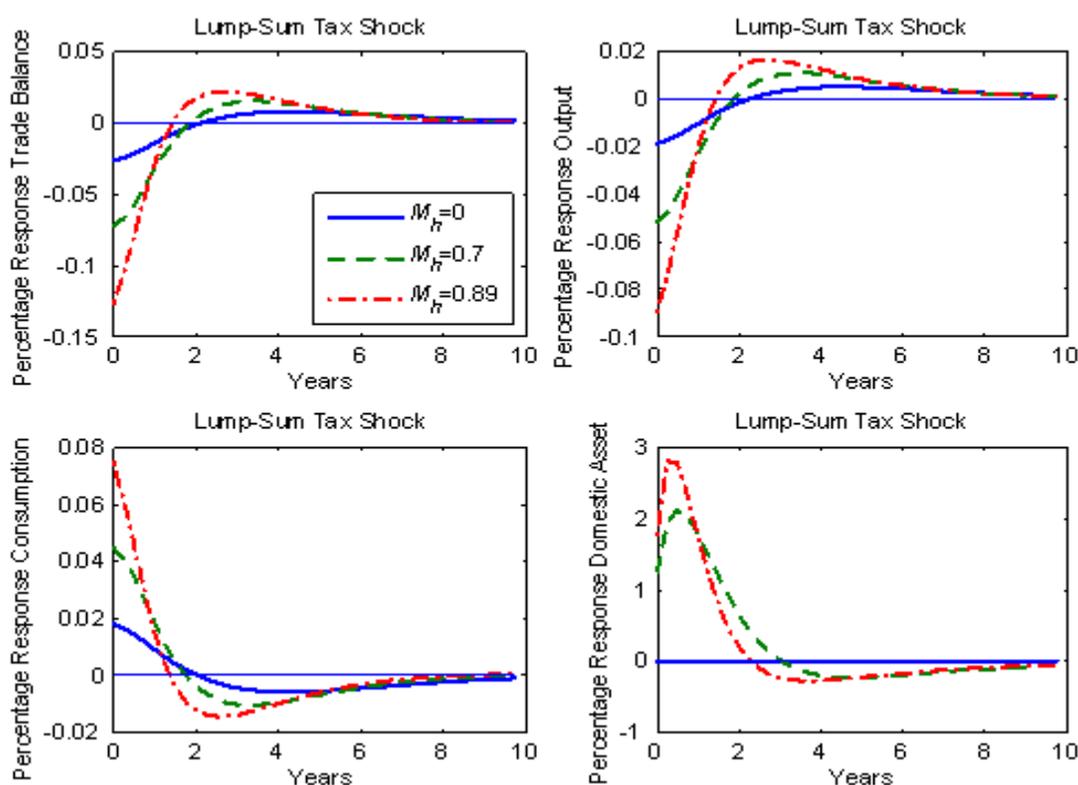


Figure 3.11: Responses to a lump-sum tax cut with different values of m_H in the collateral constraint

The behavior of Impatient agents in the labour market is once again the major factor behind this result: increasing m works as an amplifier of the positive income effect enjoyed by Impatients, which eventually lead them to work less and consume more. The amplification

effect can be seen in the last panel of figure 3.11: the response of domestic assets when $m = 0.9$ is almost three times higher than with $m = 0.5$. This leads to lower level of output which, together with the increase in aggregate consumption, leads to an increase in the trade deficit response. As shown in figure 3.6, this result is independent to the elasticity of labor supply, since the consumption change compensates for the change in output.

The effect of financial reforms have important policy implications. The analysis shows that the effects on the current account of a tax cut have bigger effects now than it was 20 years ago: the improved ability of Impatient agents to borrow (which leads to a higher steady state level of debt) entails bigger negative effects of tax cuts (which, in non-stationary economies, may lead to growth in the international net debt position). This argument provide a rational for the parallel growth of private and international debt observed from the beginning of the 80s. In case a government is interested not to increase the external trade deficit of a country, this analysis calls for a more cautious use of tax cuts in a context, like the one currently experienced by the U.S., characterized by a high level of private debt.

