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Government Spending and the Taylor Principle*

Gisle James Natvik†

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Abstract

This paper explores how government size affects the scope for equilibrium indeterminacy in a New Keynesian economy where part of the population live hand-to-mouth. I find that in this framework, a larger public sector may widen the scope for self-fulfilling prophecies to occur. This takes place even though taxes serve to reduce swings in current income. In general, government provision of goods that are Edgeworth substitutes for private consumption tend to narrow the scope for indeterminacy, while government goods that are Edgeworth complements for private consumption increase the problem of indeterminacy. Hence monetary policy should be conducted with an eye to the amount and composition of government consumption.

Keywords: Public expenditures, Taylor principle, fiscal policy rules, rule-of-thumb consumers.
JEL Classification: E32, E52, E63

1 Introduction

In most economies government purchases constitute a considerable fraction of aggregate demand. Furthermore, the amount of such expenditure varies a great deal in the cross section, ranging from around 15 to 30 percent of GDP across developed countries.[1] For the purpose of stabilising the economy through monetary policy, the magnitude of these shares raises the question of whether the fraction

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[1] In developed countries the average share lies slightly below 20 percent of GDP, the exact number depending on measurement issues. In 2002, among 24 developed countries Ireland had the lowest share (13.8%), while Sweden had the largest share (28.0 percent). All numbers are taken from UNPAN Statistical Database, at www.unpan.org.

of resources consumed by government matters for how interest rates should be set. This paper addresses that question by investigating how government size affects the usefulness of the simplest rule of thumb in monetary policy making, the "Taylor principle" (Woodford (2001)).

In essence, the Taylor principle states that the nominal interest rate must respond more than one for one to changes in inflation to ensure local uniqueness of the rational expectations equilibrium (Woodford (2001), Taylor (1999)).[2][3][4] Such a reaction is sufficient for uniqueness in a simple dynamic New-Keynesian economy where agents optimise intertemporally and prices are inflexible, since it implies that expectation-driven increases in activity and inflation are accompanied by higher real interest rates. When all households are rational and use complete financial markets to smooth consumption, this rise in the real interest rate lowers their demand. Hence, activity and inflation are forced downward, and the expectation of a boom will not become self-fulfilling.[5]

While this line of reasoning holds when households base savings decisions on the interest rate, Galí et al. (2004) (hereafter referred to as GLVb) show that the result changes when part of the population do not use financial markets to smooth consumption, but live hand-to-mouth instead.[6] The reason is that sunspot spurs to activity raise labour demand and thereby real wages. Hence hand-to-mouth households will consume more, and if this kind of behaviour is sufficiently prevalent, non-fundamentally motivated increases in activity will generate their own demand. The implication for monetary policy, GLVb argue, is that obeying the

[2] The interest rate response may be gradual or immediate, as long as it eventually leads to a positive reaction of the real interest rate to inflationary impulses.

[3] The Taylor principle is commonly taken as a benchmark criterion in evaluating whether monetary policies are adequately constructed to stabilise the economy. For instance, several authors claim that the reason why the U.S. economy became more stable under Volcker and Greenspan is that their monetary policy satisfied the Taylor principle, whereas it did not before (e.g. Taylor (1999) and Clarida et al. (2000)).

[4] The Taylor principle is relevant whenever monetary policy is conducted by a reaction function for the interest rate. Hence it matters also when the reaction function is constructed to implement optimal monetary policy. As discussed by Woodford (2003), for the rule governing the interest rate to be consistent with optimality it need only depend on exogenous state variables. However, in order to rule out any other, less desirable, outcomes, it must also react to endogenous variables. And this reaction must satisfy the Taylor principle.

[5] If the response of the nominal interest rate to inflation is below unity, the equilibrium is indeterminate since the expectation of a boom raises current demand, which pushes inflation upward. Since the nominal interest rate increases less than inflation, the real interest rate declines. Then it is optimal for households to tilt their consumption path toward the current period and the expectation-driven rise in current demand rationalises itself.

[6] GLVb describe the agents who behave in this way as "rule-of-thumb" households, reflecting that the reason why such behaviour matters for equilibrium uniqueness is not that these households do not save, but that their consumption is perfectly correlated with disposable current income.

Taylor principle need not be sufficient to rule out equilibrium indeterminacy. If hand-to-mouth households account for a sufficiently large portion of aggregate demand, the response of the interest rate to inflationary impulses must be substantially larger than unity.[7]

A missing ingredient in GLVb's analysis is a government sector. This omission is potentially important since a given level of government outlays must be financed by taxes, and as long as tax rates do not vary much over the cycle, they have a strong potential to smooth disposable income. For households that live hand-to-mouth this would feed into a more stable demand for consumer goods. Such a mechanism is indeed what lies behind the textbook Keynesian idea of automatic stabilisation. For the question of equilibrium uniqueness, the conventional concept of automatic stabilisation therefore implies that the indeterminacy problem introduced by hand-to-mouth consumption is less severe for actual economies than GLVb's results indicate, and that the need for aggressive monetary policy declines with government size.

