MAGYAR NEMZETI BANK

MNB WORKING PAPER

2004/6

Florin O. Bilbiie - Roland Straub*

FISCAL POLICY, BUSINESS CYCLES AND LABOR-MARKET FLUCTUATIONS

June, 2004

* We are particularly indebted to Roberto Perotti for many helpful comments and guidance and to Giancarlo Corsetti for extremely useful discussions. We are also grateful to Mike Artis, Paul Bergin, Russell Cooper, Roger Farmer, Oscar Jorda, Omar Licandro, Gernot Mueller, Kris Nimark, Giovanni Pica, Kevin Salyer and seminar participants at EUI, UC Davis and the Magyar Nemzeti Bank for comments/discussions leading to improvement. We thank UC Berkeley, UC Davis and the Magyar Nemzeti Bank respectively for hospitality at the time this paper was started. An earlier version of the paper was circulated under the title "Fiscal Multipliers and Monetary Policy Rules: Bridging Theory with Evidence". The usual disclaimer applies.

Online ISSN: 15 855 600
ISSN 14195 178
ISBN 963 9383 384 46 5

Roland Straub: : European University Institute, Visiting researcher at the MNB, summer 2003.

E-mail: roland.straub@iue.it

Florin O. Bilbiie: European University Institute

E-mail: florin.bilbiie@iue.it

Magyar Nemzeti Bank

H-1850 Budapest

Szabadság tér 8-9.

http://www.mnb.hu

Abstract

In this paper we study the effects and transmission of fiscal policy in a dynamic general equilibrium sticky-price model with non-Ricardian agents, distortionary taxation and a Walrasian labor market. We derive a simple analytical framework for fiscal policy similar to the workhorse 'new synthesis' model widely used in the monetary policy literature. We then explore theoretical conditions under which government spending (whether financed by lump-sum or income taxes) can increase private consumption as observed in the data. We conclude that making the model fare better in this respect necessarily makes it fare worse in what concerns real wage fluctuations. Additionally, we show that the model can generate non-Keynesian effects of fiscal policy when participation to asset markets is limited enough and the monetary policy rule is passive.

JEL classification: E32, E62

Keywords: Fiscal Policy; Dynamic General Equilibrium; Distortionary Taxation; Sticky Prices; Non-Ricardian Agents; Government Debt; Non-Keynesian Effects.

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1 Introduction

An increase in government spending on goods and services affects macroeconomic variables. While this claim is largely undisputed, there is an active debate around two questions, broadly: 'What are the direction and magnitude of these effects?' and 'How is the shock transmitted and what channels are key?'. This paper is intended to contribute to this debate.

Empirical studies have found a set of relatively uncontroversial results. Government spending shocks tend to increase consumption, hours and output, and this is robust across different studies, concerning different countries (see e.g. Blanchard and Perotti 2003, Perotti 2002, Fatas and Mihov 2001, Mountford and Uhlig 2001, Gali, Lopez-Salido and Valles 2002).[1]

Theory fails to account for some of these findings (most importantly, the positive response of private consumption and the positive correlation of consumption and hours worked). RBC models do predict a positive multiplier on output, but also invariably predict a fall in consumption; this is due to a negative wealth effect making the household work more (hence the multiplier on output) and consume less. The mechanism is different across models, most notably as a function of the type of taxation, but the negative wealth effect is always found to be the dominating force. Fatas and Mihov (2002), studying a larger menu of financing options including distortionary taxation and deficits, and considering a large span for the labor supply elasticity, find an invariable fall in consumption[2]. A quote from King and Rebelo's 2000 Handbook article (p.42) also speaks of the difficulties of the RBC approach: "Shocks to government spending cannot, by themselves, produce realistic patterns of comovements among macroeconomic variables". Instead, the empirical findings seem to support older views of the 'multiplier' whereby fiscal policy, by stimulating demand, would lead to an increase in both consumption and output[3]. While this holds for a balanced budget experiment (the 'Haavelmo multiplier'), it is amplified if spending is deficit-financed, which is what Keynes was explicitly referring to in the famous passage in Book 3, Chapter 10 of the General Theory (Section VI).

One way to bring the model closer to the data along this dimension was suggested recently by Gali, Lopez-Salido and Valles (henceforth GLV 2002), building on a proposal of Mankiw (2000). Mankiw argued, based on empirical evidence from both estimated Euler Equations and the distribution of wealth in the US, that not all agents behave as predicted by the neoclassical paradigm, for either they do not have the means (i.e., they are constrained) or they are not willing to do so. He argued that any model purported to analyze fiscal policy

[1] A different approach is taken by Burnside, Eichenbaum and Fisher (2001).

[2] A positive correlation between consumption and hours does obtain with distortionary taxes, but both would actually fall (as would output), due to intertemporal substitution. This causes even more embarassement to the RBC model.

[3] *I*ntroducing monopolistic competition and sticky prices helps to get a positive real wage response, but *not* a positive consumption response. In that case there is a demand effect making firms who cannot adjust prices want to sell more, and hence demand more labor. But this is not enough to compensate the negative wealth effect (see Linnemann and Schabert 2003).

incorporate a distinction between 'savers' (neoclassical, Ricardian households) and 'spenders' (agents with no non-human wealth living paycheck-to-paycheck), and sketched a few implications this would have[4]. GLV(2002) incorporate this type of heterogeneity into a New-Keynesian model of the business cycle with monopolistic competition, staggered pricing, lump-sum taxation and investment adjustment costs, and find that government spending can lead to an increase in priovate consumption. Specifically, this happens when the demand effect dominates the negative wealth effect, the government spending shock is deficit-financed and hours worked are (demand-) determined by an arbitrary wage schedule, while hours across the two groups are restricted to be equal at all times. Medium-scale general equilibrium models used for policy analysis and forecasting at institutions such as Central Banks and the IMF also recently incorporated the distinction between Ricardian and non-Ricardian agents, testifying to some extent its success.

Our paper is closest to (and can be seen as building upon) the approach of GLV 2002. We study the conditions under which a standard model with heterogeneity and distortionary taxation can account for qualitative features of the data. Our approach is different in three main respects. First, we use an optimization-based, Walrasian labor market. In contrast to Gali et al., we do not restrict fluctuations in hours across groups to be equal at all times, and hence total hours to be (demand-)determined by an ad-hoc wage schedule. Indeed, we emphasize labor market fluctuations' role in the propagation of fiscal shocks; this is in line with previous studies of fiscal policy and business cycles (e.g. Christiano and Eichenbaum).

Secondly, we study a larger menu of taxes. A common assumption in many studies of the effects of government spending is that unlimited lump-sum taxes are available to finance spending[5]. While this is only assumed on the grounds of simplification and could be justified implicitly by assuming very large collection costs (or high probability of tax evasion) for income taxes, it is plainly unrealistic. A large fraction of the total revenues is given by income taxes; moreover, effective tax rates vary over time as documented i.a. by Mendoza, Razin and Tesar (1996). Our framework capture this realistic feature of budgets. In particular, it is consistent with what Baxter and King (1993, pp 316-317) argue to be an appropriate description of budgetary dynamics in the US. Looking at Figure 1C therein, one concludes that after the 1970's, the increase in income tax rates was larger than that of tax revenue as a fraction of GDP, the difference being accounted by transfers (one also sees there an increasing trend in both tax rates and total tax receipts).

Thirdly, the way we model heterogeneity is slightly different. In GLV, as in Mankiw, part of the agents do not accumulate any physical capital and hence do not smooth consumption. We abstract from capital accumulation, and model the difference between households as coming from limited participation to the asset market. As in e.g. Alvarez, Lucas and Weber (2002), a sub-set of agents

[4]However, Mankiw's paper is silent about the effects of government spending.

[5]Exceptions include i.a. McGrattan 1994, Ludvigson 1996, Fatas and Mihov 2002.

does not participate to asset markets and hence will fail to smooth consumption. The main advantage of this simplification is that it allows us to derive many results analytically and to be transparent about the mechanism at work. Notably, we are able to reduce our model to a canonical form in inflation and an appropriately defined output gap, easily comparable with the workhorse 'New Synthesis' models used for monetary policy analysis. Of course, this simplification implies one limitation: we cannot study the effect of government spending on investment. However, since the major puzzles in the literature are related to the response of consumption, real wage and hours, we think the benefits outweigh this cost[6].

The contribution of our paper is twofold. First is methodological: we derive a simple 'new synthesis' model incorporating consumer heterogeneity and distortionary taxation and nesting the 'workhorse' model as a special case. Second, we study the model's ability to qualitatively fit the data, and the role played by various modelling features in doing so. Our results indicate that in order to obtain a positive response of consumption (and a positive correlation of consumption and hours), three features make a big difference: the persistence of the spending shock should not be very large; price stickiness should be high; the response of monetary policy should be accommodative enough. With distortionary taxation, relatively more stringent conditions are required to grant the same result.

Our results draw a cautionary signal. In models in the class studied here, a positive response of consumption can only be driven by high enough fluctuations in the real wage. However, this implies a failure of such a model to comply to *Lucas' less famous Critique* (in Christiano and Eichenbaum's 1992 terminology). Lucas (1981, pp 226) states that "*observed real wages are not constant over the cycle, but neither do they exhibit consistent pro- or countercyclical tendencies. [...] any attempt to assign systematic real wage movements a central role in an explanation of business cycles is doomed to failure.*" Since RBC models driven (exclusively) by productivity shocks predicted a too procyclical real wage, shocks to government spending have naturally been thought of as an additional source of fluctuations reducing procyclicality of wages. As emphasized by e.g. Christiano and Eichenbaum (1992) their negative effect on the real wage (by shifting the labor supply curve) may counteract the positive effect of technology shocks, leading to a roughly acyclical real wage. The class of models analyzed here attempts to obtain a positive response of consumption by a strong enough response of the real wage, which goes against these earlier studies: if technology and government spending move the real wage in the same direction, having both as possible sources of fluctuations would only amplify the implied real wage fluctuations. Moreover, the empirial *conditional response* of real wages to government spending shocks (e.g. Fatas and Mihov 2002) is also small, positive but insignificant. Other features seem to be needed to explain a positive response of consumption, while complying with Lucas' litmus test

[6] Moreover, a different framework seems to be necessary for understanding investment dynamics and its relationship with fiscal and moentary policy - see Basu and Kimball 2003.

and with evidence on the conditional response of wages to government spending shocks.

Additionally, our framework hints to an alternative theoretical explanation for the observed non–Keynesian effects of fiscal policy as described e.g. in Perotti (1999). The main message of this literature is that in specific periods, fiscal consolidations driven by spending cuts have expansionary effects on consumption and output. In our model, under low asset market participation and passive monetary policy rule (*a non-Ricardian economy*), the impulse response functions of our model are in line with these empirical results.

The paper is organized as follows. Section 2 presents the model. In section 3 we derive the canonical form of our model and discuss the determinancy properties under different parameterization. We presents the differences, discussed in detail in Bilbiie (2003), between what we call *Ricardian* and *non-Ricardian economies*. Section 4 discusses the importance of the labor market for the transmission of the shocks for the lump-sum and the distortionary tax case. Section 5 contains numerical simulation of the model and its successes and failures in capturing comovements in the data. Section 6 briefly explores the model's ability to generate non-Keynesian effects of fiscal policy, and section 7 concludes.

2 A Non-Ricardian Sticky-Price Model with Distortionary Taxation

The model we use draws on Gali, Lopez-Salido and Valles (2003), being a standard cashless dynamic general equilibrium sticky price model with Calvo-Yun pricing, augmented for the distinction between Ricardian and non-Ricardian households. There is a continuum of households, a single perfectly competitive final-good producer and a continuum of monopolistically competitive intermediate-goods producers setting prices on a staggered basis. There are also two policy authorities. A monetary authority sets its policy instrument, the nominal interest rate. A fiscal policy authority purchases the consumption good, raises lump-sum and income taxes and issues nominal debt. The model is different from GLV in a few important respects, as detailed in the introduction above[7]. Two other differences are: (i) a slightly different utility function, necessary for being able to consider different Frisch elasticities of labor supply while being consistent with the same steady-state hours worked; and (ii) a free parameter governing increasing returns to scale in the intermediate-goods sector (set to zero in GLV), which when set properly insures there are no long-run profits, as documented i.a. by Rotemberg and Woodford 1995 (see appendix A for the derivation of the log-linearized equilibrium).

[7]We have studied numerically a version of the model with capital accumulation subject to adjustment costs.The conclusions being largely robust, this extension did not justify the increase in complexity. For the sake of space and clarity we stick to the version without investment.

2.1 Households

There is a continuum of households $[0, 1]$. A $1 - \lambda$ share is represented by standard, neoclassical, 'Ricardian' households, who smooth consumption being able to trade in all markets for state-contingent securities. The rest of the households on the $[0, \lambda]$ interval are labeled as 'non-Ricardian '.

2.1.1 Ricardian Households

Each saver $j \in [1 - \lambda, 1]$ chooses consumption, asset holdings and leisure solving the following standard intertemporal problem (we drop the j index as we look at the representative saver):

$$\max E_t \sum_{i=0}^{\infty} \beta^i U_S \left(C_{S,t+i}, 1 - N_{S,t+i} \right)$$

$$: \quad U_S \left(C_{S,t}, 1 - N_{S,t} \right) = \ln C_{S,t} + \theta_S \frac{\left(1 - N_{S,t}\right)^{1-\gamma_S}}{1 - \gamma_S}$$

subject to the sequence of constraints:

$$B_{S,t} \leq Z_{S,t} + (1 - \tau_t) W_t N_{S,t} + (1 - \tau_t) P_t D_{S,t} - P_t C_{S,t} - P_t L_t$$

An S subscript stands for 'saver', i.e. a Ricardian household, and $U_S(.,.)$ is saver's momentary felicity function, which takes the form considered here to be consistent with most DSGE studies[8]. $\beta \in (0, 1)$ is the discount factor, $\theta_S > 0$ indicates how leisure is valued relative to consumption, and $\gamma_S > 0$ is the coefficient of relative risk aversion to variations in leisure. $C_{S,t}, N_{S,t}$ are consumption and hours worked by saver (time endowment is normalized to unity), $B_{S,t}$ is the nominal value at end of period t of a portfolio of all state-contingent assets held by the Ricardian household, except for shares in firms. $Z_{S,t}$ is beginning of period wealth, not including dividend payoffs. Profits are rebated to these agents only as dividends $D_{S,t}$ - that is to say that Ricardian households own the firms. We distinguish this from the rest of the assets since we do not model the equity market explicitly; we find the assumption of Ricardian households receiving the profits realistic since (i) the forward-looking behavior of firms modeled later would be hard to square with the static behavior of non-Ricardian households; (ii) we will use the stochastic discount factor of Ricardian households to value future income streams in the profit-maximizing pricing decision of firms.

Absence of arbitrage implies that there exists a stochastic discount factor $\Lambda_{t,t+1}$ such that the price at t of a portfolio with payoff $Z_{S,t+1}$ at t+1 is:

$$B_{S,t} = E_t \left[\Lambda_{t,t+1} Z_{S,t+1} \right] \tag{1}$$

[8] This function is in the King-Plosser-Rebelo class and would lead to constant steady-state hours.