3.7 Conclusions

This paper shows how the introduction of Impatient agents and household debt modifies the response of a standard one-good, open economy model to tax cuts and other business cycle shocks.

We find that tax-cut shocks tend to generate a positive income effect on Impatients, and as a consequence the trade balance response is unambiguously negative and well in line with both the common sense and the observed evidence. The model adds realism without foregoing simplicity and effectiveness in explaining the transmission mechanism.

The role of household debt and financial frictions in the case of government expenditure shock is also important, since the negative wealth effect lowers the price of collateral triggering an additional reduction of wealth to both Patient and Impatient agents: this last effect is what we define as the *indirect wealth effect*. For Impatient agents, the fall in the collateral's price tightens the borrowing constraint, reducing the stock of debt: the consequent fall in cash-on-hand results in an increase of labour supply which rises the trade balance response, overturning the sign of the impact response after a permanent shock to G_t . Allowing for Impatient agents in the economy tends to generate a higher trade balance response, in line with the non-negative response generated by our VAR estimates and in the literature.

In synthesis, the responses generated by the model with household debt are in line with the structural VAR estimate on US data, which clearly supports the presence of twin deficit after a tax cut and indicates a non-negative response of the trade balance after a government

expenditure increase. This model constitutes a significant step forwards in matching these responses, compared with the standard RBC model.

A possible and desirable extension is a more detailed estimation of the model's parameters so to assess the actual importance of financial frictions in the economy, as Coenen and Straub (2004) do with the model with rule-of-thumb agents. Another interesting frontier of research may be the analysis of optimal fiscal policy in this framework, with an explicit consideration of its effects on the current account.

Furthermore, this model seems to have promising implications concerning the movements in prices: introducing home and foreign tradable goods and looking at the variations in real exchange rate and terms of trade might thus represent a further step in understanding the role of private debt in the transmission mechanism of fiscal shocks.

BIBLIOGRAPHY

- [1] Backus, D, Kehoe, P. and F. Kydland (1995) "International Business Cycles: Theory and Evidence" in Cooley, T. (Ed.) *Frontiers of Business Cycle Research*, 331-356

- [2] Baxter, M. (1995), "International Trade and Business Cycles", NBER Working Paper n.5025

- [3] Baxter, M. and M. Crucini (1995), "Business Cycles and the Asset Structure of Foreign Trade" *International Economic Review*, 36, 821-854

- [4] Blanchard, O. and R. Perotti (2002) "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*, Vol.117, 1329-1368

- [5] Bussière, M., M. Fratzscher and G. Mueller (2005) "Productivity Shocks, Budget Deficits and the Current Account", *ECB Working Paper*, n. 509

- [6] Cagetti, M. (1999) "Wealth Accumulation Over the Life-Cycle and Precautionary Savings", *mimeo*, University of Chicago

- [7] Callegari, G. (2005) "Government Expenditure, Durable Goods and Rule-of-Thumb behavior", *mimeo*, European University Institute

- [8] Calza, A., T. Monacelli and L. Stracca (2006) "Mortgage Markets, Collateral Constraints and Monetary Policy: Do Institutional Factors Matter?", *mimeo*, European Central Bank

- [9] Carroll, C. D., (1997) "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis", *Quarterly Journal of Economics*, Vol.62, 1-55.
- [10] Carroll, C. D. and A. Samwick (1997), "The Nature of Precautionary Wealth," *Journal of Monetary Economics*, Vol. 40, 41-71.
- [11] Campbell, J. R. and Z. Hercowitz (2005) "The Role of Collateralized Household Debt in Macroeconomic Stabilization", *NBER Working Paper* n. 11330
- [12] Campbell, J. R. and Z. Hercowitz (2006), "The Transition to a High Debt Economy", *mimeo*, University of Chicago
- [13] Campbell, J.Y. and G. Mankiw (1989), "Consumption, Income and Interest Rates: Reinterpreting the Time Series Evidences", in O.J. Blanchard and S. Fischer (eds.) *NBER Macroeconomics Annual 1989*, 185-216, MIT Press
- [14] Coenen, G. and R. Straub (2004) "Non-Ricardian Households and Fiscal Policy in an Estimated DSGE Model of the Euro Area", *mimeo*, ECB
- [15] Corsetti, G. and G. Mueller (2006) "Twin Deficit: Squaring Theory, Evidence and Common Sense", *mimeo* European University Institute.
- [16] Ferguson, R. W. (2005) "U.S. Current Account Deficit: Causes and Consequences", Speech to the Economics Club of the University of North Carolina at Chapel Hill, North Carolina
- [17] Gali, J., J.D. Lopez-Salido and J. Valles (2006) "Understanding the Effects of Government Spending on Consumption", *Journal of European Economic Association*, forthcoming.
- [18] Iacoviello, M. (2005) "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", *American Economic Review*, V. 95 n.3, 739-764