The main finding of this study is that government size may well alter the scope for indeterminacy, but not in the way conventional wisdom implies. Although more steady state government spending implies higher steady state taxes, and therefore more countercyclical public deficits, a larger government need not ameliorate the indeterminacy problem generated by hand-to-mouth consumption. In general, the relationship between steady state government size and the scope for indeterminacy is non-monotonic, and highly sensitive to the degree of substitutability between private and government consumption. Only if the two are Edgeworth substitutes will government consumption and the automatic stabilisation it entails reduce the room for belief-driven business cycle fluctuations. Tax-financed provision of goods that complement private consumption, on the other hand, increase the scope for indeterminacy.

In a nutshell, traditional Keynesian logic breaks down in the New Keynesian framework because the former treats gross wage dynamics as given, independent of government size, while the latter does not. In stead, the standard New Keynesian model assumes that real wages are driven by fluctuations in households' marginal willlingness to substitute leisure for consumption. It then follows that by crowding out private consumption, steady state government spending stimulates the relative change in private consumption that follows a given change in household wealth. Hence, as long as the elasticity of real wages with respect to consumption is not increasing in consumption, a larger government stimulates the response of real wages to wealth changes.

[7] In a similar setting, Bilbiie (2006) shows that an alternative way for the Central Bank to pin down the equilibrium is to react significantly *less* than one for one to inflationary impulses. Throughout this paper, however, I choose to investigate how determinacy is ensured by reacting sufficiently strongly.

More specifically, in my analysis households have CRRA preferences, which implies that a given increment to consumption reduces their marginal utility of consumption more when starting from a low than a high initial consumption level.[8] As a consequence households' marginal willingness to substitute leisure for consumption drops more following a consumption spur if a large public sector has drained households of their initial purchasing power. Such a consumption spur is exactly what occurs among hand-to-mouth households following a sunspot rise in activity, and it is therefore clear that the more government spends in steady state, the more sensitive is *gross* labour income to sunspot shocks. On the other hand, more government expenditure implies higher taxes in steady state. Unless these adjust one for one to changes in output to balance the budget period by period, they will tend to smooth *disposable* income. This is the conventional way by which government size stabilises the economy. When accounting for these two opposing effects in the benchmark case of separability between private and government consumption, the relationship between government size and the scope for indeterminacy is non-monotonic. As long as government is relatively small, increasing its size reduces the region of parameter values within which the Taylor principle fails to ensure quilibrium uniqueness. However, there exists a threshold level of government spending (about 10 percent of GDP in the benchmark calibration) beyond which increasing it further widens the scope for indeterminacy.

Obviously, if government purchases substitute perfectly for private consumption, households do not care if they buy goods themselves directly in the market, or via lump sum taxes. Hence, perfect substitutability removes the destabilising effect, and government spending will unambiguously serve to reduce the indeterminacy problem. However, empirical evidence does not support perfect substitutability. Indeed, some studies conclude that government consumption works as an Edgeworth complement to private consumption. In this case the destabilising effect of government spending becomes even stronger than under separability, and for moderate degrees of complementarity government consumption unambiguously increases the parameter range under which the rational expectations equilibrium is indeterminate.

My analysis relates to three strands of literature. First, a substantial number of studies have uncovered circumstances under which indeterminacies occur even though the Taylor principle is satisfied.[9] My results add public goods that are

[8] This property holds for a broad class of utility functions. The requirement is that the third derivative is positive, which holds for any utility function that is both concave and always increasing in consumption.

[9] Relevant examples are Edge & Rudd (2002) and Røisland (2003) who emphasise that capital taxation may render the Taylor principle insufficient, as well as Sveen & Weinke (2005) and Carlstrom & Fuerst (2005) who show that the presence of capital in the economy is another source of indeterminacy. Emphasising similar mechanisms, Benhabib & Eusepi (2005) show how

Edgeworth complements to private consumption to this list. On the other hand I show that public goods that are Edgeworth substitutes for private consumption have the opposite effect, and strengthen the relevance of the Taylor principle in the presence of rule-of-thumb consumption. Second, several studies, for example Fatás & Mihov (2001) and Galí (1994), document that across countries and regions, macroeconomic volatility is negatively correlated with government size, and many others, a recent example of which is Andrés & Doménech (2006), seek to explain this stylised fact. My results shed some light on this discussion, indicating mechanisms by which larger governments affect macroeconomic volatility. Furthermore, these mechanisms relate to a point made by Guo & Harrison (2006) within the context of a real business cycle model: In a dynamic general equilibrium framework, the correlation between government size and macroeconomic volatility depends on the utility function assumed.[10] Third, the importance of tax dynamics for equilibrium determinacy is also emphasised by Schmitt-Grohé & Uribé (1997) and Christiano & Harrison (1999). In very different frameworks from mine, they too show that unless tax revenue is allowed to increase when output grows, the presence of government consumption enables recurring fluctuations in activity without fundamentals to justify them.