The riskless gross short-term nominal interest rate R_t is a solution to:

$$\frac{1}{R_t} = E_t \Lambda_{t,t+1} \tag{2}$$

Substituting the no-arbitrage condition (1) into the wealth dynamics equation gives the flow budget constraint. Together with the usual 'natural' no-borrowing limit for *each* state, this will then imply the usual intertemporal budget constraint:

$$\begin{aligned} E_t \sum_{i=t}^{\infty} \Lambda_{t,i} P_i C_{S,i} &\leq Z_{S,t} + E_t \sum_{i=t}^{\infty} \Lambda_{t,i} (1-\tau_i) W_i N_{S,i} + E_t \sum_{i=t}^{\infty} \Lambda_{t,i} (1-\tau_i) P_i D_{S,i} \\ & -E_t \sum_{i=t}^{\infty} \Lambda_{t,i} P_i L_{S,i} \end{aligned} \tag{3}$$

Maximizing utility subject to this constraint gives the first-order necessary and sufficient conditions at each date and in each state:

$$\begin{aligned} \beta \frac{U_C (C_{S,t+1})}{U_C (C_{S,t})} &= \Lambda_{t,t+1} \frac{P_{t+1}}{P_t} \\ \theta_S (1 - N_{S,t})^{-\gamma_S} &= (1-\tau_t) \frac{1}{C_{S,t}} \frac{W_t}{P_t} \end{aligned}$$

along with (3) hold with equality (or alternatively flow budget constraint hold with equality and transversality condition ruling out overacummulation of assets and Ponzi games be satisfied: $\lim_{i\to\infty} E_t [\Lambda_{t,t+i} Z_{S,t+i}] = 0$). Using (3) and the functional form of the utility function, the short-term nominal interest rate must obey:

$$\frac{1}{R_t} = \beta E_t \left[\frac{C_{S,t}}{C_{S,t+1}} \frac{P_t}{P_{t+1}} \right]$$

2.1.2 Non-Ricardian Households

Non-Ricardian consumers also **optimize**. We prefer to think of these households as not participating to asset markets, either due to constraints or to their being shortsighted (case in which their optimal asset holdings are zero). One obvious generalization could treat these agents as saving a fixed (insensitive to interest rates) portion of their present income - it will become obvious that this would not change our results qualitatively. The problem these agents face then looks finally as a period-by-period one:

$$\begin{aligned} &\max_{C_{H,t}, N_{H,t}} \ln C_{H,t} + \theta_H \frac{(1-N_{H,t})^{1-\gamma_H}}{1-\gamma_H} \\ &: \quad C_{H;t} = (1-\tau_t) \frac{W_t}{P_t} N_{H;t} - L_t \end{aligned} \tag{4}$$

The first order condition is:

$$\theta_H (1 - N_{H,t})^{-\gamma_H} = (1 - \tau_t) \frac{1}{C_{H;t}} \frac{W_t}{P_t} \tag{5}$$

It is important to observe that given this optimal choice, we can solve for reduced-form (functions only of $\frac{W_t}{P_t}$ and exogenous processes) expressions for $C_{H;t}$ and $N_{H;t}$. There is no need to keep consumption (or marginal utility of income) of H constant, as this does not depend on saving decisions or any other intertemporal feature. Hours will be a solution to:

$$(1 - N_{H,t})^{-\gamma_H} \left[(1 - \tau_t) \frac{W_t}{P_t} N_{H,t} - L_t \right] = \frac{1 - \tau_t}{\theta_H} \frac{W_t}{P_t}$$

and then consumption will track the real wage to exhaust the budget constraint. Note that due to the very form of the utility function, hours are constant for these agents when there are no lump-sum taxes or transfers, $L_t = 0$: the utility function is chosen to obtain constant hours in steady state, and this agent is 'as if' she were in the steady state always. In this case labour supply of non-Ricardian agents is fixed, no matter γ_H, as income and substitution effects cancel out.

2.2 Firms

The firms' problem is completely standard - see Gali (2002) or Woodford 2003 (one generalization is in the production function of intermediate goods).

2.2.1 Final Good Producers

The final good is produced by a representative competitive firm .The aggregation technology for producing final goods is of the CES form (constant elasticity of substitution ε):

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{6}$$

Final goods producers behave competitively, maximizing profit each period:

$$\max[P_t Y_t - \int_0^1 P_t(i) Y_t(i) di) \tag{7}$$

where P_t is the overall price index of the final good, $P_t(i)$ are the prices index of the intermediate goods. The demand for each intermediate input and the price index can be shown to be:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} Y_t \tag{8}$$

$$P_t = \left(\int_0^1 P_t(i)^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}} \tag{9}$$

2.2.2 Intermediate Goods Producers

We assume that the intermediate firms face a technology which is linear in labor, for simplification:

$$Y_t(i) = \begin{cases} A_t N_t(i) - F(i), \text{ if } N_t(i) > F(i) \\ 0, \text{ otherwise} \end{cases}$$

$F(i)$ is a firm-specific fixed cost: this will be a free parameter that can be chosen such that profits are zero in steady state and there are increasing returns to scale, consistent with evidence by Rotemberg and Woodford (1995). Alternatively, if the fixed cost is zero, there are steady-state profits (which is the case in GLV). We shall encompass both cases. Cost minimization taking the wage and the rental cost of capital as given implies the following conditions (written as relative factor demands and nominal marginal cost):

$$\frac{MC_t}{P_t} = \frac{W_t/P_t}{A_t} \tag{10}$$

When fixed cost is zero, $Y_t(i)$ is a constant returns to scale function, and there will be positive steady state profits. When positive and properly chosen, there will be increasing returns and no profits in steady-state. The (nominal) profit function is given by:

$$P_t(i)\, O_t(i) = P_t(i)Y_t(i) - MC_t\left(Y_t(i) + F(i)\right)$$

2.2.3 Price setting

Following Calvo (1983) and Yun (1996) intermediate good firms adjust their prices infrequently. The opportunity to adjust follows a Bernoulli distribution. We define θ as the probability of keeping the price constant. This exogenous probability is independent of history. Thus each period there is a fraction of firms that keep their prices unchanged. The dynamic program of the firm is (maximizing discounted sum of future nominal profits, hence using the relevant stochastic discount factor $\Lambda_{t,t+i}$ used as pricing kernel for nominal payoffs):

$$\max_{P_t(i)} E_t \sum_{s=0}^{\infty} (\theta^s \Lambda_{t,t+s}\left[P_t(i)Y_{t,t+s}(i) - MC_{t+i}Y_{t,t+s}(i)\right]$$

subject to the demand equation (at $t+s$, conditional upon price set s periods in advance):

$$Y_{t,t+s}(i) = \left(\frac{P_t(i)}{P_{t+s}}\right)^{-\varepsilon} Y_{t+s} \tag{11}$$

The optimal price of the firm is then found as usually as a markup over a weighted average of expected future nominal marginal costs:

$$P_t^{opt}(z) = (1+\mu)E_t \sum_{s=0}^{\infty} \varpi_{t,t+s} MC_{t+s} \quad (12)$$

$$\varpi_{t,t+s} = \frac{\theta^s \Lambda_{t,t+s} \left(\frac{1}{P_{t+s}}\right)^{(1-\varepsilon)} Y_{t+s}}{E_t \sum_{s=0}^{\infty} \theta^s \Lambda_{t,t+s} \left(\frac{1}{P_{t+s}}\right)^{(1-\varepsilon)} Y_{t+s}}$$

In equilibrium each producer that chooses a new price $P_t(i)$ in period t will choose the same price and the same level output. Then the dynamics of the price index given the aggregator above is:

$$P_t = \left((1-\theta) P_t^{opt}(i)^{1-\varepsilon} + \theta P_{t-1}(i)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}} \quad (13)$$

The combination of this two conditions leads in the log-linearized equilibrium to the well known New Keynesian Phillips curve given below. Profits will also be equal across producers, and equal to:

$$O_t = \left(1 - \frac{MC_t}{P_t}\right) Y_t - \frac{MC_t}{P_t} F$$

2.3 Monetary policy

The monetary authority follows an *instrument rule.* We consider a simplified version of the Taylor rule where the short-term nominal interest rate is a function of expected inflation [9]:

$$R_t = R \left[E_t \frac{P_{t+1}}{P_{t+1}}\right]^{\phi_\pi} \quad (14)$$

2.4 Fiscal policy

The fiscal authority purchases consumption goods (G_t) (using the same aggregator as the household and hence using the same price level for deflating nominal quantities), raises distortionary and lump-sum taxes (a negative lump sum tax L is a transfer) and issues debt (B_{t+1}) consisting of one-period nominal discount bonds, paying 1 unit at the beginning of next period. The government budget constraint has the following form,

$$\frac{B_{t+1}}{R_t} = B_t + P_t \left[G_t - \tau_t Y_t - L_t\right] \quad (15)$$

For debt dynamics, we need to specify a deficit rule, i.e. to what extent is an exogenous shock to government spending financed through taxes and debt respectively. The last equation in the fiscal sub-system should then specify how tax revenues' dynamics is composed of lump-sum and distortionary taxes.

[9] The reason why we focus on this simplified rule lies in the fact that the conditions of the inverted Taylor principle, that occurs potentially in the presence of non-ricardian agents, are particularly simple.

2.5 Market Clearing

Market clearing and aggregation require:

$$
\begin{aligned}
N_t &= \lambda N_{H,t} + (1-\lambda)\, N_{S,t} && (16)\\
O_t &= (1-\lambda) D_{S,t} && (17)\\
C_t &\equiv \lambda C_{H,t} + (1-\lambda)\, C_{S,t} && (18)\\
C_t + G_t &= Y_t && (19)
\end{aligned}
$$

Last equality (goods market clearing or economy resource constraint) holds by Walras' law, if we consider that state-contingent assets are in zero net supply, as is the case since markets are complete and agents who can trade are identical.

3 Equilibrium Dynamics

3.1 The IS-AS System

In the following we will present the linearized equilibrium dynamics of our model economy. All derivations are detailed in the Appendix. First we express everything in terms of aggregate variables and then reduce the system to get dynamics only in terms of output, inflation and interest rate. We first solve for hours and consumption of non-Ricardian as a function of after-tax real wage and lump-sum transfers:

$$
\begin{aligned}
n_{h,t} &= (\tau - G_Y)\, \theta \omega_t + \theta l_t && (20)\\
c_{h,t} &= [1 - \varphi (\tau - G_Y)\, \theta]\, \omega_t - \varphi \theta l_t && (21)\\
\theta &\equiv \frac{1}{1 - \tau + \varphi (1 - G_Y)}
\end{aligned}
$$

Note that non-Ricardian agents have a standard labor supply function, where elasticity $(\tau - G_Y)\, \theta$ is determined by the budgetary structure and preferences (this is different from GLV). Note that hours are positively related to the real wage as long as $\tau > G_Y$, which is consistent with US data (see discussion in Introduction and Figure 1). The parameter φ plays a special role: it dictates the relative extent to which the effect of taxation is accommodated through labor supply or consumption (e.g. when φ is low, consumption tracks real wage to a greater extent, and the wealth effect goes mainly to the labor supply). Using these expressions, we can derive (see Appendix) the *equilibrium wage-hours locus* WN, which will play an important role in understanding the transmission of fiscal policy:

$$
WN : \left(\varphi + \frac{1+\mu}{1 - G_Y} \right) n_t = \omega_t + \frac{1}{1 - G_Y} g_t \qquad (22)
$$

We can now have a relationship between forward-looking part of aggregate demand and total aggregate demand, i.e. we express consumption of Ricardian agents as a function of output:

$$c_{s,t} = \delta y_t + \nu l_t - \frac{1}{1-G_Y}\left[\nu\left(\tau - G_Y\right)+1\right] g_t \tag{23}$$

where $\delta \equiv \frac{1}{1-G_Y} - \varphi\frac{\lambda}{1-\lambda}\frac{1}{1+\mu} + \nu\left(\tau - G_Y\right)\left(\frac{1}{1-G_Y} + \varphi\frac{1}{1+\mu}\right)$ and $\nu = \frac{\lambda}{1-\lambda}\varphi\theta$. We can further write this equation such that we emphasize that government spending has an effect on its own and one through the mismatch between spending and taxes $g_t - l_t = d_t + \tau y_t + \tau_t$,where d_t is the budget deficit implicitly defined here as deviations from steady state output. Substituting this we have:

$$c_{s,t} = \Delta y_t - \nu d_t - \nu\tau_t + \frac{1}{1-G_Y}\left[\nu\left(1-\tau\right)-1\right] g_t$$

where $\Delta \equiv \delta - \nu\tau$. The presence of non-Ricardian agents affects the link between the forward-looking part of aggregate demand $c_{s,t}$ and total aggregate demand y_t via two channels: (i) a 'slope effect', changing the elasticity savers' consumption to total output[10]; and (ii) a 'shift' effect, making deficits and government spending matter beyond resource absorption. This effect goes through the influence of lump-sum taxes on non-Ricardian consumption and hours. Note that these effects are higher, the higher are λ and φ (and hence the higher is ν). They are absent exactly when Ricardian equivalence holds, namely when either $\lambda = 0$ or $\varphi = 0$. The former is the standard case where all agents are Ricardian. The latter point is somewhat more subtle: when $\varphi = 0$, labor supply is infinitely elastic, and consumption is *independent of wealth*, so the economy is 'Ricardian' regardless of the magnitude of λ. Notice that only lump-sum taxes (and not the tax rate directly) have an effect on this equilibrium relationship, since it is l_t that directly influences consumption of non-Ricardian agents. The tax rate merely appears here because we have emphasized the effect of deficits separately.

The system can now be reduced to a representation in terms of output, inflation and fiscal variables (as in the baseline new-Keynesian model). As discussed in detail in appendix D, the AS curve of the model has the following form:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t - \psi\frac{1}{1-G_Y} g_t + \psi\frac{1}{1-\tau}\tau_t$$

where $\kappa = \psi\left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right)$, $\psi = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}$, $G_Y = \frac{G}{Y}$ and $\varphi = \left[\frac{\gamma N}{1-N}\right]$ .To derive this equation we used the log-linearized pricing equation of the firms and the log-linear relationship between marginal costs, real wage and distortionary taxes $mc_t = w_t = \omega_t + \frac{1}{1-\tau}\tau$, where ω_t is the after tax real wage. Notice that the AS-curve is not affected by the share of non-Ricardian agents[11]. In contrast

[10] This can change the sign of the coefficient - for details see below and Bilbiie (2003), where empirical evidence for such cases is also presented.

[11] This is not a general result, but is due to assumptions making steady-state consumption shares equal across groups (namely, a fixed costs in production equal to steady state markup such that steady state profits are nil; and $B_{PY} = 0$ such that there is no steady-state interest income). Changing one of these assumptions would be sufficient to make the output elasticity of inflation dependent on the share of non-ricardian agents.

to the baseline sticky price model, there is a trade off between output and inflation stabilization. This is due to the tax rate acting like a cost push shock, i.e. increasing the gross wage requested by households[12]. For the derivation of the IS-curve, we used (23) in the loglinearized Euler equation of the Ricardian household to get:

$$\begin{aligned} y_t &= E_t y_{t+1} - \Delta^{-1}(r_t - E_t\pi_{t+1}) - \nu\Delta^{-1}[E_t d_{t+1} - d_t] - \nu\Delta^{-1}[E_t\tau_{t+1} - \tau_t] \\ &\quad + \frac{1}{1-G_Y}[\nu(1-\tau)-1]\Delta^{-1}[E_t g_{t+1} - g_t] \end{aligned} \tag{24}$$

We decomposed the effect of government spending on output in an direct and indirect channel (through the deficit). This gives us an indication how the chosen fiscal rule (i.e. the chosen path for the fiscal deficit) is affecting the demand for output. As noticed before, the model collapses to the standard Ricardian case when either λ or φ are zero. We now seek to reduce the model further and write dynamics in terms of gaps of variables from some 'notional' levels defined below, to facilitate comparison with a standard sticky-price framework. For this, we need to explore the details of the budgetary structure.