- [19] Iacoviello, M. and R. Minetti (2004) "International Business Cycles with Domestic and Foreign Lenders", forthcoming *Journal of Monetary Economics*.
- [20] King, RG and MW Watson (1996) "Money, Prices, Interest Rates and the Business Cycle" *The Review of Economics and Statistics*,
- [21] Kiyotaki, N., and J. Moore (1997) "Credit Cycles" *Journal of Political Economy*, 211-248
- [22] Kraay, A. and J. Ventura (2005) "The Dot-Com Bubble, the Bush Deficits, and the US Current Account" in R. Clarida (ed.) *G7 Current Account Imbalances: Sustainability and Adjustments*, NBER.
- [23] Kollmann, R. (1998) "US Trade Balance Dynamics: the Role of Fiscal Policy and Productivity Shocks and of Financial Market Linkages", *Journal of International Money and Finance*, 17, 637-669.
- [24] Lawrence, E.C. (1991) "Poverty and the Rate of Time Preference: Evidence from Panel Data", *Journal of Political Economy*, 99(1), 54-77
- [25] Lucas, R. E. and N. Stokey (1984) "Optimal Growth with Many Consumers" *Journal of Economic Theory*
- [26] Mendicino, C. (2005) "Credit Market and Macroeconomic Volatility" *mimeo*, Stockholm School of Economics
- [27] Monacelli, T. (2006) "New Keynesian Models, Durable Goods and Collateral Constraints", *mimeograph*, IGIER, Università Bocconi
- [28] Mueller, G. (2006) "Understanding the Dynamic Effects of Government Spending on Foreign Trade", forthcoming *Journal of International Money and Finance*.
- [29] Rotemberg, J. and M. Woodford (1997) "An Optimization Econometric Framework

for the Evaluation of Monetary Policy" in O.J. Blanchard and S. Fischer (eds.) *NBER Macroeconomics Annual 1997*, MIT Press

[30] Rotemberg, J. and M. Woodford (1999) "Interest Rate Rules in an Estimated Sticky Price Model" in J. B. Taylor (ed.), *Monetary Policy Rules*, University of Chicago Press and NBER

[31] Roubini, N and B. Setser (2004) "The US as a Net Debtor: The Sustainability of the US External Imbalances", *mimeo*, NYU

APPENDICES

A. Log-Linearized System

The log-linearized budget constraint of Patient agents is

$$\begin{aligned} \frac{\hat{C}}{Y}\hat{c}_t + \frac{p^D \hat{H}}{Y}\Delta\hat{h}_t + \frac{\delta_K}{1-\lambda}\frac{K}{Y}i_t + b_t + b_t^H + b_t^g = \\ (1-\alpha)(w_t + \hat{n}_t) + \left(\frac{B}{\beta(1-\lambda)Y} + \frac{B^g}{\beta(1-\lambda)Y} + \frac{\lambda}{1-\lambda}\frac{B^H}{Y} \right) r_{t-1} + \\ + \frac{1}{\beta(1-\lambda)}b_{t-1} + \left(\frac{\alpha}{1-\lambda} \right) (r_t^K + k_t) \\ + \frac{\lambda}{\beta(1-\lambda)}b_{t-1}^H + \frac{1}{\beta(1-\lambda)}b_{t-1}^g - l_t \end{aligned}$$