The paper is organised as follows. Section 2 presents the benchmark model, which is identical to the one constructed by Galí et al. (ming) (GLVa hereafter). In section 3.1 I analyse equilibrium dynamics within this framework, emphasising the effects of government consumption on equilibrium uniqueness and the implications for monetary policy as conducted by a simple interest rate rule. Section 3.2 brings the stabilising effect of procyclical taxation into the picture, before section 3.3 quantifies the impact of different degrees of substitutability between private and government consumption. Section 4 concludes.

2 The model

The model is based on the New Keynesian framework developed by GLVa. They show that the model is successful in accounting for the effects of government spending found in the data. For my purposes, this is an important quality, since I too aim to understand how government expenditure matters for the economy, albeit in another dimension.

Two modifications to GLVa's model are introduced. First, the utility function is

equilibria may be globally unstable allthough they locally are unique.

[10]While my emphasis is on how consumption enters the utility function, Guo & Harrison (2006) emphasise the utility of leisure.They show that in an economy driven by technology shocks macroeconomic volatility increases with government purchases if utility is convex in hours worked. The opposite applies when utility is logarithmic in hours.

generalised to allow the possibility that government consumption is non-separable from private consumption. Second, the process for taxes is modified so that total tax revenues are increasing in output, and more strongly so the higher steady state taxes are.

Since most of the model follows GLVa, who explains it in some detail, the presentation below is brief. Only the two extensions are discussed in some depth, while for the rest of the model emphasis is on the log-linearised epressions. Unless otherwise noted, lower case variables denote percentage deviations from steady state.

2.1 Households

There is a continuum of infinitely-lived households. A fraction $1 - \lambda$ of them have access to complete financial markets, and buy and sell physical capital which they rent out to firms. These households will be referred to as *optimizing* or *Ricardian*, and their variables denoted by superscript "o" . Rule-of-thumb, or *non-Ricardian* consumers, have neither assets nor liabilities, and consume their entire labour income each period.[11] Their variables will be denoted by "r".

Both consumer types have preferences over private consumption C_t, exogenously fixed government consumption G, and labour hours N_t. Their period utility function is

$$U^i \left(C_t^i, N_t^i\right) = \frac{\left(C_t^i + \xi G\right)^{1-\sigma}}{1-\sigma} - \frac{N_t^{i1+\varphi}}{1+\varphi} + f(G), \tag{1}$$

for $i = o, r$, where φ is the inverse of the Frisch elasticity. ξ indicates the degree to which the public good is substitutable for private goods in the Edgeworth sense. That is, marginal utility of private consumption depends positively on the amount of government spending G if ξ is negative, and negatively if ξ is positive. Hence, the two goods are Edgeworth substitutes when ξ is positive, complements if ξ is negative. A priori, the sign of ξ is not clear, and likely to depend on the composition of government expenditure. For example, a public swimming pool is likely to be a substitute for private consumption, since one would expect that when such a good is made available for households, their marginal utility of private swimming pools declines, while a good like public transportation is likely to complement private consumption. The term $f(G)$ is added to the utility function to allow

[11] This type of heterogeneity follows the proposition in Mankiw (2000) who argues that such behaviour is consistent with a range of empirical findings, and must be accounted for inorder to understand how government purchases influence the economy. Campbell & Mankiw (1989) estimate the prevalence of rule of thumb consumption, and find it to be quantitatively significant in both the U.S. and other industrialised countries. Bilbiie (2006) provides some microfoundation for this rule-of-thumb behaviour, based on the assumption that asset market participation involves transaction costs that are heterogenous across households.

complementarity (i.e. $\xi < 0$) without necessarily assuming that households receive a negative utility stream from government consumption. The exact functional form of $f(G)$ need not be specified here, as it does not affect behaviour.

Note that when this period utility function is combined with the assumption of time-separable preferences, the intertemporal elasticity in private consumption is $\frac{\xi\gamma_g+\gamma_c}{\sigma\gamma_c}$. This reflects that government provision of goods that substitute for private consumption lowers households' aversion against fluctuations in private consumption. On the other hand, if government provides more goods that complement private consumption, agents will to a stronger extent avoid fluctuations in private consumption, since the public goods increase the utility fluctuations associated with varying private consumption. The specification of GLVa is nested in (1) as the special case where $\xi = 0$.