3.2 The fiscal rule and debt dynamics

Under the assumptions we made, debt dynamics is particularly simple. Namely, it is independent on whether prices are sticky or not, and on what type of taxation is being used. To see this, combine the government budget constraint, definition of deficit and deficit rule (all variables except for tax rate are deviations from SS as fractions of SS output; tax rate is in deviations from steady-state value; ϕ_g gives the extent of deficit financing: when it is zero, spending is entirely deficit-financed, when it is one it is tax- financed).

$$\beta b_{t+1} = b_t + g_t - l_t - \tau y_t - \tau_t \tag{25}$$

$$d_t = g_t - l_t - \tau y_t - \tau_t \tag{26}$$

$$d_t = \left(1-\phi_g\right) g_t - \phi_b b_t \tag{27}$$

What we obtain is a difference equation dictating debt dynamics:

$$b_{t+1} = \beta^{-1}(1-\phi_b) b_t + \beta^{-1}\left(1-\phi_g\right) g_t \tag{28}$$

As long as fiscal policy is locally Ricardian (in the sense of Woodford 1996), i.e. under $\beta^{-1}(1-\phi_b) < 1$, this equation can be solved backward. This gives a unique path of debt as a function of the entire history of the exogenous spending process and the initial, given level of debt b_0.

$$b_t = \left[\beta^{-1}(1-\phi_b)\right]^t b_0 + \beta^{-1}\left(1-\phi_g\right)\sum_{i=0}^{t-1}\left[\beta^{-1}(1-\phi_b)\right]^i g_{t-1-i} \tag{29}$$

[12] See also Benigno and Woodford 2003 for a similar Philips curve, although taxation is at firm level on sales.

Note that the debt process will be more persistent, the more the fiscal authority resorts to deficit financing, and the less it responds to debt. But debt dynamics are independent of the degree of price stickiness and distortionary taxation, as long as the initial level of debt b_0 is the same under all scenarios[13]. Consequently, from the deficit rule, 51 deficit dynamics features the same property. This is a result of two simplifications: (i) the steady-state level of debt is zero: otherwise, inflation and nominal interest rate would matter for debt dynamics, and these are different depending on price stickiness and degree of tax distortion; (ii) there is no 'stabilization motive' of fiscal policy in the deficit rule (27): otherwise, the 'output gap' (defined below) would matter for the gap between debt levels under different scenarios. These simplifications are minor for the message of our paper. All foregoing results are independent of the particular taxation scheme adopted, i.e. how is the burden of additional spending shared between changes in the tax rate and changes in lump-sum instruments. While reality is most probably a convex combination of the two, we will consider two extreme cases. Note, from the discussion above, that the only difference between dynamics of lump-sum taxes and tax rates will come from the different response of output under the two scenarios[14]. This is discussed further below.

3.3 The efficient and the natural level of activity and gap dynamics

In the following we discuss the properties of the natural and the efficient level of activity in our model with non-Ricardian agents under different taxation schemes (see appendix F and G for detailed derivation of the equations). Following Woodford (2003, Ch. 6), the **natural level of activity** is the level of activity prevailing under flexible prices. This level of activity is not necessary always the efficient., i.e. the welfare optimizing level of activity. For example, in a new-keynesian model with sticky prices only, the efficient and the natural level of activity coincides only if one ensures that the price mark up generated by monopolistic competition is offset by a distortionary tax. Under this circumstances the monetary authority that is committed to complete stabilization of the price index is welfare optimal. However, complete stabilization of inflation ceases to be optimal, even when this applies that aggregate output should perfectly track the equilibrium level of output under flexible prices, if the gap between the natural and efficient level is not constant. This is the case if government spending is financed by distortionary taxation. Consequently, we define the **efficient level of activity** (denoted with a star) as that prevailing when prices are flexible and lump-sum instruments are available to finance government spending (case

[13] To see this, denote the level of debt under the alternative scenario (i.e. with flexible prices, with lump-sum taxation only, or with both) as $\tilde{b}_t$ and the gap between actual level and this level as $f_t = b_t - \tilde{b}_t$, where dynamics of this are given by $f_{t+1} = \beta^{-1}(1 - \phi_b) f_t$. Under locally Ricardian fiscal policy, $f_t = 0$ is the unique solution if we assume $f_0 = 0$.

[14] Note, however, that the consequences for equilibrium dynamics of the two types of taxation are radically different, even in the absence of automatic stabilization (i.e. $\tau = 0$).

in which the natural and the efficient level coincide)[15]. In the **efficient level** we have $mc_t = \tau_t = 0$ and using the wage-hours locus WN and the production function we have:

$$y_t^* = \gamma g_t \tag{30}$$

where $\gamma = \frac{1}{1+\varphi\frac{1-G_Y}{1-\tau}}$. As this equation makes clear, when steady-state consumption share are the same for both agents, potential output is the same as in the case of no non-Ricardian agents. Hence, the presence of these agents only affects output insofar as prices are sticky. This is not the case for the Wicksellian interest rate, defined as:

$$\begin{aligned} r_t^* &= \left[\Delta\gamma + \frac{1}{1-G_Y}\left(\nu\left(1-\tau\right)-1\right) - \nu\left(1-\phi_g\right)\right]\left(\rho_g - 1\right) g_t + \\ &+ \nu\phi_b\left[b_{t+1}^* - b_t^*\right] \end{aligned} \tag{31}$$

This is different from the natural interest rate obtained in the Ricardian economy ($\nu = 0$) since for any ν and for a given level of output and consumption of non-Ricardian agents, a different interest rate path is required to make intertemporal choices of Ricardian agents consistent with optimality.

Given these definitions, we are able to define the dynamics of our system when **only lump-sum instruments are available** ($\tau_t = 0$) as a function of inflation, interest rate, Wicksellian rate of interest and the output gap.

$$\begin{aligned} x_t &= E_t x_{t+1} - \Delta^{-1}\left(r_t - E_t\pi_{t+1} - r_t^*\right) \\ \pi_t &= \beta E_t \pi_{t+1} + \kappa x_t \end{aligned} \tag{32}$$

Note that we have used the properties of debt dynamics described in the previous section: debt is an exogenous process, and it matters only insofar as it modifies the Wicksellian interest rate. The system 32 has the form familiar from recent research in the monetary policy literature; most notably, exogenous government spending shocks influence the efficient output and Wicksellian interest rate. The only modifications are: (i) elasticity of aggregate demand to interest rate is changed; (ii) the shock to government spending has a different effect on the Wicksellian interest rate, as can be seen from 31.

When **lump-sum taxes are not available** ($l_t = 0$) all spending is financed via distortionary taxation, and since the automatic response does not match government spending the tax rate will have to vary. The **natural level of activity** (denoted with subscript 'n') is found as:

$$y_t^n = \gamma g_t - \gamma\frac{1-G_Y}{1-\tau}\tau_t^n = y_t^* - \gamma\frac{1-G_Y}{1-\tau}\tau_t^n$$

[15] Notice that the equilibrium is actually still not efficient in levels since the distortinary taxation in the steady state continues to generate a gap from the welfare optimal equilibirum. But since this gap is constant, reproducing the former equilibrium is still optimal. Consequenly, we call the discussed equilibrium efficient in the described sense.

As discussed before, under these conditions there is a gap between the efficient and the natural level of activity, coming from variations in the natural tax rate, which is also an endogenous variable. We can use the deficit rule at the natural equilibrium $\tau_t^n = \phi_g g_t + \phi_b b_t^n - \tau y_t^n$ to get[16]:

$$\begin{aligned} \tau_t^n &= \frac{\phi_g - \tau\gamma}{1 - \tau\gamma\frac{1-G_Y}{1-\tau}} g_t + \frac{\phi_b}{1 - \tau\gamma\frac{1-G_Y}{1-\tau}} b_t^* \\ y_t^n &= y_t^* - \gamma\frac{\left(\phi_g - \tau\gamma\right)\left(1 - G_Y\right)}{1 - \tau - \tau\gamma\left(1 - G_Y\right)} g_t - \gamma\frac{\phi_b\left(1 - G_Y\right)}{1 - \tau - \tau\gamma\left(1 - G_Y\right)} b_t^* \end{aligned} \tag{33}$$

Similarly, we can express the **natural interest rate** as a function of the efficient interest rate as:

$$r_t^n = r_t^* - \left[\delta\gamma\frac{1 - G_Y}{1 - \tau} + \nu\left(1 - \tau\gamma\frac{1 - G_Y}{1 - \tau}\right)\right]\left[E_t\tau_{t+1}^n - \tau_t^n\right]$$

Finally, note that the deviations of the tax rate from its natural, flex-price level (the 'tax gap') are proportional to the output gap with respect to the natural level, $x_t^n = y_t - y_t^n$:

$$\tau_t - \tau_t^n = -\tau x_t^n \tag{34}$$

Using the above, the canonical form of the model under endogenous tax rate variations is:

$$\begin{aligned} \pi_t &= \beta E_t\pi_{t+1} + \eta x_t^n \\ x_t^n &= E_t x_{t+1}^n - \delta^{-1}\left(r_t - E_t\pi_{t+1} - r_t^n\right) \end{aligned} \tag{35}$$

where $\eta = \psi\left(\chi - \frac{\tau}{1-\tau}\right)$.The presence of distortionary tax rate variations, compared to the lump-sum case, modifies two things beyond changing the natural level of activity: (i) slope of NPC (decreasing elasticity to output gap) and (ii) slope of IS curve, decreasing (in absolute value) elasticity of aggregate demand to real interest rate (unless the tax rate is zero, case in which $\delta = \Delta$). This also modifies determinacy properties as discussed in the next section.

Finally, since we were able to express 'natural' levels under distortionary taxation as functions of 'efficient' levels and exogenous shocks, it is useful to write the dynamic system in terms of gaps of actual levels from these 'efficient' levels. This ensures comparability of reduced-form dynamics under the two different taxing schemes. The output gap relative to the efficient level in terms of the output gap relative to the natural level is:

$$x_t = x_t^n - \gamma\frac{1 - G_Y}{1 - \tau}\tau_t^n \tag{36}$$

[16] Recall that the natural level of debt is equal to the efficient level of debt and to the actual level of debt, as argued previously, $b_{t+1}^n = b_{t+1}^* = b_{t+1}$.

We can then write the system having as shocks the efficient interest rate and the natural level of the tax rate:

$$\pi_t = \beta E_t\pi_{t+1} + \eta x_t + \eta\gamma\frac{1-G_Y}{1-\tau}\tau_t^n \tag{37}$$
$$E_t x_{t+1} = x_t + \delta^{-1}\left(r_t - E_t\pi_{t+1} - r_t^*\right) + \delta^{-1}\nu\left(1 - \tau\gamma\frac{1-G_Y}{1-\tau}\right)\left[E_t\tau_{t+1}^n - \tau_t^n\right]$$

This shows the specific way in which propagation of shocks is different (along with differences in coefficients):

a. shocks to tax rate under flexible prices act as cost-push shocks in the AS curve when output gap is defined with reference to the efficient level; this is *independent* of the share of non-Ricardian agents.

b. expected changes in tax rates under flexible prices act as shocks to the IS curve; this is *true only* in the presence of non-Ricardian agents.

Finally, note how Ricardian equivalence fails with distortionary taxation even when $\nu = 0$ (e.g. when only Ricardian agents are present). Government debt still affects the real allocation through its impact on the natural tax rate 33.

3.4 Equilibrium determinacy discussion

As discussed in detail in Bilbiie (2003) the key parameter to look at is the sensitivity of aggregate demand to the real interest rate. In the standard new Keynesian model this is equal to the intertemporal elasticity of substitution of the Ricardian agents (which is equal to one under log utility in consumption). However, given the introduction of fiscal policy and non-Ricardian agents this parameter modifies, and depends on the taxation scheme adopted. Under lump-sum taxation, the relevant elasticity is $\Delta \equiv \frac{1}{1-G_Y} - \nu(1-\tau)\left(\frac{G_Y}{1-G_Y} + \frac{1+\varphi}{1+\mu}\right)$.If $\Delta < 0$ (i.e. for high λ and/or φ) we end up in an economy where a real interest rate increase has a positive effect on aggregate demand. In this case, the equilibrium wage hours locus WN is less upward sloping than the aggregate labor supply curve. This is what we will call later a non-Ricardian economy. This changes the necessary conditions for equilibrium determinacy significantly. We show in the appendix that in a reasonably calibrated non-Ricardian economy, the monetary authority should behave according to an Inverted Taylor principle to ensure determinacy of the equilibrium. If $\Delta > 0$, we end up in a Ricardian economy where the Taylor principle holds in a standard way. Under distortionary taxation the relevant elasticity is $\delta > \Delta \equiv \delta - \nu\tau$ and the slope of the aggregate labor supply curve is accordingly lower (labor supply more elastic), hence it is harder to end up in the non-Ricardian case. Moreover, the slope of the AS curve η may become negative too[17]. This changes determinacy conditions, but for reasonable parameterization the modification is minor and does not alter the main message.

[17] However, this requires a tax rate larger than any empirically plausible value.

In summary, in this section we have shown how a sticky price model incorporating limited participation to asset markets and distortionary taxation can be cast in a form similar to standard models. With *lump-sum taxation*, the effects of government spending go through their impact upon the efficient (flex-price) levels of output and interest rate, as in the standard framework (see e.g. Woodford 2003). Differences come from: (i) how government spending shocks influence these 'notional' efficient levels; (ii) the elasticity of aggregate demand to real interest rates. With *distortionary taxation*, two further differences arise: (i) the tax rate under flexible prices τ_t^n occurs as an additional shock important for dynamics; (ii) the elasticities of both aggregate demand to real interest rate and inflation to output gap are changed. While this gives us a compact way of characterizing dynamics, it may tell little about the mechanism underlying the effects of fiscal policy at a more 'micro' level. This is what we try to describe next.

4 Inspecting the mechanism

4.1 The labor market

In the following we will discuss how a government spending shock is transmitted in our framework, under different financing schemes. The purpose is to understand intuitively the role of each feature in the transmission of fiscal policy; we will then perform simulations to assess quantitatively the potential importance of each channel. Following a long tradition in the fiscal policy literature (especially the RBC literature - see e.g. Christiano and Eichenbaum 1992), we emphasize the role and study closely the details of the labor market. Note that this mechanism is completely absent from GLV, as discussed at the end of this section.