where b_t, b_t^H, b_t^g and l_t are ratio between the variable's differential and steady state output. The log-linearization of the FOCs are

$$\begin{aligned} q_t &= \hat{\beta}Eq_{t+1} + \left[1 - \hat{\beta}(1 - \delta_K) \right] E_t \{ r_{t+1}^K \} - r_t^H \\ i_t - k_{t-1} &= \eta q_t \\ k_t &= \delta_K i_t + (1 - \delta_K) k_{t-1} \\ \sigma \hat{n}_t &= w_t - \hat{c}_t \\ \left[1 - \hat{\beta}(1 - \delta_H) \right] \left(\hat{c}_t - \bar{p}_t^D - \hat{h}_t \right) + \hat{\beta}(1 - \delta_H) \left(E_t \Delta \bar{p}_{t+1}^D - E_t \Delta \hat{c}_{t+1} \right) &= 0 \\ E_t \Delta \hat{c}_{t+1} &= r_t - \psi b_t \\ E_t \Delta \hat{c}_{t+1} &= r_t^H \end{aligned}$$

where $\sigma = \varphi \chi \frac{N^j}{1-N^j}$. χ and φ in the two utility functions are adjusted such that the two elasticities are equal across agents and the labour supply in steady state is equal to 1/3 for both groups.

The equations relative to the impatient consumers are

$$\begin{aligned} \frac{\tilde{C}}{Y}\tilde{c}_t + \frac{p^D\tilde{H}}{Y}\Delta\tilde{h}_t + \frac{1}{\tilde{\beta}}\frac{B^H}{Y}r_{t-1}^H + \frac{1}{\tilde{\beta}}b_{t-1}^H &= \\ (1-\alpha)(w_t + \tilde{n}_t) + b_t^H - l_t & \\ \tilde{\beta}E_t\Delta\tilde{c}_{t+1} = \tilde{\beta}r_t^H + (\hat{\beta} - \tilde{\beta})\tilde{\Xi}_t & \\ \sigma\tilde{n}_t = w_t - \tilde{c}_t & \\ b_t^H = \frac{\hat{\beta}mp^D\tilde{H}}{Y}E_t(p_{t+1}^D + \tilde{h}_t - r_t^H) & \end{aligned}$$

and the durable/nondurable flow condition is given by the following equation

$$\begin{aligned} \tilde{\beta}(E_t\Delta\bar{p}_{t+1}^D - E_t\Delta\tilde{c}_{t+1}) + m(\hat{\beta} - \tilde{\beta})(E_t\Delta\bar{p}_{t+1}^D + \hat{\Xi} - r_t^H) &= \\ = [1 - \tilde{\beta} - m(\hat{\beta} - \tilde{\beta})](\bar{p}_t^D + \tilde{h}_t - \tilde{c}_t) & \end{aligned}$$

where $\tilde{\Xi}_t$ is the log-deviation of the multiplier on the borrowing constraint, \bar{p}_t^D is the log-deviation of the relative price.

The only differences between these conditions and the ones relative to the foreign is the sign of the adjustment costs in the Patient agent Euler equation.

The production function is

$$y_t = \alpha k_{t-1} + (1-\alpha)n_t$$

The cost minimization process of the firms lead to the following first-order conditions

$$\begin{aligned} w_t &= y_t - n_t \\ r_t^K &= y_t - k_t \end{aligned}$$

The conditions relative to the government sector

$$g_t + \frac{1}{\beta}\frac{B^g}{Y}r_t^H + \frac{1}{\beta}b_{t-1}^g = l_t + b_t^g$$

The flow budget constraint defines the government policy together with the tax rules (??) and (??). Similar equations hold for the foreign country. Equilibrium is guaranteed by the following conditions

$$\begin{aligned} y_t + y_t^* &= \gamma_c c_t + \gamma_c^* c_t^* + \gamma_i i_t + \gamma_i^* i_t^* + g_t + g_t^* \\ \lambda\tilde{H}\tilde{h}_t + (1-\lambda)\hat{H}\hat{h}_t &= 0 \\ \lambda\tilde{H}^*\tilde{h}_t^* + (1-\lambda)\hat{H}^*\hat{h}_t^* &= 0 \\ n_t &= \lambda\tilde{n}_t + (1-\lambda)\hat{n}_t \\ n_t^* &= \lambda\tilde{n}_t^* + (1-\lambda)\hat{n}_t^* \end{aligned}$$

where γ_i is the steady state output ratio of variable i : the star denotes a foreign variable.