2.1.1 Ricardian households

Optimising households choose consumption, C_t^o, and investment I_t^o. They have access to complete markets for state contingent money claims and maximize expected discounted lifetime utility $E_t \sum_{k=0}^{\infty} \beta^k U\left(C_{t+k}^o, N_{t+k}^o\right)$. The first order conditions for their choice of C_t^o and I_t^o are therefore standard,[12] and take the log-linearised form

$$c_t^o = E_t c_{t+1}^o - \frac{\xi\gamma_g + \gamma_c}{\sigma\gamma_c}\left(r_t - E_t \pi_{t+1}\right), \tag{2}$$

$$i_t = \eta q_t + k_t \tag{3}$$

where

[12] Maximization is subject to the sequence of budget constraints

$$P_t\left[C_t^o + I_t^o\right] + R_t^{-1} B_{t+1}^o \leq B_t^o + W_t^o N_t^o + R_t^k P_t K_t^o + D_t^o - P_t T_t^o$$

and the law of motion of capital

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

where P_t is the time t price level, W_t is the nominal wage, and B_{t+1}^o is the quantity of nominally riskless one-period bonds purchased in period t and paying off one unit of the numeraire in period $t+1$. R_t is the gross nominal return on such bonds carried over from period t to $t+1$. D_t^o denotes dividends from ownership of firms, and $D_t^o = D_t$ since firms are owned by optimising households only. T_t^o denotes lump sum real taxes that are levied upon the Ricardian households. The capital stock that these households hold, K_t^o, depreciates at a rate δ. The term $\phi\left(\frac{I_t^o}{K_t^o}\right)K_t^o$, with $\phi' > 0$, $\phi'' \leq 0$, $\phi'(\delta) = 1$, $\phi(\delta) = \delta$, makes capital adjustment costly, as the marginal effect of investment on the capital stock is decreasing in the investment to capital ratio.

$$q_t = \beta E_t\{q_{t+1}\} + [1-\beta(1-\delta)]E_t\{r^k_{t+1} - p_{t+1}\} - (r_t - E_t\{\pi_{t+1}\} \tag{4}$$

in which r_t is the log nominal interest rate, π_t is the CPI inflation rate, q_t is the log-deviation of Tobin's Q and η is the elasticity of the investment-to capital ratio with respect to Q_t.[13]

Their labour market adjustment is discussed below.

2.1.2 Non-Ricardian households

Non-Ricardian households neither borrow nor save and therefore cannot freely adjust their consumption path to fluctuations in labour income or interest rates. Their consumption is then equal to their disposable income. Hence, $C^r_t = \frac{W_t}{P_t}N^r_t - T^r_t$, where N^r_t denotes labour hours and T^r_t denotes tax payments. Log-linearising this expression leads to

$$c^r_t = \frac{WN^r}{PC^r}(n^r_t + w_t - p_t) - \frac{Y}{C^r}t^r_t \tag{5}$$

where w_t is the real wage and $t^r_t = \frac{T^r_t - T^r}{Y^r}$ is lump sum taxes levied upon rule-of-thumb households. $\frac{WN^r}{PC^r}$ is the ratio of rule-of-thumb consumers' real labour income to consumption. It will generally deviate from 1 due to taxes and transfers, and increase with government size.

In order to simplify the analysis, taxes differ across the two households, and in steady state they are such that the consumption choice of Ricardian households coincides with the disposable income, and hence the consumption level, of non-Ricardian households. Thus, by assumption $T^r \neq T^o$and $C^r = C^o = C$. This assumption follows GLVa, and ensures that λ not only denotes the steady state fraction of households that consume according to the rule-of-thumb, but also that λ denotes the share of aggregate consumption that is governed by such behaviour in steady state. The sensitivity analysis presented below shows that relaxing this assumption of redistribution only increases the quantitative significance of my main findings.[14]

2.1.3 Aggregation

Aggregate consumption is given by $C_t = \lambda C^r_t + (1-\lambda)C^o_t$. Similarly, reflecting that only one group of agents accumulate capital, investment and the capital

[13] With the notation of the preceding footnote, $\eta = \frac{-1}{\phi''(\delta)\delta}$.

[14] A driving mechanism in this study is that government spending reduces private consumption in steady state. Relaxing the assumption of redistribution has the same effect. It does not, however, remove the negative relationship between government size and steady state private consumption, and therefore does not qualitatively influence the link between government size and indeterminacy.

stock aggregate by $I_t = (1-\lambda)I_t^o$ and $K_t = (1-\lambda)K_t^o$. Labour supply aggregates straightforwardly by $N_t = \lambda N_t^r + (1-\lambda)N_t^o$.