First, we outline the properties of the labor supply curve and the equilibrium wage-hours locus independently of the financing scheme. Later we will discuss the mechanism under two extreme cases of lump sum and distortionary taxation only. The equilibrium wage-hours locus labeled WN is derived by taking into account all equilibrium conditions (for detailed derivation we refer to the appendix):

$$\begin{aligned} WN &: \omega_t = \left(\varphi + \frac{1+\mu}{1-G_Y}\right) n_t - \frac{1}{1-G_Y} g_t \\ LS &: \omega_t = \frac{\varphi \frac{1}{1-\lambda}}{(1+\nu(\tau - G_Y))} n_t - \frac{\nu}{(1+\nu(\tau - G_Y))} l_t + \frac{1}{(1+\nu(\tau - G_Y))} c_{s,t} \end{aligned} \tag{38}$$

Crucial to the response of all variables is the response of real wage and hours to a government spending shock. Generally, in standard models with Ricardian agents only, the main channel through which a non-productive fiscal shock is influencing the economy is the wealth effect. Ricardian agents feel poorer after a spending shock, by the present discounted value of taxes. This depresses consumption of goods and leisure and generates a downward pressure on the real wage. If prices are sticky, there is also a labor demand effect. Since firms face an increase in demand but some of them are not able to reset their price, they increase production. This generates an upward pressure on the real wage. Now the question arises which effect dominates if we introduce non-Ricardian agents in the new-keynesian set up and whether this is sufficient to get a positive response of aggregate consumption. Note that the WN curve will always shift right after a shock to government spending and this shift is independent of the share of non-Ricardian agents (again due to our assumption of no profits and no debt in the steady state). But the LS curve will also shift right. An increase in real wage would come about if: (i) the shift in LS is small enough and (ii) LS is inelastic enough.

On the latter point, we know that the labour supply elasticity depends on φ and λ. The choice of these parameters can be as high as allowed by preserving the Taylor Principle, i.e. preserving a slope of WN larger than that of LS (for a discussion of the determinacy conditions see appendix or Bilbiie 2003). But note that the reduced-form slope now depends on the reaction of taxes l_t, since these respond to output. This will be discussed in more detail below when we consider the effects of different financing schemes.

On the former point, the shift in LS is made of two components. One is the 'wealth effect' on non-Ricardian agents generated by lump-sum taxes (second term on right-hand side of LS). The size of this effect depends on the taxing scheme adopted. Note that this effect (given a magnitude of l_t) is weaker, less non-Ricardian agents there are, and more elastic is labor supply (lower ν). Since the smaller shift in labor supply means a more likely real wage increase, this partial effect goes against what might be thought at first glance: that more non-Ricardian agents make it generally easier to obtain an increase in real wage. The second shift in labor supply comes from the standard effect on Ricardian agents (shift in $c_{s,t}$) and depends on the following things.

1. The persistence of the shock ρ_g: the more persistent the shock is, the higher is the wealth effect and the larger the shift, which makes it less likely to get the increase in real wage.

2. Response of monetary policy to inflation ϕ_π: when government spends demand increases, so some firms will increase prices. This generates inflation and an interest rate response response by the monetary authority. If the response is strong (i.e. the increase in the real interest rate is strong), the Ricardian agents will prefer to postpone consumption by intertemporal substitution. Lower is ϕ_π, the lower is this effect.

3. Price stickiness α: this is related to the previous effect, higher price stickiness makes the increase in inflation smaller, and hence the potential increase in real rate is smaller[18];

[18] Both b. and c. have another interpretation, namely that the demand effect of government spending is reinforced.

4. Intertemporal path of taxation: the impact response depends on the degree of deficit financing ϕ_g and the response of deficits to debt ϕ_b (i.e on the underlying fiscal policy rule). To see the impact of the chosen fiscal policy rule we solve for the implicit tax process using the debt process found before 29 by abstracting from automatic stabilization (the quantitative effect of this is generally small). If debt starts from steady state $b_0 = 0$, the implied process for the tax item that does the adjustment (say $a_t = l_t, \tau_t$ respectively) is generally, from $a_t = \phi_g g_t + \phi_b b_t$:

$$a_t = \phi_g g_t + \phi_b \beta^{-1} \left(1 - \phi_g\right) \sum_{i=0}^{t-1} \left[\beta^{-1} \left(1 - \phi_b\right)\right]^i g_{t-1-i} \tag{39}$$

   The tax increase depends on the degree of deficit financing and debt reaction. The combination of ϕ_g and ϕ_b will matter not only for the impact response, but more importantly for the dynamics and persistence of the implied tax process and hence of all variables. Lower ϕ_g today means smaller tax response today (lower weight of contemporaneous g_t), but higher in the future (higher weight of history of process). How fast will the tax increase is dictated by ϕ_b. A higher ϕ_b means that the implied debt process will be less persistent, so the implied tax process will be less persistent ceteris paribus. Hence, the wealth effect on Ricardian agents is smaller when the response to debt is higher, since it is the present value of future taxes that matters for Ricardian agents.

5. Financing scheme: lump-sum taxation and distortionary taxation have different effects. We now elaborate on the last two points.

4.2 Lump-sum taxes

Consider first the case when government spending is financed by lump sum taxes only. The absence of distortionary taxation means that the after tax real wage is equal to the real wage $\omega_t = w_t$. By combining the fiscal rule with the definiton of deficit and setting $\tau_t = 0$ we get:

$$l_t = \phi_g g_t + \phi_b b_t - \tau \left(1 + \mu\right) n_t$$

Substituting this into the labor supply curve:

$$\begin{aligned} LS \quad : \quad w_t = {} & \frac{\varphi \frac{1}{1-\lambda} + \nu \tau \left(1 + \mu\right)}{\left(1 + \nu \left(\tau - G_Y\right)\right)} n_t - \frac{\nu}{\left(1 + \nu \left(\tau - G_Y\right)\right)} \phi_g g_t \\ & - \frac{\nu}{\left(1 + \nu \left(\tau - G_Y\right)\right)} \phi_b b_t + \frac{1}{\left(1 + \nu \left(\tau - G_Y\right)\right)} c_{s,t} \end{aligned}$$

First, the slope of the labor supply curve is higher than in 38 due to automatic stabilization (the sensitivity of lump-sum taxes to hours). This helps, ceteris paribus, to get a positive response of the real wage after a government spending shock. The second and third term come from the effect of taxation on non-Ricardian agents. Deficit financing (lower ϕ_g) decreases the shift in the labour supply curve directly through the impact on non-Ricardian agents (smaller wealth effect). A lower response to debt (ϕ_b) also decreases the wealth effect by the same channel since taxes increase less on impact. However, the path of taxation (given by 39, replacing a with l) matters for consumption of the Ricardian agents (last term). In order to get an impact increase in the real wage (a smaller wealth effect) we need *a high enough extent of deficit financing and a strong enough response to deb*t. The former makes the tax response lower for the first few periods, while the latter ensures that the present discounted value of future taxes (relevant for wealth effect on Ricardian agents) is smaller. However, note that this is only about the impact response. Since taxes will have to increase in the near future, after which they are expected to decrease, one will expect the negative wealth effect to dominate the response of consumption - this will indeed be the case, as we show when studying the quantitative effects below.

4.3 Distortionary taxes

Consider the other extreme whereby there is distortionary taxation only, where the tax rate evolves according to:

$$\tau_t = \phi_g g_t + \phi_b b_t - \tau (1 + \mu) n_t$$

The equilibrium after-tax real wage decreases when the tax rate increases. This net decrease needs to be compensated now by the shifts in the two curves for an increase in the after-tax real wage to obtain. Since $l_t = 0$ the wealth effect on non-Ricardian agents is absent, but tax rate generates substitution for Ricardian agents.

$$LS : \omega_t = \frac{\varphi \frac{1}{1-\lambda}}{(1 + \nu (\tau - G_Y))} n_t + \frac{1}{(1 + \nu (\tau - G_Y))} c_{s,t}$$

Beyond what happens to the after-tax real wage, the shift in LS is exclusively due to the effect of tax rates on Ricardian agents[19]. As shown above, the dynamics of τ_t obey (abstracting from automatic stabilization):

$$\tau_t = \phi_g g_t + \phi_b \beta^{-1} \left(1 - \phi_g\right) \sum_{i=0}^{t-1} \left[\beta^{-1} (1 - \phi_b)\right]^i g_{t-1-i}$$

The tax rate dynamics matter beyond the simple wealth effect due to their impact on the intertemporal allocation of consumption, leisure and hours by Ricardian agents. Ricardian agents postpone work for periods when taxed less and enjoy more leisure in periods of high taxation. But this also means that they transfer consumption to periods of higher taxation of labor. This substitution

[19] This is one way to see that with distortionary taxation, there is no wealth effect without intertemporal substitution.

effect on consumption works in the opposite direction of the wealth effect; which effect will dominate depends on the particular parameterization considered. The crucial parameters for the influence of tax rates on the intertemporal allocation are the intertemporal elasticity of substitution in labor supply φ and the deficit rule parameters.

Finally, notice that even a strong increase in (after-tax) real wage and therefore a strong increase in consumption of non-Ricardian agents **does not ensure** that aggregate consumption responds positively to a government spending shock. An increase in the real wage implies a strong increase in marginal cost (countercyclical markup) and hence a fall in profits, so a further decrease in consumption of Ricardian agents. This last effect is stronger the higher is the ratio of Ricardian agents in the economy and the more inelastic labor supply is. So a strong increase in real wage does not grant an increase in aggregate consumption and needs to be complemented by other features. For instance in GLV, wages and hours are not determined by optimization and market clearing. Instead of a labor supply decision, a 'generalized wage schedule' is postulated that relates total hours to the real wage. Moreover, hours are taken to be equal across the two types of agents at all times and states. Given wealth heterogeneity, we see no obvious reason for shutting off one potentially informative (and perhaps plausible) channel of implied behavioral heterogeneity, namely the response of hours worked to taxation. Indeed, we emphasize the labor market and real wage determination as crucial for the transmission of fiscal policy.

5 Impulse Responses after a Government Spending Shock

In the foregoing we have discussed channels for the transmission of government spending shocks (and the implied tax dynamics). We now try to assess their relative importance quantitatively. We shall study separately the two financing schemes. We start from the deterministic steady state and assume that government is purchasing one unit of the final good (hence, we shock the g process accordingly). We then study the dynamic responses of macroeconomic variables as dictated by either 32 or 37 for the lump-sum and the distortionary tax case respectively. Since 32 and 37 are canonical forms[20], having found a path of output gap and inflation the paths of the other variables are easily found.

For each of the two financing schemes, we study the relative importance of some parameters for the response of the economy to a spending shock. We consider a baseline parameterization, and then vary one parameter at a time. We group parameters or which this exercise is carried in three classes: (i) parameters crucial for the slope of aggregate demand (and for the difference of slopes between LS and WN) such as φ and λ; (ii) fiscal policy rule parameters ϕ_g, ϕ_b and (iii) other parameters, namely the monetary policy response to inflation ϕ_π,

[20] To be rigorous, in the canonical form the interest rate is also substituted using the interest rate rule.

the shock persistence ρ_g and the price stickiness parameter α. The reason why we study these last parameters separately is, as the alert reader would expect, that they are crucial for a positive response of private consumption to obtain. In the baseline parameterization we use the following parameter values. The price stickiness parameter α is set to 0.75. The steady state tax rate τ equals 0.3.The share of government spending in total output $G_Y = 0.2$. Both the fixed cost parameter F_Y and the steady state mark up are equal to 0.2. The time preference rate β equals 0.99. The persistence parameter of the government spending shock is set to the value of 0.9. In the benchmark case we set the inverse elasticity of labor supply φ to 2 (such that Frisch elasticity is 0.5).The deficit response to government spending (1-ϕ_g) is equal to 0.88, while the response to debt ϕ_b is set to 0.3. For the described parameter values, the real interest rate elasticity of aggregate demand is positive if the share of non-Ricardian agents is larger that 0.4275 . Therefore we set first the share of the non-Ricardian agents λ to 0.4 and the response coefficient of the monetary authority ϕ_π to 1.5; since the Taylor principle is a good policy guide in this case, this ensures equilibrium determinacy.

The first set of experiments in Figure 1 compares the baseline parameterization with two alternatives in which φ and λ are varied respectively. Limits to the choice of both φ and λ are dictated by the desire to preserve the positive slope of aggregate demand. Since for the baseline parameterization we are already close to the threshold, the variations consider a lower share of non-Ricardian agents $\lambda = 0$ and and infinitely elastic labor supply $\varphi = 0$. Under the baseline parameterization, a positive impact response of private consumption is possible, although this only lasts for two quarters. Thereafter, consumption decreases. We can explain this using the mechanism described in the previous section. Since under the baseline parameterization the slopes of LS and WN are not very different, an increase in the real wage requires a small shift in the LS curve. This is the case here since there is a high degree of deficit financing and a high response to debt. Consumption increases on impact because of the strong increase in real wage making consumption of non-Ricardian agents dominate that of Ricardian agents. However, since the implied tax process is hump-shaped, once taxes increase the non-Ricardian agent starts to work more and enjoy less leisure and consumption, while the Ricardian agents' fall in consumption is persistent (for permanent income reasons). This makes aggregate consumption fall, reaching a minimum value where the tax process reaches its maximum. Output and inflation increase, since both hours and real wage go up. When the share of non-Ricardian agents tends to zero, as in the ... graph, the response of the real wage is much lower. Consumption falls unambiguously and the multiplier on output is lower than one (this depends on labor supply elasticity). The real wage does increase but by much less despite the shift in LS being smaller, since the difference between the slopes of WN and LS is higher. This leads to a smaller response of hours also, and hence a smaller multiplier on output. When labor supply is infinitely elastic, consumption and the real wage do not move. Note that in this case, as argued before, consumption is independent of wealth and all wealth effect is accommodated through labor supply (by both agents) . Hence, the shift in the WN curve is along the horizontal LS curve, and hours and output increase proportionally to the spending shock. Consumption does not move (only because there is no capital), no inflation results and output is at its efficient level. We interpret this first set of experiments as showing that if one wants to explain a positive and persistent response of private consumption (as seen in the data at least for some periods) one needs to look elsewhere than at labor supply elasticity and share of non-Ricardian agents.

Figure 2 considers variations in the second set of parameters (concerning the deficit rule). We consider respectively a high $\phi_g = 1$ and low $\phi_b = 0.03$ (since in the baseline parameterization ϕ_g is 'low' and ϕ_b 'high'). As anticipated in the discussion of the role of the fiscal rule, in both cases there is a smaller increase in real wage with respect to the baseline. A smaller degree of deficit financing (higher ϕ_g) implies that taxes are raised earlier and debt does not accumulate. This induces a higher wealth effect, so a higher shift in LS with respect to the baseline. The real wage still goes up, but consumption falls (the multiplier on output is less than unity). With a low response to debt $\phi_b = 0.03$ debt is allowed to accumulate for a long period, and taxes go gradually from low to persistently high values (pretty much the opposite of the balanced-budget case). The real wage increases by slightly more than in the balanced-budget case, since the wealth effect on non-Ricardian agents is largely absent. Recall, however, that the wealth effect on Ricardian agents is stronger in this case, since the present discounted value of taxes that they face is higher. The relative importance of these effects on the two groups determines the relative magnitude of the real wage response. In the two parameterization considered, it happens that the responses of output, consumption and inflation are largely the same; but it should be clear that the mechanism underlying them is completely different and relies upon an 'internalization' by Ricardian agents of the reaction of the non-Ricardian through their taking into account of future taxation.