B. Steady State

Recall that B, B^g, L, L^* are defined in the calibration section. $B = B^g = 0$.

The other relevant coefficients for the steady state are

$$\begin{aligned}
 R &= R^H = R^F = \frac{1}{\hat{\beta}} \\
 \frac{p^D \tilde{H}}{Y} &= \frac{\theta [(1 - \alpha) - L/Y]}{(1 - \theta) [1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})] + \theta (1 - \tilde{\beta}) m} \\
 \frac{B^H}{Y} &= \hat{\beta} m \frac{p^D \tilde{H}}{Y} \\
 \frac{\tilde{C}}{Y} &= \frac{1 - \theta}{\theta} \frac{p^D \tilde{H}}{Y} [1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})] \\
 R^K &= \frac{1}{\hat{\beta}} - 1 + \delta_K \\
 \frac{\hat{I}}{Y} &= \frac{\delta_K \hat{\beta} \alpha}{(1 - \hat{\beta} + \delta_K) (1 - \lambda)} \\
 \frac{\hat{C}}{Y} &= \frac{1 - \lambda (1 - \alpha)}{1 - \lambda} + \frac{\lambda (1 - \hat{\beta})}{\hat{\beta} (1 - \lambda)} \frac{B^H}{Y} - \frac{\hat{I}}{Y} - \frac{L}{Y} \\
 \frac{p^D \hat{H}}{Y} &= \frac{\theta}{1 - \theta} \frac{\hat{C}}{Y} / (1 - \hat{\beta})
 \end{aligned}$$

C. Nondurable goods consumption condition

In this section, all the equations are relative to Impatient agents.

Let Impatient agents' cash-on-hand be defined as

$$dw_t \equiv (1 - \alpha) (w_t + \tilde{n}_t) - l_t - \frac{1}{\hat{\beta}} b_{t-1}^H + \gamma_{p^D H} \tilde{h}_{t-1}$$

By substituting the borrowing constraint in the budget constraint of Impatient agents is obtained the following condition

The following condition for the demand of durable goods is obtained by rearranging the durable/nondurable flow condition and substituting in it the Euler equation

$$\tilde{h}_t = (\tilde{c}_t - \tilde{p}_t^D) + oc_t \frac{\tilde{\beta} + m (\hat{\beta} - \tilde{\beta})}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} - \tilde{\Xi}_t \left[1 - \frac{1 - \hat{\beta}}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} \right]$$

where

$$oc_t \equiv r_t^H - E_t \Delta p_{t+1}^D$$

is the "shadow" opportunity cost of Impatient agents, i.e. the user cost of holding durables in terms of nondurable goods that would hold if $\lambda = 1$.

Plugging this condition in the budget constraint (??) and arranging in a proper way we get

$$\tilde{c}_t = \kappa_1 \left\{ \frac{p^D \tilde{H}}{Y} \left[p_t + \kappa_2 oc_t + \kappa_3 \tilde{\Xi}_t \right] + dw_t \right\}$$

where

$$\begin{aligned} \kappa_1 &= \frac{1}{\frac{\tilde{C}}{Y} + \frac{p^D \tilde{H}}{Y} (1 - \hat{\beta}m)} \\ \kappa_2 &= \frac{(1 - \hat{\beta}m) (\hat{\beta} - \tilde{\beta}) (1 - m)}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} \\ \kappa_3 &= \frac{\tilde{\beta} (1 - m)}{1 - \tilde{\beta} - m (\hat{\beta} - \tilde{\beta})} \end{aligned}$$

D. Business Cycle Properties of the Model

Home Productivity Shock

We study the effects of temporary and permanent productivity shocks, comparing the impulse responses with those generated by a standard RBC model, obtained by setting $\lambda = 0$ ²⁰.