2.1.4 The labour market

The labour market ties the real wage to households' marginal rate of substitution between consumption and leisure. Log-linearised around the steady state where all households work and consume equally much it takes the form

$$w_t - p_t = \frac{\sigma\gamma_c}{\xi\gamma_g + \gamma_c} c_t + \psi n_t. \tag{6}$$

where $n_t = \lambda n_t^r + (1-\lambda)n_t^o$ and $c_t = \lambda c_t^r + (1-\lambda)c_t^o$ are the aggregate quantities of labour and consumption, respectively.[15] Since $\frac{\sigma\gamma_c}{\xi\gamma_g+\gamma_c}$ effectively is the degree of relative risk aversion of households in this economy, the expression is identical to the market clearing condition of a competitive labour market with a representative agent.

Although the above is also compatible with a competitive labour maket framework, I will here assume, as in GLVa, that it is the outcome of a non-competitive labour market where labour hours are demand determined. This distinction is important, since in the latter case both households types will always work equally much, whereas their working hours will differ outside of steady state if the labour market is perfectly competitive.

In the appendix equation (6) is derived as the outcome of a labour market where unions set wages, subject to producers' demand for hours. In the sensitivity analysis below I discuss how results are affected by moving to a perfectly competitive labour market in stead.

2.2 Firms

A representative, perfectly competitive firm combines different varieties of goods $X_t(j)$, $j \epsilon [0,1]$, to produce a final good Y_t with the CES-technology

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

where ε is the elasticity of substitution between different varieties of goods $X_t(j)$. Profit maximisation then yields the standard CES-demand schedules $X_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} Y_t$, where P_t is the price of the final good. The zero profit condition that minimised unit costs equals the price is $P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$.

[15] These aggregate relationships (6) hold because taxes are set to equalise steady state consumption across households.

The differentiated goods are produced by imperfectly competitive intermediate firms indexed by j, who apply the production technology

$$X_t(j) = F(K_t(j), N_t(j)) = K_t(j)^{\alpha} N_t(j)^{1-\alpha}$$

Cost minimisation then implies the log-linearised relationships

$$mc_t(j) = (1-\alpha)(w_t - p_t) + \alpha(r_t^k - p_t) \tag{7}$$

and

$$k_t(j) - n_t(j) = w_t - r_t^k, \tag{8}$$

where $mc_t(j)$ denotes the real marginal cost, which is common across producers, and r_t^k is the rental rate of capital. Each firm is indifferent between hiring rule-of-thumb or Ricardian households. Hence different consumer types are equally distributed across firms, $N_t(j) = \lambda N_t^r(j) + (1-\lambda)N_t^o(j)$.

Price setting of intermediate firms is staggered as in (Calvo (1983)). Hence, in every period there is an exogenous probability $(1-\theta)$ that a firm may adjust its price, otherwise the price must remain unchanged. By familiar reasoning it then follows that inflation will evolve by a typical forward looking Philips curve

$$\pi_t = \beta E_t \pi_{t+1} + \lambda_p mc_t \tag{9}$$

where $\lambda_p = \frac{(1-\beta\theta)(1-\theta)}{\theta}$.[16]

Furthermore, log-linearised aggregate output is given by

$$y_t = (1-\alpha)n_t + \alpha k_t. \tag{10}$$

That this holds up to a first order approximation is shown in Woodford (2003).

2.3 Monetary Policy

The monetary authority controls the nominal interest rate r_t and sets it according to the rule

$$r_t = r + \phi_\pi \pi_t \tag{11}$$

where $\phi_\pi \geq 0$ and r is the steady state nominal interest rate $R_t - 1$.

[16] When allowed to adjust its price, intermediate firm j solves the problem

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,t+k} Y_{t+k}(j)((P_t^*/P_{t+k}) - MC_{t+k}) \right\}$$

subject to the demand constraint $X_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} Y_t$. Here $\Lambda_{t,t+k}$ is the stochastic discout factor between period t and $t+k$. Combining the solution to this problem with the aggregate result that $p_t = \theta p_{t-1} + (1-\theta)p_t^*$ yields equation (9). For further details see e.g. Woodford (2003).

2.4 Fiscal Policy

Each period the government buys an exogenous amount G of final goods. In steady state these purchases constitute a fraction γ_g out of the economy's total output, i.e. $\gamma_g = \frac{G}{Y}$.

The government finances its expenditures by lump-sum taxation and issuance of one-period nominally riskless bonds worth B at annuity. Hence the budget constraint is

$$P_tT_t + R_t^{-1}B_{t+1} = B_t + P_tG$$

where $T_t = \lambda T_t^r + (1-\lambda)T_t^o$, and R_t is the nominally riskless return offered at time t.[17]

Two tax rules will be considered. First, I assume the same tax scheme as in GLVa, where total taxes respond to debt and current period expenditure. With constant expenditure, it takes the log-linear form

$$t_t = \phi_b b_t, \tag{12}$$

where $b_t = \frac{B_t/P_{t-1}-B/P}{Y}$, $t_t = \frac{T_t-T}{Y}$. Since government expenditure is constant and steady state debt is zero, this process is tantamount to a balanced budget policy rule.[18]