In Figure 3 we present variations in the third set of parameters with respect to the baseline, namely: a smaller monetary policy response to inflation ϕ_π =1.1, but not small enough to generate indeterminacy; a smaller persistence of the government spending shock $\rho_g = 0.8$ (large enough to be empirically implausible, see e.g. Finn 1998); a slightly higher price stickiness parameter $\alpha = 0.8$ (well in line with some estimates, e.g. Smets and Wouters 2003). As already anticipated when 'inspecting the mechanism' (see points 1 to 3), all these variations make the response of the real wage higher, and consequently consumption is higher, and the positive response is more persistent. This happens since a lower ρ_g means a smaller wealth effect on Ricardian agents, while both lower ϕ_π and higher α reinforce the demand effect of government spending (see discussion in previous section). Only a combination of these three variations can lead to a positive and persistent aggregate consumption response.

In Figures 4 to 6 we report exactly the same experiments where government spending is financed by distortionary taxation[21]. Generally this set of exercises

[21] Notice that output gap is defined this time as deviation from the efficient and not from the natural level of output (which were equal in the last set of experiments).

shows that it is less likely to get a positive response of aggregate consumption. The main reason is, as discussed in the previous section, that the after tax real wage response is generally lower under distortionary taxation. Indeed, for variations in the first two sets of parameters (figures 4 and 5), the real wage actually decreases in most cases, since the shift in the LS curve induced by the wealth effect on Ricardian agents is high enough to offset the shift in the WN curve, and the substitution effect. The only exception is the case whereby the debt response is low, case in which the real wage increase for the first few quarters, since Ricardian agents face a low tax rate today with respect to a long-lasting high tax rate in the future, and hence prefer to work more today. Note that in some cases (infinitely elastic LS or zero mass of non-Ricardian agents) output and hours can even decrease, which is due to the substitution effect dominating[22]. One other thing to note is the response of output and inflation in Figure 5. While the inflation responses are very similar no matter the deficit rule adopted, the output response is very different and follows the path of tax rates: with balanced budget, there is a small multiplier, but stays persistently above zero. With deficit financing and a big response to debt, the multiplier is much larger in the first periods, but actually becomes negative after the tax process has reached its peak, for then it becomes optimal to postpone work. Finally, in Figure 6 we vary parameters that we judged as crucial for a positive consumption response with lump-sum taxation. Variations of the same magnitude turn out not to be enough anymore, as expected. However, a persistently positive consumption response can still be obtained by adopting some combination of these three parameters (not reported).

6 Non-Keynesian effects of fiscal policy

Some authors, starting with Giavazzi and Pagano 1990[23] have found that fiscal consolidations (reductions in deficits, and especially spending cuts) may have expansionary effects on output and consumption: 'expansionary fiscal contractions', or 'non-Keynesian' effects of fiscal policy. A variety of theoretical explanations have been offered (for a review see Perotti 1999). The model outlined here is able to produce expansionary fiscal contractions (spending cuts) under a particular scenario, i.e. in a *non-Ricardian economy*, whereby the share of non-Ricardian agents is high enough to make the slope of the IS curve change sign, or equivalently to make the WN locus less upward sloping than the LS curve. In such a case the Inverted Taylor principle is a good guide for policy - see Bilbiie 2003 for details and empirical evidence favoring such a view for the US economy in the pre-Volcker era. In this parameterization, we change $\lambda = 0.5$ and $\phi_\pi = 0.8$ with respect to the baseline.

We report results of cutting government spending by one commodity unit

[22] Note that such a situation can generate co-movement of consumption and hours, but both would actually decrease, which is not observed in the data - see also Fatas and Mihov 2003 for a discussion in the standard RBC model.

[23] See also Perotti 1999, Alesina Perotti and Tavares , etc.

in Figures 7 and 8 (one for each financing scheme), varying the deficit rule parameters as previously[24]. With lump-sum taxation, a cut in government spending increases private consumption and output; notably, if the spending cut is associated with a tax cut (and hence not a reduction in deficit), output can actually decrease. When the response to debt is low, the fall in debt and deficits (increase in surplus) is sustained, private consumption increases and the effcet on output is negligible. The intuition for such non-Kynesian effects is simple once one recognizes that shifts in the LS and WN curves are largely the same as in a Ricardian economy (however, note opposite sign since government spending decreases), except for two interrelated issues: the slope of the LS curve is higher than that of WN, and the passive monetary policy rule makes any increase in inflation be associated with a fall in the real rate, and an increase in consumption of Ricardian agents. A shift of WN to the left now means an increase in both wage and hours, keeping constant LS. Hours (and even wage) can only decrease if LS shifts left too much, which is the case under the balanced-budget experiment. Note, however, that a fiscal consolidation is a spending cut leading to a fall in deficit rather than in taxes. With distortionary taxation, the responses are very similar. However, even when the cut in spending leads to a fall in the tax rate, output still increases.

Figures 7 and 8 here.

The effects of fiscal policy *switch sign* once the value of the share of Non-Ricardian agents switches (and implicitly, the policy response to inflation also changes to make the model consistent with a unique equilibrium). The described results depend on the interaction of two different factors: low asset market participation and a passive monetary policy rule. We are exploring the empirical plausibility of such a scenario in explaining such non-Keynesian fiscal policy effects in current work.

7 Conclusion

Recent research has tried to explain why private consumption increases after a positive government spending shock. Gali, Lopez-Salido and Valles (2003) augment a standard sticky price dynamic general equilibrium model with two other key frictions: part of the agents do not smooth consumption and the labor market is non-Walrasian in a specific sense. Namely, hours worked and wages obey an ad-hoc schedule, and fluctuations in hours worked are independent of wealth (and consumption smoothing). Under these assumptions, a deficit-financed spending shock can generate an increase in consumption.

We have studied a model similar to GLV, but with distortionary taxation and a Walrasian labor market, emphasizing the role of the labor market in the transmission of fiscal policy. For each of the extreme cases of lump-sum and distortionary taxation, we have reduced the model to a two-equation system similar to the workhorse 'new synthesis' model used in modern monetary policy

[24] Other variations similar to those found before preserved the same features and intuition as the baseline case.

analysis. We emphasized the modifications induced upon dynamics by the presence of non-Ricardian agents and distortionary taxation. Given the simplicity of these reduced-form systems, some researchers might find these of independent interest.

In what concerns the response of macroeconomic variables to government spending shocks, we find that in general it is very difficult to obtain the positive response of private consumption found in the data (see body text for details and explanation of mechanism). This result is relatively more difficult to obtain with distortionary taxation. The three ways to obtain a positive and persistent increase in consumption in the present framework are: if the spending shock is not too persistent and/or the monetary response to inflation is low enough and/or price stickiness is high enough. Most importantly, in the framework presented here, even when a positive consumption response is obtained, it is entirely driven by a strong positive response of the real wage. This in itself is not a desirable feature of such models, since it is at odds both with the acyclicality of the real wage and with the small conditional response of real wage to government spending. The model gives too much role to cyclical movements in real wages in explaining business cycle fluctuations, contradicting what Christiano and Eichenbaum call *Lucas' less famous critique.*

Finally, we have presented an alternative theoretical explanation of the expansionary effects of fiscal consolidations on output and consumption. Our current research investigates the empirical plausibility of this paper's mechanism (a structural change in asset markets participation and aggregate demand) to underlie non-Keynesian effects of fiscal policy.

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A Loglinearized equilibrium

Ricardian:

Euler equation, intratemporal and budget constraint (o_t are profits as a share of steady-state GDP, $o_t = \frac{O_t - O}{Y}$ and $b_t = \frac{B_t - B}{PY}$):

Note also that τ_t is deviations of tax rate from its steady state value τ.

$$
\begin{aligned}
E_t\left[c_{s,t+1}\right] - c_{s,t} &= r_t - E_t\left[\pi_{t+1}\right] && (40)\\
\varphi_s n_{s,t} &= w_t - c_{s,t} - \frac{1}{1-\tau}\tau_t \text{ where } \varphi_S = \left[\frac{\gamma_S N_s}{1-N_s}\right] && (41)\\
\frac{C_S}{Y} c_{s,t} &= (1-\tau)\frac{W}{P}\frac{N_s}{Y}\left(w_t + n_{s,t} - \frac{1}{1-\tau}\tau_t\right) - l_t \\
&\quad + (1-\tau)\frac{1}{1-\lambda} o_t - R^{-1}\frac{1}{1-\lambda} b_{t+1} + \frac{1}{1-\lambda} b_t && (42)
\end{aligned}
$$

Non-Ricardian

Intratemporal and budget constraint:

$$
\begin{aligned}
\varphi_h n_{h,t} &= w_t - c_{h,t} - \frac{1}{1-\tau}\tau_t,\ \varphi_H = \left[\frac{\gamma_H N_H}{1-N_H}\right] && (43)\\
\frac{C_H}{Y} c_{h,t} &= (1-\tau)\frac{W}{P}\frac{N_h}{Y}\left(w_t - \frac{1}{1-\tau}\tau_t + n_{h,t}\right) - l_t && (44)
\end{aligned}
$$

Firms:

$$
\begin{aligned}
y_t &= (1+F_Y)\, n_t && (45)\\
mc_t &= w_t && (46)\\
o_t &= -\frac{1+F_Y}{1+\mu} mc_t + \frac{\mu}{1+\mu} y_t && (47)\\
\pi_t &= \beta E_t \pi_{t+1} + \psi mc_t,\ \psi = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} && (48)
\end{aligned}
$$

Government:

Note $B_{PY} = 0$ to simplify debt dynamics, $g_t = \frac{G_t - G}{Y}, l_t = \frac{L_t - L}{Y}, b_{t+1} = \frac{B_{t+1}/P_t - B/P}{Y}$ is real debt deflated by previous period's price level to keep it predetermined

$$\beta b_{t+1} = b_t + g_t - l_t - \tau y_t - \tau_t \tag{49}$$

g_t is an AR(1) exogeous process, we need two more equations for l_t and τ_t. It is useful to define the policy-relevant variable budget deficit d_t deviations from steady state as percent of SS GDP:

$$d_t = g_t - l_t - \tau y_t - \tau_t \tag{50}$$

Note that here is automatic stabilization from distortionary taxation: when y is high, deficit is low. First, we need a rule for the deficit, taken as in Woodford's 4.4, also Gali et al, Leeper, etc.

$$d_t = \left(1 - \phi_g\right) g_t - \phi_b b_t \tag{51}$$

ϕ_g gives the extent of deficit financing: when it is zero, spending is entirely deficit-financed, when it is one it is tax- financed. ϕ_b is there to make fiscal policy locally Ricardian in the standard model. The foregoing says how tax revenues adjust when spending modifies: we need one more equation to divide the burden between the two types of taxation. The obvious extremes are (i) no variation in the tax rate; (ii) no lump-sum instruments.

Market clearing

Labour market (n =labour demand by firms)

$$n_t = \frac{\lambda N_H}{N} n_{h,t} + \frac{(1-\lambda) N_s}{N} n_{s,t} \tag{52}$$

Aggregate consumption is:

$$c_t = \frac{\lambda C_H}{C} c_{h,t} + \frac{(1-\lambda) C_s}{C} c_{s,t} \tag{53}$$

Aggregate resource constraint - equilibrium in goods market, holds by Walras' law, and is redundant.

$$y_t = \frac{C}{Y} c_t + g_t \tag{54}$$

Monetary policy rule:

$$r_t = \phi_\pi E_t \pi_{t+k} \tag{55}$$

B Steady state

$$\begin{aligned} R &= \frac{1}{\beta} \text{where } R \equiv 1 + r \\ \frac{W}{P} &= \frac{Y+F}{N}\frac{MC}{P} = \frac{Y}{N}\frac{1+\frac{F}{Y}}{1+\mu} \\ profits &: \frac{O}{Y} = \frac{\mu - F_Y}{1+\mu} \end{aligned}$$

We assume hours are the same for the two groups in steady state only, $N_H = N_S = N$, and the risk aversion to variations in leisure is also homogeneous across groups, $\gamma_H = \gamma_S = \gamma$[25]. Then, for the loglinear budget constraints of

[25] From the intratemporal optimality conditions evaluated at the steady state, $\theta_j (1-N)^{-\gamma} = (1-\tau) \frac{1}{C_j} \frac{W}{P}$ this can be the case only if relative preference for leisure θ_j is different across groups, such that consumption in steady state can also be different. When these latter are equal, preferences for leisure are also homogeneous.

both agents the coefficients are fully determined:

$$\begin{aligned}
(1-\tau)\frac{W}{P}\frac{N}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu}; \\
\frac{C_S}{Y} &= (1-\tau)\frac{1}{1-\lambda}\left(1-\lambda\frac{1+F_Y}{1+\mu}\right)-L_Y \\
\frac{C_H}{Y} &= (1-\tau)\frac{1+F_Y}{1+\mu}-L_Y
\end{aligned}$$

For simplification, let $\mu = F_Y$ so share of profits in steady-state O_Y is zero, consistent with evidence and arguments in i.a. Rotemberg and Woodford (1995), and with the very idea that the number of firms is fixed in the long run. Assume also $B_{PY} = 0$ which makes:

$$\frac{C_H}{Y} = \frac{C_S}{Y} = C_Y = 1-\tau-L_Y = 1-G_Y$$

In this case the relative preference for leisure is also common to both agents.