Figure 3.12 shows the responses generated by a temporary shock: the rise in real wage increases cash-on-hand dw_t allows Impatient agents to buy more durable and nondurable goods; the rise in debt demand translates into an increase in the interest rate and in the (shadow) opportunity cost oc_t . All these elements, as expressed in (3.16), contribute to increase consumption \tilde{c}_t .

The output impact response is smaller when $\lambda = 0.5$ for two reasons: first, the fall in Impatient agents' labour supply, and second, the investment response is now smaller because

²⁰The model obtained by setting $\lambda = 0$ is equal to the RBC model as in Baxter (1995) modified to allow for durable goods.

Rather than on the presence of H_t , the differences with Baxter (1995) are mainly due to the elasticity of the Tobin's q with respect to investment, η , which is here set to one, according to King and Watson (1996). Baxter (1995) set it to 15, which implies a much bigger variations of investment.

Kollmann (1998), differently to our specification, assumed quadratic costs of adjusting capital and distortionary taxes only on labour.

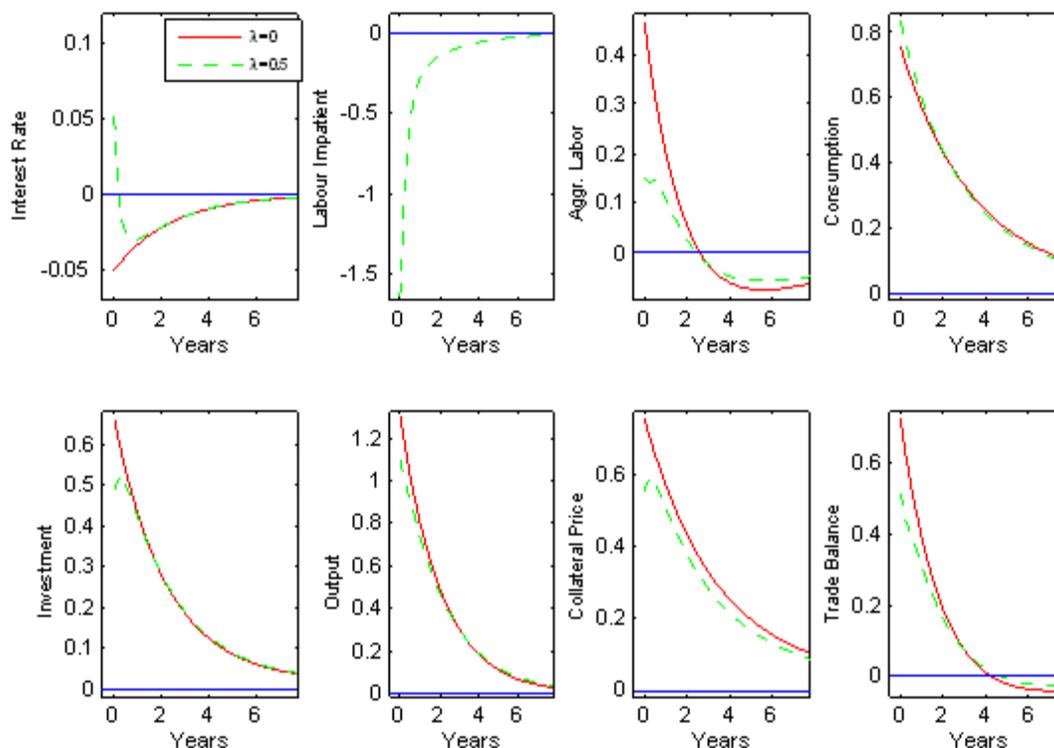


Figure 3.12: Temporary Shock to Technology

of the increase in the interest rate. Both the higher increase in consumption and the smaller rise of output leads to a smaller trade surplus, which is now almost one third of that observed in the $\lambda = 0$ case.

After a permanent shock (figure 3.13) the wealth effect is so big that it prevails on the income effect (due to the rise in real wage) also for Patient agents, so that the labour supply falls also in the $\lambda = 0$ case. Introducing Impatients leads to a bigger variability of the economy responses: labour and output drop more (so that investment rises less on impact), and consumption jumps up of a bigger amount. As a consequence the trade balance deficit is in the order of 1% of GDP, much higher than the 0.2 level generated by the standard RBC model.