An implication of this specification is that total net tax revenues do not respond to swings in economic activity. Hence, since government expenditure is constant, it implies that government deficits are acyclical. This is clearly at odds with the strong empirical regularity that governments, after controlling for discretionary policy changes, tend to run surpluses in upswings and deficits in downturns.[19] In environments where Ricardian equivalence holds, this misalignment with reality is unimportant. In the current setting, however, it is likely to matter. Furthermore, assuming that total tax revenues, net of transfers, do not change when output fluctuates, amounts to assuming that the average net tax rate adjusts immediately and one for one with variations in activity. In reality, on the other hand, decision and implementation lags will prevent fiscal authorities from adjusting tax rates and transfer schemes on a quarterly basis to contemporaneous fluctuations in output.[20] Hence, one will generally expect tax revenues to react positively to

[17] Since the economy is cashless, government may not finance its expenditures by seigniorage.

[18] This form of tax rule is commonly assumed in theoretical literature, see for example Schmitt Schmitt-Grohe & Uribe (2004) and Benhabib & Eusepi (2005).

[19] That is, the cyclical component of governments' deficits is negatively correlated with output (Noord (2000), Galí & Perotti (2003)).

[20] Through estimating tax processes for the postwar U.S. economy, Jones (2002) finds that tax rates are highly autocorrelated. He also finds that their elasticity with respect to output is nowhere near to -1. In fact, the contemporaneous effect of output on the average capital tax rate is positive.

output swings. Furthermore, the response of tax revenue to output should be increasing in government size, since larger governments imply higher average tax rates. Noord (2000) documents that across OECD countries both these features apply.

The second tax rule I will consider follows from the above considerations, and in log-linearised form it reads

$$t_t = \phi_b b_t + \gamma_g y_t. \tag{13}$$

A more detailed explanation of this tax process is provided in the appendix. The implication of (13) is that tax revenues will increase on impact when activity increases, raising government surplus for a given amount of purchases G. As this reduces public debt, the tax rate will fall next period, assuming that the necessary and sufficient condition for non-explosive debt dynamics $\phi_b > \frac{\rho}{1+\rho}$ is satisfied. Hence, tax revenues will eventually move downward even though the spur in activity persists. Such dynamics are exactly what one would obtain in an economy with flat and identical distortionary tax rates that are constant, and lump sum net taxes that react to fluctuations in debt.[21] My specification is chosen to align with such dynamics, without complicating the analysis by introducing tax distortions. Obviously, for economies where tax rates are progressive or differ across goods and factors of production, or where the prevalence of transfer schemes are not correlated with the steady state amount of government purchases, the evolution of taxes will differ from what (13) implies. However, the motivation for the tax function in (13) is not to perfectly characterise actual tax processes, but to capture the positive correlation between government revenues and steady state purchases that follows when tax and transfer schemes do not immediately adjust to changes in output.

Finally, we need to know how variations in the total tax burden are divided between the two household types. At this point I assume tax changes are distributed evenly across consumer types, i.e. that $t_t^r = t_t^o = t_t$.

2.5 Market clearing

The final goods market clears when

$$y_t = \gamma_c c_t + \gamma_i i_t + g_t$$

[21] Constant distortionary taxes are what generate a link between government size and countercyclicality of public debt in Andrés & Doménech (2006). They emphasise this as a distinction between distortionary and lump sum taxes. My approach is different, assuming lump sum taxes. The reason is that the distortionary nature of taxes is substantively different from the proportionality between between total tax revenues and output that actual tax schemes entail. Since it is the latter effect that lies behind the conventional idea of automatic stabilisation, that is what I wish to emphasise here and I therefore neglect tax distortions.

where $\gamma_c = \frac{C}{Y}$ and $\gamma_i = \frac{I}{Y}$ are the steady state shares of aggregate household consumption and investment out of total output, while $g_t = \frac{G_t - G}{Y}$.

2.6 The Steady State

Certain aspects of the steady state are key to the results that follow, and therefore deserve comment. Analytical derivations are provided in the appendix.

First, note that steady state real wages are independent of government size (γ_g). This follows from the fact that private sector factor shares, $\frac{WN^P}{PY}$ and $\frac{RK}{Y}$, only depend on technology, pricing behaviour and preferences. Thus, since a larger government implies less private consumption, households are willing to work more as government grows. Steady state hours therefore increase with government size, and since the capital share is constant, the capital stock increases too.