C Derivations of the Wage Hours Locus

Derive wage-hours equilibrium locus, first expressing hours of Ricardian agents as function of total hours and hours of non-Ricardian and using 60:

$$n_{s,t} = \frac{1}{1-\lambda}n_t - \frac{\lambda}{1-\lambda}(\tau-G_Y)\,\theta\omega_t - \frac{\lambda}{1-\lambda}\theta l_t \tag{56}$$

From intratemporal optimality of Ricardian agents:

$$\begin{aligned}
&: \quad \varphi\frac{1}{1-\lambda}n_t - \varphi\frac{\lambda}{1-\lambda}(\tau-G_Y)\,\theta\omega_t - \varphi\frac{\lambda}{1-\lambda}\theta l_t = \\
&= \quad \omega_t - \frac{1}{1-\lambda}c_t + \frac{\lambda}{1-\lambda}\left[1-\varphi(\tau-G_Y)\,\theta\right]\omega_t - \nu l_t \\
&: \quad \varphi\frac{1}{1-\lambda}n_t + \frac{1}{1-\lambda}c_t = \left[\frac{1}{1-\lambda} - \frac{\lambda}{1-\lambda}\varphi(\tau-G_Y)\,\theta + \varphi\frac{\lambda}{1-\lambda}(\tau-G_Y)\,\theta\right]\omega_t \\
&: \quad \varphi n_t + \frac{1}{1-G_Y}y_t - \frac{1}{1-G_Y}g_t = \omega_t
\end{aligned}$$

So WN locus is now:

$$WN : \left(\varphi + \frac{1+\mu}{1-G_Y}\right)n_t = \omega_t + \frac{1}{1-G_Y}g_t \tag{57}$$

In terms of output, from the produciton function:

$$\left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right)y_t = \omega_t + \frac{1}{1-G_Y}g_t \tag{58}$$

We can now express consumption of Ricardian agents as a function of output:

$$
\begin{aligned}
&: \quad c_{s,t} = \frac{1}{1-\lambda}\left[\frac{1}{1-G_Y}y_t - \frac{1}{1-G_Y}g_t\right] - \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\omega_t + \nu l_t = \\
&: \quad = \frac{1}{1-\lambda}\frac{1}{1-G_Y}y_t - \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right)y_t + \\
&: \quad + \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\frac{1}{1-G_Y}g_t - \frac{1}{1-\lambda}\frac{1}{1-G_Y}g_t + \nu l_t + \nu g_t - \nu g_t = \\
&: \quad = \frac{1}{1-\lambda}\frac{1}{1-G_Y}\left[1-\lambda\left(1-\varphi\left(\tau - G_Y\right)\theta\right)\left(1+\frac{\varphi\left(1-G_Y\right)}{1+\mu}\right)\right]y_t - \nu\left(g_t - l_t\right) + \\
&: \quad + \frac{1}{1-\lambda}\frac{1}{1-G_Y}\left[\lambda\varphi\theta\left(1-G_Y\right) - 1 + \lambda\left(1-\varphi\theta\left(\tau - G_Y\right)\right)\right]g_t
\end{aligned}
$$

$$
\begin{aligned}
c_{s,t} &= \delta y_t - \nu\left(g_t - l_t\right) + \frac{1}{1-G_Y}\left(\nu\left(1-\tau\right) - 1\right)g_t \qquad (59) \\
\delta &\equiv \frac{1}{1-G_Y} - \varphi\frac{\lambda}{1-\lambda}\frac{1}{1+\mu} + \nu\left(\tau - G_Y\right)\left(\frac{1}{1-G_Y} + \varphi\frac{1}{1+\mu}\right)
\end{aligned}
$$

When there is no lump-sum taxation, consumption of Ricardian agents as a function of output is:

$$
\begin{aligned}
&: \quad c_{s,t} = \frac{1}{1-\lambda}\left[\frac{1}{1-G_Y}y_t - \frac{1}{1-G_Y}g_t\right] - \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\omega_t = \\
&: \quad = \frac{1}{1-\lambda}\frac{1}{1-G_Y}y_t - \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right)y_t + \\
&: \quad + \frac{\lambda}{1-\lambda}\left[1-\varphi\left(\tau - G_Y\right)\theta\right]\frac{1}{1-G_Y}g_t - \frac{1}{1-\lambda}\frac{1}{1-G_Y}g_t \\
&: \quad = \frac{1}{1-\lambda}\frac{1}{1-G_Y}\left[1-\lambda\left(1-\varphi\theta\left(\tau - G_Y\right)\right)\left(1+\frac{\varphi\left(1-G_Y\right)}{1+\mu}\right)\right]y_t - \\
&: \quad - \frac{1}{1-\lambda}\frac{1}{1-G_Y}\left[1-\lambda\left(1-\varphi\theta\left(\tau - G_Y\right)\right)\right]g_t = \\
&: \quad = \delta y_t - \frac{1}{1-G_Y}\left[1+\nu\left(\tau - G_Y\right)\right]g_t
\end{aligned}
$$

Where $\delta \equiv \frac{1}{1-G_Y} - \varphi\frac{\lambda}{1-\lambda}\frac{1}{1+\mu} + \nu\left(\tau - G_Y\right)\left(\frac{1}{1-G_Y} + \varphi\frac{1}{1+\mu}\right)$.

D Deriving the IS-AS system

We seek to express everything in terms of aggregate variables, and then use the two dynamic equations to get dynamics only in terms of output, inflation and interest rate. All derivations are detailed in the appendix. Let $\omega_t \equiv w_t - \frac{1}{1-\tau}\tau_t$ be after-tax real wage and note $\varphi_S = \varphi_H = \varphi$. We first solve for hours and consumption of non-Ricardian as a function of after-tax real wage and lump-sum transfers:

$$
\begin{aligned}
n_{h,t} &= (\tau - G_Y)\,\theta\omega_t + \theta l_t && (60)\\
c_{h,t} &= [1 - \varphi(\tau - G_Y)\,\theta]\,\omega_t - \varphi\theta l_t && (61)\\
\theta &\equiv \frac{1}{1 - \tau + \varphi(1 - G_Y)}
\end{aligned}
$$

The equilibrium wage-hours locus locus is:

$$
WN : \left(\varphi + \frac{1+\mu}{1-G_Y}\right) n_t = \omega_t + \frac{1}{1-G_Y} g_t \qquad (62)
$$

We can now express consumption of Ricardian agents as a function of output as:

$$
\begin{aligned}
c_{s,t} &= \delta y_t - \nu(g_t - l_t) + \frac{1}{1-G_Y}(\nu(1-\tau) - 1)\, g_t && (63)\\
\delta &\equiv \frac{1}{1-G_Y} - \varphi\frac{\lambda}{1-\lambda}\frac{1}{1+\mu} + \nu(\tau - G_Y)\left(\frac{1}{1-G_Y} + \varphi\frac{1}{1+\mu}\right)
\end{aligned}
$$

We now have a relationship between forward-looking part of aggregate demand (consumption of savers) and total aggregate demand. Note that we have written the equation such that we emphasize that government spending has an effect on its own, and one through the mismatch between spending and taxes $g_t - l_t = d_t + \tau y_t + \tau_t$. Substituting this we have

$$
\begin{aligned}
c_{s,t} &= (\delta - \nu\tau)\, y_t - \nu d_t - \nu\tau_t + \\
&: +\frac{1}{1-G_Y}(\nu(1-\tau) - 1)\, g_t
\end{aligned}
$$

Now to the canonical form: we first derive the AS equation, noting $mc_t = w_t = \omega_t + \frac{1}{1-\tau}\tau_t$, using the relation betwen output and after-tax real wage and the NKPC in terms of marginal cost:

$$
\begin{aligned}
&: \quad mc_t = \left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right) y_t - \frac{1}{1-G_Y} g_t + \frac{1}{1-\tau}\tau_t \\
&: \quad \pi_t = \beta E_t \pi_{t+1} + \psi\left(\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}\right) y_t - \psi\frac{1}{1-G_Y} g_t + \psi\frac{1}{1-\tau}\tau_t
\end{aligned}
$$

The IS curve is obtained by replacing consumption in the Euler equation of Ricardian agents:

$$
\begin{aligned}
&: \quad (\delta - \nu\tau)\,[E_t y_{t+1} - y_t] = r_t - E_t[\pi_{t+1}] + \nu[E_t d_{t+1} - d_t] + \\
&: \quad +\nu[E_t\tau_{t+1} - \tau_t] - \frac{1}{1-G_Y}(\nu(1-\tau) - 1)[E_t g_{t+1} - g_t]
\end{aligned}
$$

E Lump-sum taxation

In the first scenario, tax rates do not vary, $\tau_t = 0$ at all times, but tax *revenues* of course vary automatically in response to cyclical conditions (since τ is different from zero) - this captures a realistic feature of budgets. Recalling that the dynamics of deficit and debt are the same independently of the distortions, we obtain the IS curve:

$$(\delta - \nu\tau)\left[E_t x_{t+1} - x_t\right] = \left(r_t - E_t\left[\pi_{t+1}\right] - r_t^*\right)$$

So as long as debt does not explode (FP locally Ricardian) $\beta^{-1}(1-\phi_b) < 1$, we need two explosive roots of the system :

$$\begin{aligned} x_t &= E_t x_{t+1} - \Delta^{-1}\left(r_t - E_t\left[\pi_{t+1}\right] - r_t^*\right) \\ \pi_t &= \beta E_t \pi_{t+1} + \kappa x_t \\ r_t &= \phi_\pi E_t \pi_{t+1} \\ r_t^* &= \text{ given above as fct. of } g_t, b_t^* \end{aligned}$$

Where $\Delta \equiv \delta - \nu\tau = \frac{1}{1-G_Y} - \nu(1-\tau)\left(\frac{G_Y}{1-G_Y} + \frac{1+\varphi}{1+\mu}\right)$. Note $\Delta < 0$ iff $\frac{\lambda}{1-\lambda} > \frac{1}{\varphi\theta(1-\tau)\left(G_Y + (1-G_Y)\frac{1+\varphi}{1+\mu}\right)}$

$$\lambda > \bar{\lambda} \equiv \frac{1}{1 + \varphi\theta(1-\tau)\left(G_Y + (1-G_Y)\frac{1+\varphi}{1+\mu}\right)} \tag{64}$$

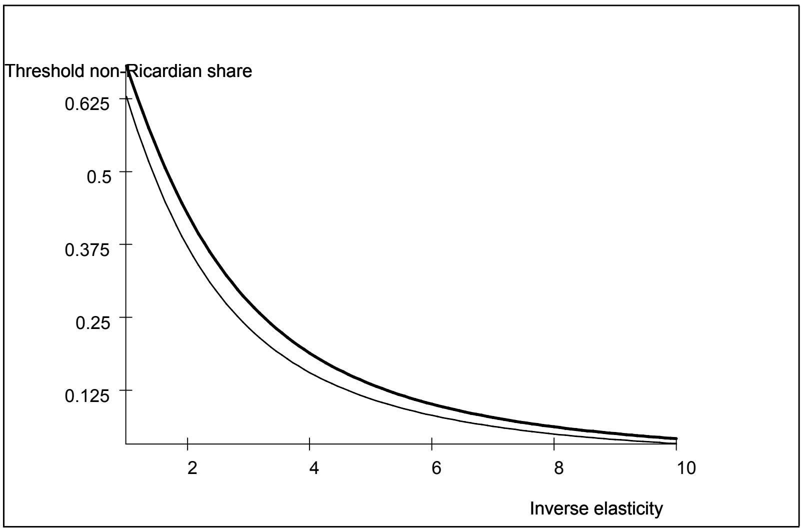

Fig A:Threshold non-Ricardian share as function of inverse Frisch elasticity for zero tax rate (dashed) and 0.3 (solid).

F Endogenous tax rate variations

Suppose no lump-sum taxes are available

$$\begin{aligned} d_t &= g_t - \tau y_t - \tau_t = \left(1 - \phi_g\right) g_t - \phi_b b_t \\ \tau_t &= \phi_g g_t + \phi_b b_t - \tau y_t \end{aligned}$$

We can now write the Philips curve in terms of the output deviation from the natural level, $x_t^n = y_t - y_t^n$. First note that the deviations of the tax rate from its flex-price level (the 'tax gap'):

$$\tau_t - \tau_t^n = -\tau x_t^n \tag{65}$$

The New Philips curve and the IS curve are then (replacing 65 into **??** and re-writing the Euler equation):

$$\begin{aligned} \pi_t &= \beta E_t \pi_{t+1} + \eta x_t^n, \eta = \psi \left(\chi - \frac{\tau}{1-\tau} \right) \\ E_t x_{t+1}^n &= x_t^n + \delta^{-1} \left(r_t - E_t \pi_{t+1} - r_t^n \right) \end{aligned}$$

It is useful to write the dynamic system in terms of gaps of actual levels from these 'efficient' levels. The output gap relative to the efficient level in terms of the output gap relative to the natural level is:

$$x_t = x_t^n - \gamma \frac{1 - G_Y}{1 - \tau} \tau_t^n$$

We can then write the system having as shocks the efficient interest rate and the natural level of the tax rate:

$$\begin{aligned} \pi_t &= \beta E_t \pi_{t+1} + \eta x_t + \eta \gamma \frac{1 - G_Y}{1 - \tau} \tau_t^n \\ E_t x_{t+1} &= x_t + \delta^{-1} \left(r_t - E_t \pi_{t+1} - r_t^* \right) + \delta^{-1} \nu \left(1 - \tau \gamma \frac{1 - G_Y}{1 - \tau} \right) \left[E_t \tau_{t+1}^n - \tau_t^n \right] \end{aligned}$$

This shows the specific way in which propagation of shocks is different (along with differences in coefficients): a. shocks to tax rate under flexible prices act as cost-puch shocks in the AS curve - this is independent of the share of non-Ricardian agents; b. changes in tax rates under flexible prices act as shocks to the IS curve - this is true only in the presence of non-Ricardian agents.

Determinacy properties: the transition matrix is now:
$\begin{pmatrix} \left(1 - \beta^{-1} \eta \delta^{-1} \left(\phi_\pi - 1\right)\right) & \delta^{-1} \left(\phi_\pi - 1\right) \beta^{-1} \\ -\beta^{-1} \eta & \beta^{-1} \end{pmatrix}$,

Need eigenvalues be outside unit circle, trace: $\frac{1}{\beta} - \frac{\eta}{\beta\delta} \left(\phi_\pi - 1\right) + 1$, determinant: $\frac{1}{\beta}$.

$$\begin{aligned} \det - trace &= \frac{\eta}{\beta\delta} \left(\phi_\pi - 1\right) - 1 \\ \det + trace &= \frac{2}{\beta} - \frac{\eta}{\beta\delta} \left(\phi_\pi - 1\right) + 1 \end{aligned}$$

Figure 1:

CAse A: $\det - trace > -1$, $\det + trace > -1$ so

$$\begin{aligned} \eta\delta^{-1}\left(\phi_{\pi}-1\right) &> 0 \\ \eta\delta^{-1}\left(\phi_{\pi}-1\right) &< 2\left(1+\beta\right) \end{aligned}$$

Case B can be ruled out. So now even if $\delta^{-1} < 0$, can have Taylor principle hold (for $\delta^{-1} > 0$, can have Inverted Taylor principle hold) if $\eta < 0$ that is $\frac{\tau}{1-\tau} > \frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}; \eta > \frac{2\delta(1+\beta)}{\phi_{\pi}-1}$ so

$$\tau > \frac{\frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}}{1 + \frac{\varphi}{1+\mu} + \frac{1}{1-G_Y}}$$

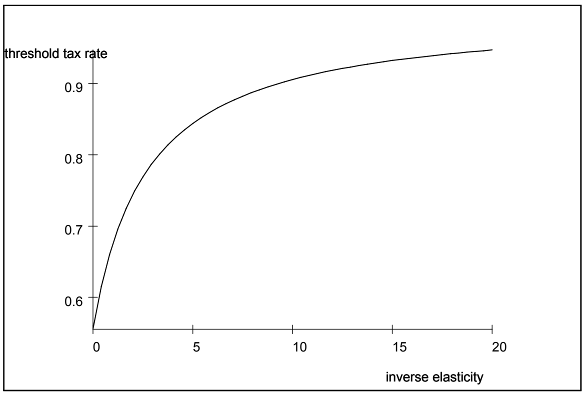

Fig B: Threshold tax rate making slope of Philips curve change

However, this is empirically implausible (tax rates are only around 0.3 on average - see Mendoza, Razin and Tesar).