Table 1 shows the cross-country correlations implied by this model in presence of temporary shocks to productivity, government expenditure and to the tax rate: the AR(1) coefficient is set to 0.9 for all the processes, roughly consistently with the evidences in Kehoe and Perri (2002) and Kollmann (1998). This model cannot solve the quantity anomaly presented in Backus, Kehoe and Kydland (1995), since the cross-country correlation of output

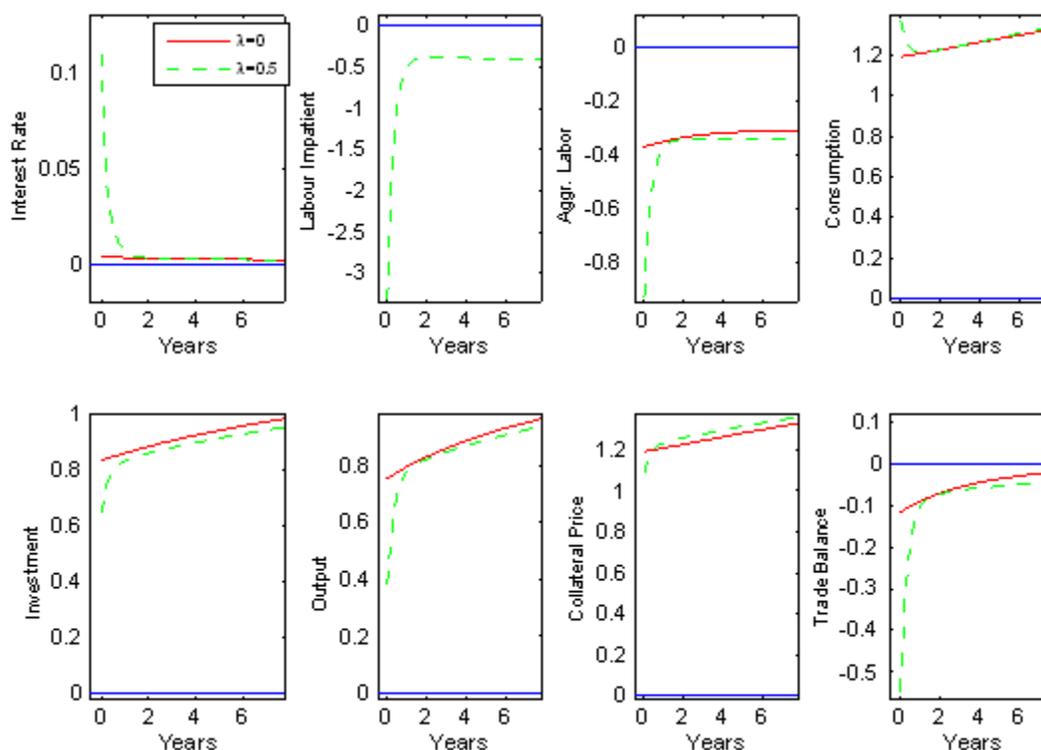


Figure 3.13: Permanent Shock to Technology

is still negative and lower than that of consumption, while in the data it is positive and higher than that of consumption; moreover, the cross-correlation of labor is negative while it is positive in the data²¹. However, our model does not perform worst than the standard RBC model, and actually the second moment are closer to the actual ones than in the $\lambda = 0$ case.

Table 1 - Second Moments of the Model

Cross-Country Correlations				
Temporary Shock				
	$Corr(y, y^*)$	$Corr(c, c^*)$	$Corr(i, i^*)$	$Corr(n, n^*)$
US Data	0.58	0.36	0.3	0.42
Our Model	-0.28	0.45	0.71	-0.11
RBC model	-0.35	0.52	0.76	-0.28

The US Data are the one reported in Kehoe and Perri (2002)

²¹Another problem described in Backus, Kehoe and Kydland (1995) is the negative correlation of investment, which does not show up here because of the kind of adjustment cost process assumed.