For the equilibrium dynamics of real wages the above is important. The reason is that the ratio $\frac{WN}{PC}$, which will be further emphasised in the discussion below, relates to government size by

$$\frac{WN}{PC} = \frac{WN}{PY}\frac{Y}{C} = \frac{1-\alpha}{(1+\mu^p)}\frac{1}{\gamma_c}, \tag{14}$$

where, as shown in the appendix, the consumption share γ_c is given by $\gamma_c = 1 - \frac{\delta\alpha}{(1+\mu^p)(\rho+\delta)} - \gamma_g$. Hence, the steady state ratio of wage income to consumption is increasing in government size. Since factor shares are constant, for a given degree of relative risk aversion government spending affects real wage dynamics in no other way.[22]

2.7 Calibration

Apart from ξ, γ_g, ϕ_π and λ which are at the centre of attention here, the model is parametrised as in GLVa. This parametrisation is presented in Table (20) in the appendix.

As a benchmark, I conform to most New Keynesian literature that accounts for government spending (f. ex GLVa, Woodford (2003)), and assume that the utility function is separable in government and private consumption ($\xi = 0$). Empirically, however, this choice of ξ is not obvious as a range of studies have estimated the degree of substitutability between private consumption and government purchases and reached values that differ substantially from zero. Unfortunately, the estimates

[22] The response of labour demand to sunspot shocks, will not depend on government size because the steady state shares of hours and capital are independent of government size.

vary a great deal, depending in particular on the form of the utility function assumed and how the real interest rate is measured Ni (1995).[23]

Furthermore, results differ across types of government expenditure. This is hardly surprising, but more problematic is it that little consensus exist here either. For example, while Evans & Karras (1998) find that military spending and private consumption are Edgeworth complements and that non-military spending and private consumption are substitutes, Fiorito & Kollintzas (2004) reach the opposite conclusion, using a different methodology and sample.

Due to the lack of robust empirical evidence on how substitutable government and private consumption is, the remaining analysis will derive results under different values of ξ.

A possible reason for the lack of robust empirical evidence, and a further complication for my analysis, is the possibility that the degree of substitutability varies with the amount of government spending. Certain types of purchases have a public good nature, such as a national defense and infrastructure, and will be the first goods for a government to provide. As government grows, it will increasingly provide goods and services that markets to a stronger extent are able to provide, such as health care, education, swimming pools etc. Some empirical evidence supports this idea, and Karras (1994) and Evans & Karras (1998) find an upward sloping relationship between substitutability and government's share of output.[24] Treating ξ parametrically is obviously inconsistent with this. But conducting the analysis under different paramatrisations of ξ will give some indication on the potential importance of a relationship between government size and ξ.

3 Results

Government size may affect the scope for determinacy through two channels. On the one hand, government purchases may alter the dynamics of gross wages by crowding out steady state private consumption. On the other hand, given the stream of gross income, a larger government will stabilise net income if taxes do not adjust immediately to fluctuations in output. Each of theses effects are presented separately below. The importance of substitutability between private and government consumption, as measured by ξ, is explored in the end.

[23] Under the functional form in (1), Ni (1995) estimates ξ to lie between 0.4 and 1.6 in the U.S., when real interest rates are measured net of taxes.

[24] However, this relationship is likely to be inconsistent with the conclusion drawn by Fiorito & Kollintzas (2004) that public goods acts as stronger substitutes than goods closer to what markets may provide.

3.1 Government size and indeterminacy with acyclical tax revenues

Rule-of-thumb consumers are source of a potential indeterminacy problem in the economy formulated above. This is established by GLVb, and the intuition is as follows. A sunspot-driven increase in production will raise labour demand and thereby real wages. As a consequence real marginal costs increase, motivating firms to raise prices. As inflation picks up, the nominal interest rate will rise too via the reaction function (11). If the reaction function satisfies the Taylor principle ($\phi_\pi > 1$), the real rate of interest increases as well, inducing Ricardian households to contract their consumption. This contraction tends to make the initial boom non-sustainable. Rule-of-thumb consumers behave differently, however. Increased employment and higher wages raises their disposable income, and thereby their consumption. Hence, it is clear that if the latter group is sufficiently large, an expansionary sunspot shock will generate its own demand even though monetary policy satisfies the Taylor principle.[25]

Now, introduce a government that absorbes resources from the economy and does not let tax revenues vary with aggregate activity, i.e. taxes are set by the rule (12). Assume further that government purchases enter the utility function separably from private consumption ($\xi = 0$), or not at all. Figure 1 shows that such a government destabilises the economy, in the sense that the scope for indeterminacy increases with government size as measured by γ_g. When $\phi_\pi = 1.0001$ in the interest rate rule (11), so that monetary policy just satisfies the Taylor principle, the figure shows that if no part of private output is consumed by government, at least 61 percent of households must obey the rule-of-thumb for indeterminacy to occur. When steady state government consumption grows relative to private output, the required share of rule-of-thumb consumers declines steadily, dropping below one half when $\gamma_g = 0.3$. In essence, government purchases stimulate the destabilising influence of rule-of-thumb households. As explained in more detail below, the reason is that government purchases crowd out steady state private consumption and when the latter falls real wages react stronger to sunspot shocks.