G Figures

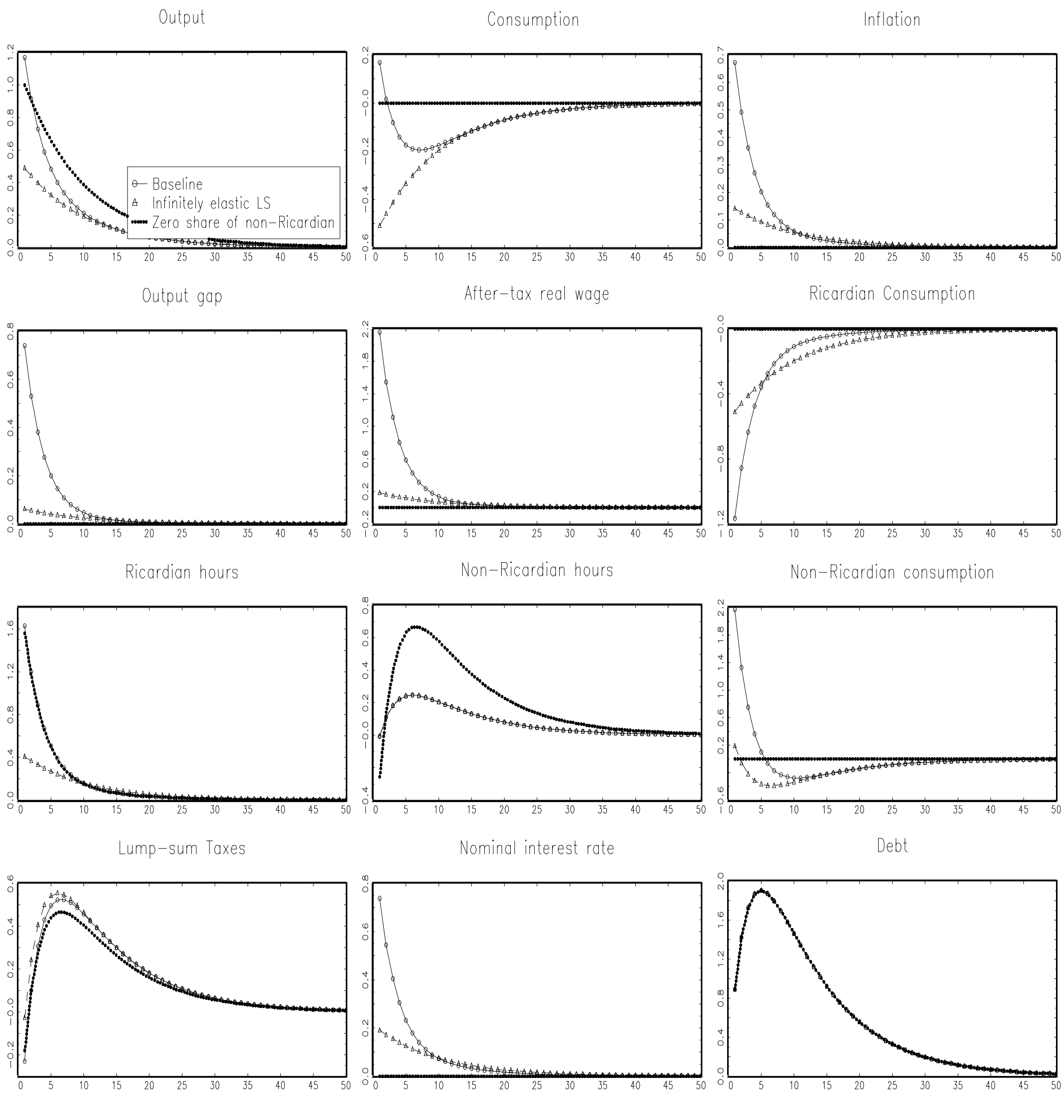

Fig 1: Effects of one unit shock to government spending under lump-sum taxation, first set of parameters.

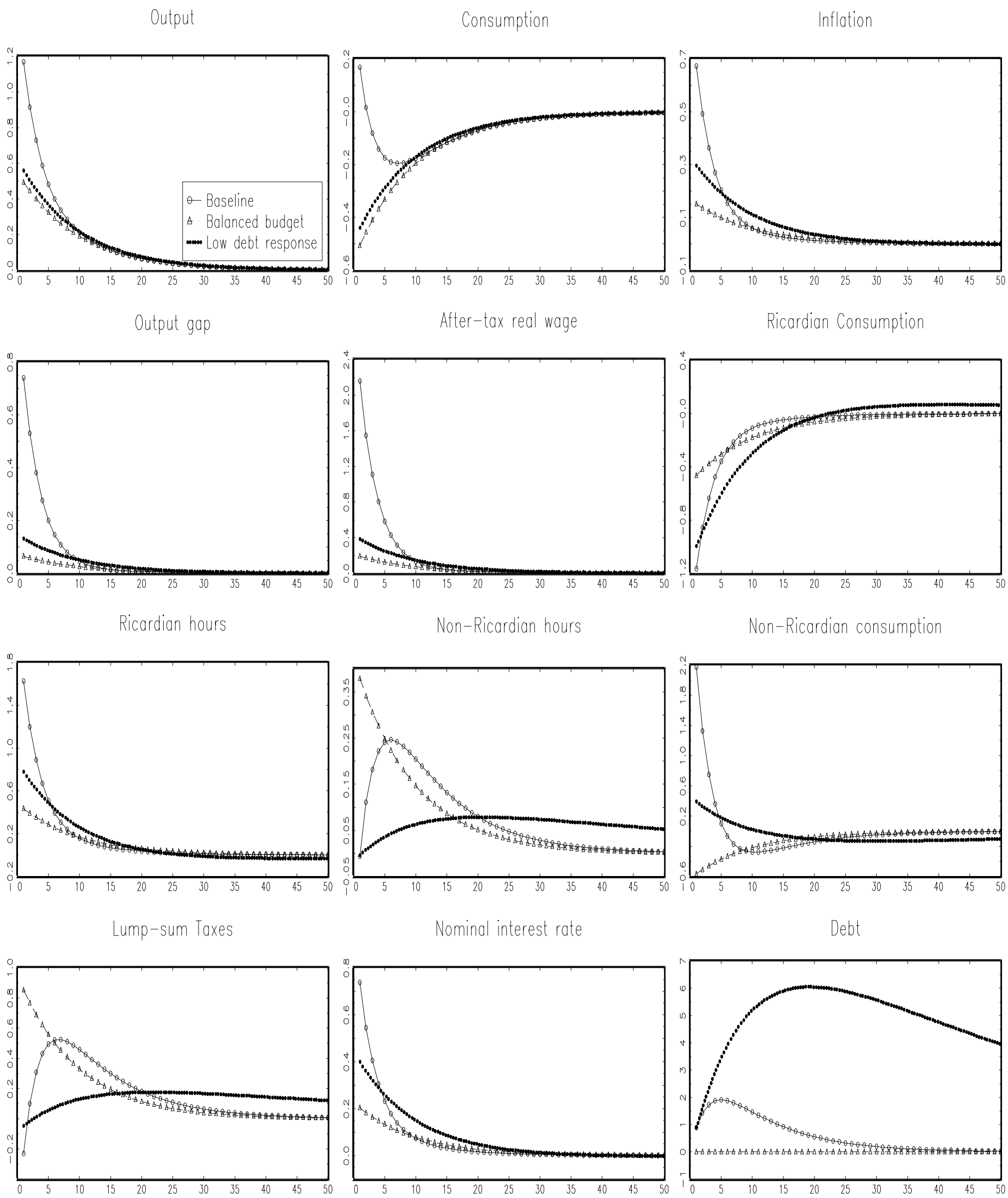

Fig 2: Effects of one unit shock to government spending under lump-sum taxation, second set of parameters varies.

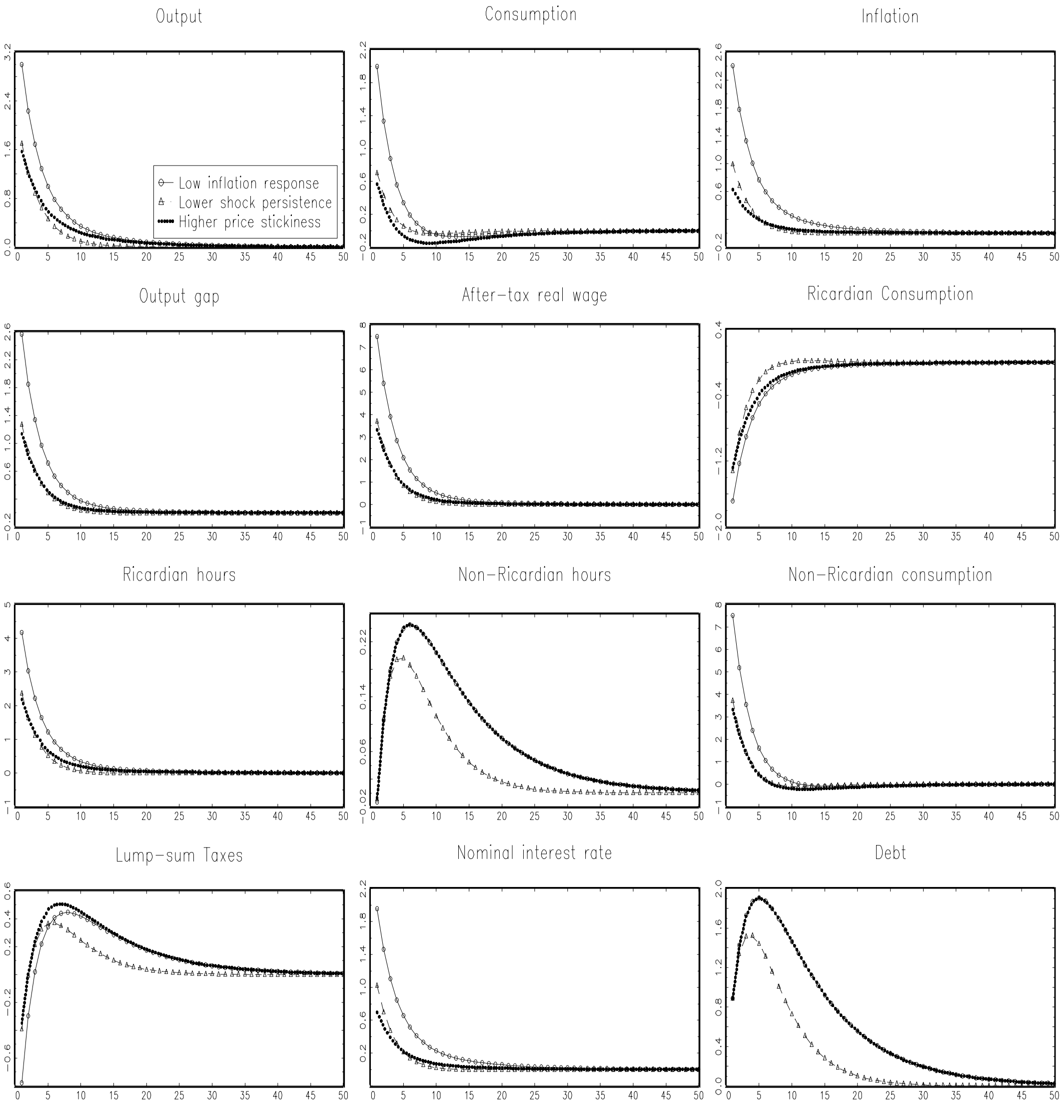

Fig 3: Effects of one unit shock to government spending under lump-sum taxation, third set of parameters varies.

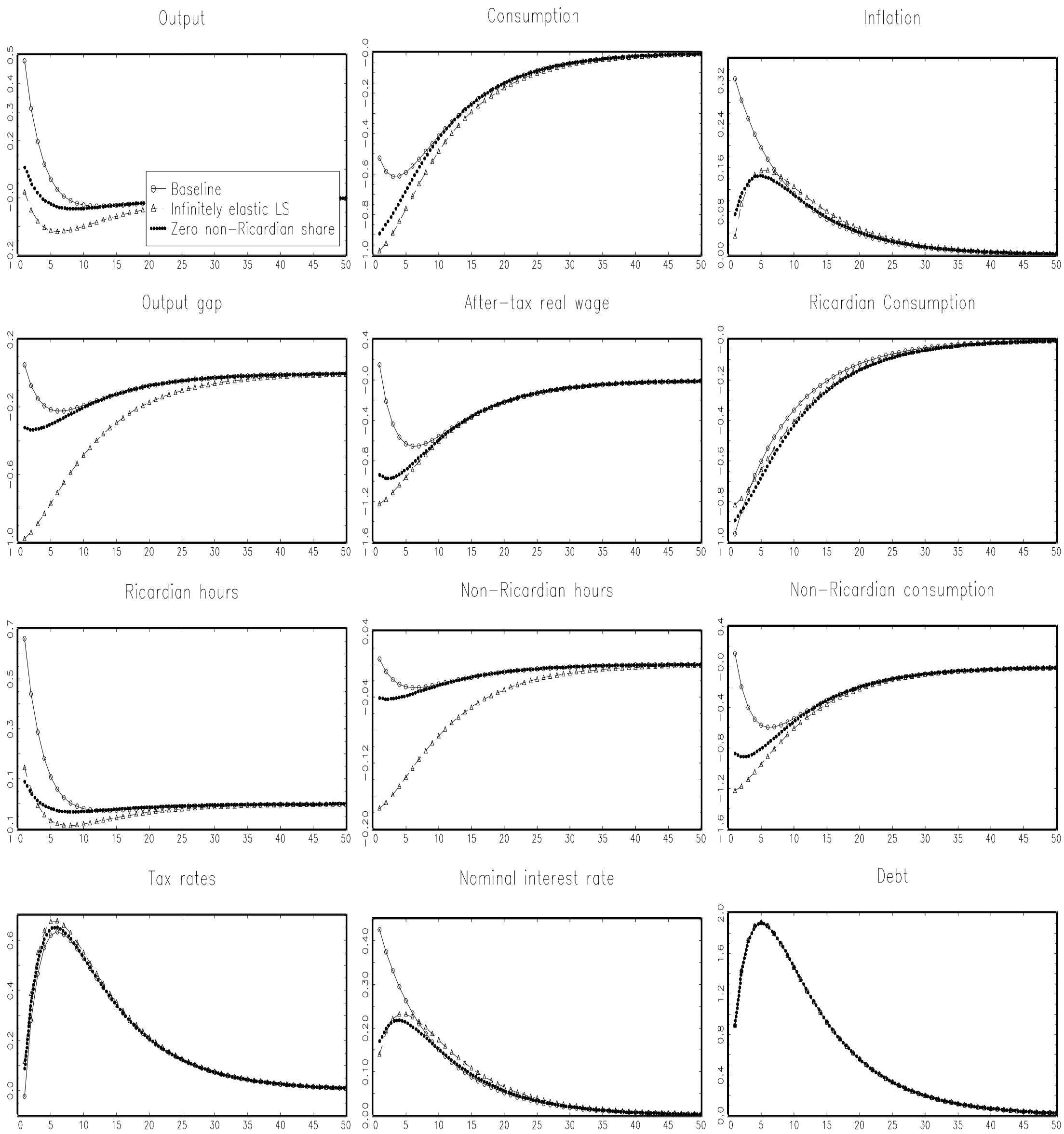

Fig 4: Effects of one unit shock to government spending under distortionary taxation, first set of parameters varies.

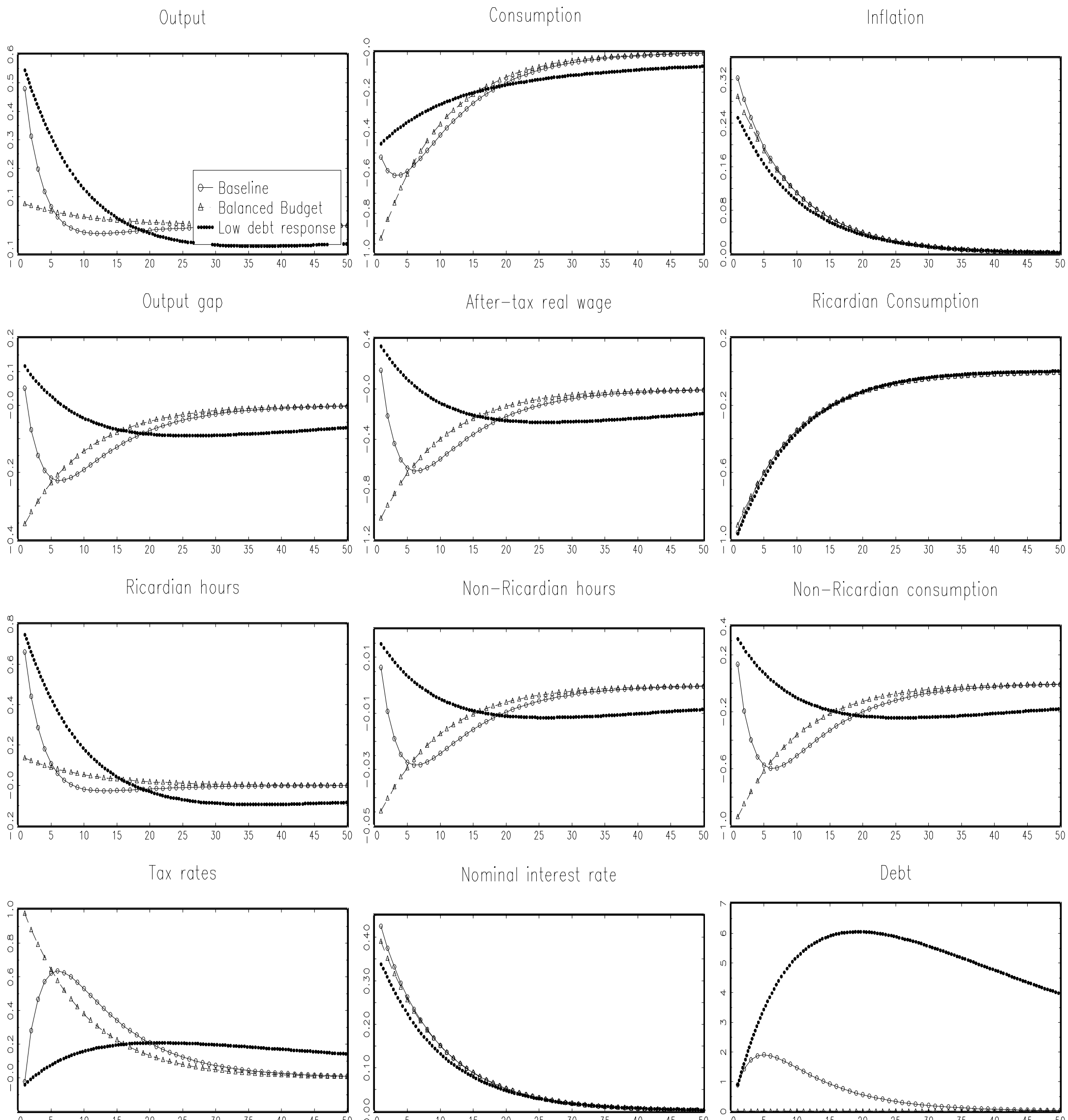

Fig 5: Effects of one unit shock to government spending under distortionary taxation, second set of parameters varies.

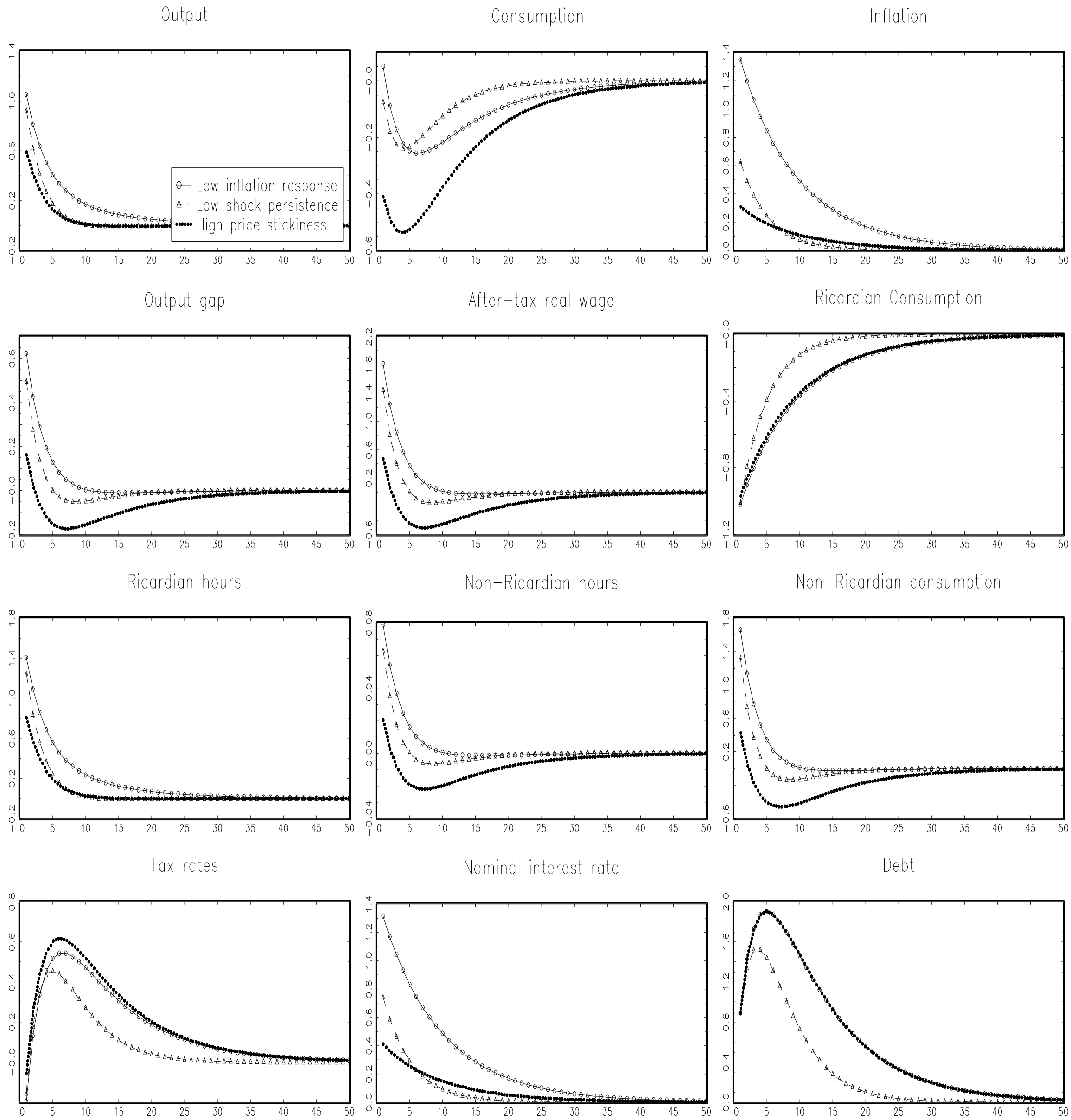

Fig 6: Effects of one unit shock to government spending under distortionary taxation, third set of parameters varies.

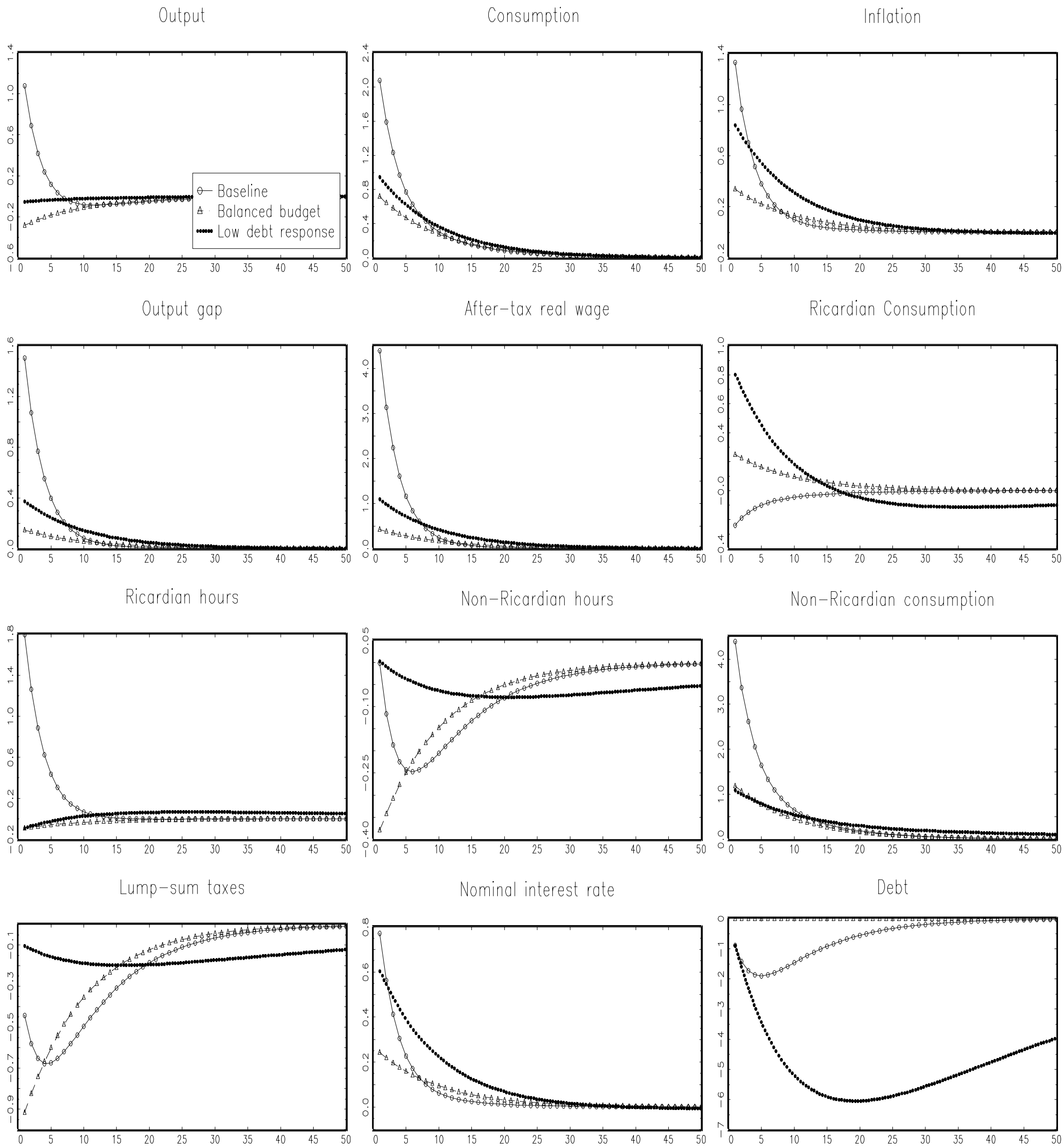

Fig 7: *Non-Ricardian scenario*: Effects of fiscal consolidation (government spending **cut)** under lump-sum taxation, deficit rule parameters vary.

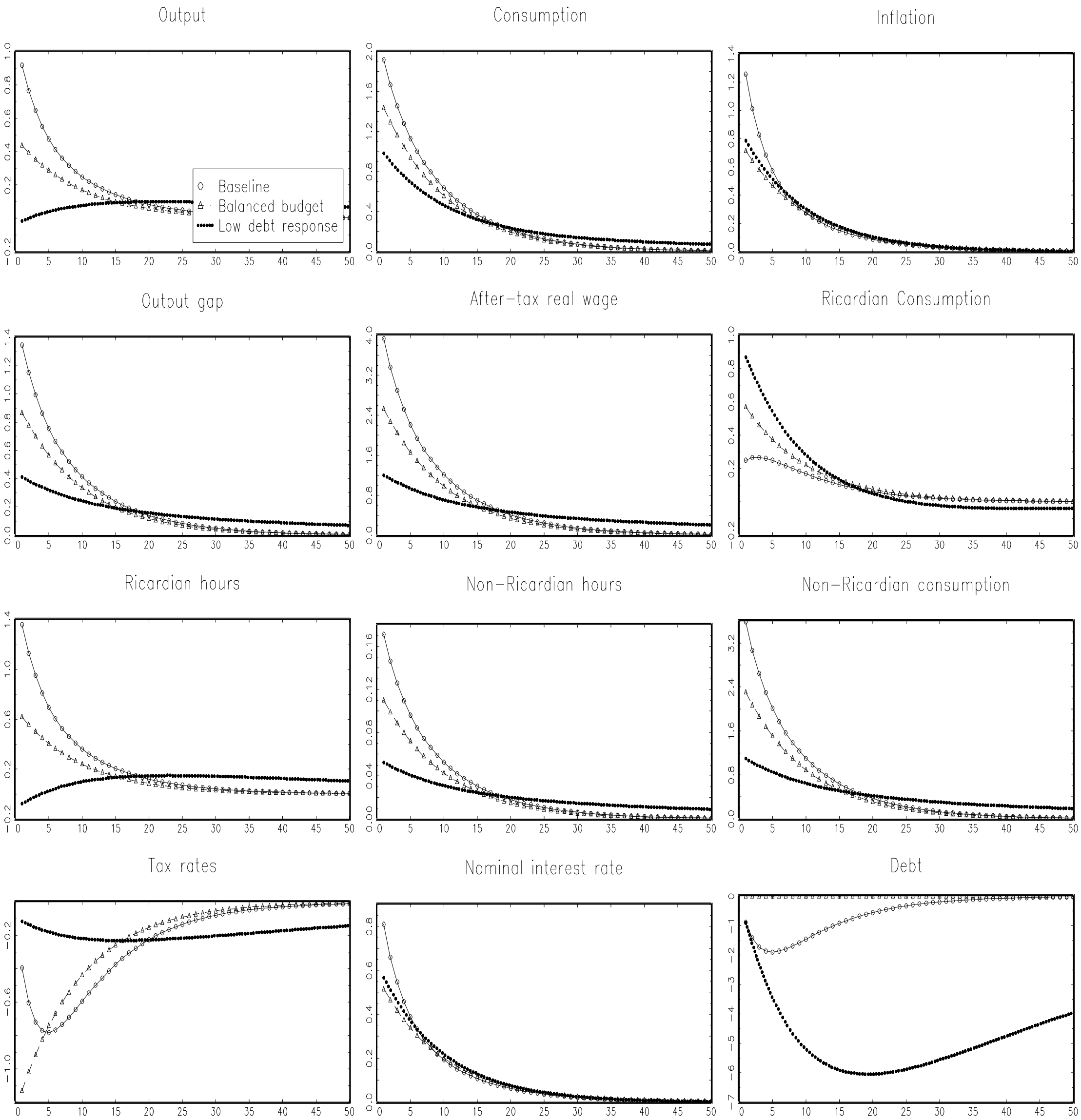

Fig 8: *Non-Ricardian scenario*: Effects of fiscal consolidation (government spending **cut)** under distortionary taxation, deficit rule parameters vary.

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