Figure (2) lets the interest rate reaction to inflation (ϕ_π) increase to ensure a locally determinate equilibrium as government grows. The horisontal parts of the plots indicate combinations of λ and γ_g for which the Taylor principle is sufficient. It is evident that once λ and γ_g are of magnitudes that render the Taylor principle insufficient, ϕ_π must increase rapidly with γ_g in order to prevent indeterminacy. This result mirrors the finding in GLVb that once λ is so high that the Taylor principle does not hold, ϕ_π must increase rapidly with λ for the equilibrium to be

[25] The destabilising influence of rule-of-thumb households is increasing in the elasticity of real wages to labour hours, φ, the coefficient of relative risk aversion σ, convexity of adjustment costs in investment, η, and price stickiness indicated by θ.

unique.

To understand why the scope for indeterminacy is increasing in government size, combine the non-Ricardian consumption rule (5) with the wage equation (6) and set $\xi = 0$. Since all households work equally much $n_t^r = n_t$, and the resultant expression may be solved for rule-of-thumb labour hours, which then must satisfy the following equation

$$n_t^r = \frac{1}{\sigma\lambda\frac{WN}{PC} + \psi}\left[\left(1 - \sigma\lambda\frac{WN}{PC}\right)(w_t - p_t) + \sigma\lambda\frac{Y}{C}t_t - \sigma(1-\lambda)c_t^o\right]. \qquad (15)$$

This equation shows that the elasticity of non-Ricardian labour supply with respect to real wages is lower the less these households consume out of their steady state gross income, $\frac{WN}{PC}$. Hence, since $\frac{WN}{PC}$ increases with γ_g, as shown in equation (14) above, it follows that the elasticity of rule-of-thumb households' labour supply with respect to real wages decreases as government grows.

Why does this occur? The answer lies in households' willingness to accept fluctuations in their consumption of private goods. When households' relative risk aversion is constant, as assumed here, their marginal utility of consumption is decreasing and convex ($U''_{CC} < 0$, $U'''_{CCC} > 0$).[26] Hence, a given increment to consumption reduces their marginal utility of consumption more, if their initial consumption level is low than if it is high. This implies that if rule-of-thumb households receive an extra unit of income, at unchanged hours worked, the resultant change in their marginal rate of substitution between leisure and consumption will be larger, the less they were consuming at the outset. Since real wage movements are driven by fluctuations in this marginal rate of substitution, when government crowds out steady state consumption it raises the sensitivity of real wages to changes in consumption. In effect, by reducing steady state consumption relative to wage income, government propagates the income effect in rule-of-thumb households' labour supply.[27]

Consider now an increase in production that is not motivated by fundamentals. This increase is accompanied by a rise in real disposable income. At this point

[26] The assumption of positive third derivative is not very restrictive. It holds for CARA preferences as well as the CRRA preferences assumed here. In general, it must holds for any utility function that is concave in consumption, if the marginal utility of consumption is never to be negative.

[27] Since non-Ricardian households have no wealth, the parameter σ governs the income effect of real wages in their labour supply. Thus, since σ is everywhere multiplied by $\frac{WN}{PC}$ in (15), it follows that government propagates the income effect by increasing $\frac{WN}{PC}$. Another way of stating this is that since households' *relative* aversion to risk (σ) is constant, their *absolute* risk aversion increases as government reduces their consumption.

government size matters, because the income effect in non-Ricardian labour supply increases with steady state government consumption, as explained above. Hence, real wages are going to increase more if government is large than if it is small. Obviously, a larger response of wages implies a stronger response of rule-of-thumb consumption, and the destabilising influence of government consumption occurs. In short, government purchases crowd out steady state private consumption which stimulates the wage response to sunspot shocks, and thereby increases the response of rule-of-thumb consumption too.

3.2 Government size and indeterminacy with procyclical tax revenues

The traditional argument of how government size affects macroeconomic volatility is that higher steady state expenditure raises the average tax rate which in turn stabilises disposable income. Such an effect is of course neglected in Figures 1 and 2 where net government revenues are independent of output and the average tax rate drops one for one with increases in activity. I therefore study the effects of government size under the fiscal policy rule of equation (13).

Figure 3 displays how government size affects the scope for indeterminacy under this fiscal regime. The plot is constructed under the same calibration as that behind Figure 1. The traditional Keynesian logic that a larger government is stabilising would imply a positive sloped curve dividing the determinacy and indeterminacy regions from one another. As the figure makes clear, this does not occur under my benchmark calibration. Instead, the relationship between government size and the scope for indeterminacy is non-monotonic, with automatic stabilisation only working when government is small. Under the benchmark calibration used in the figure, government spending only stabilises the economy when it constitutes less than approximately 10 percent of output in steady state, while it leads toward indeterminacy thereafter. Furthermore, for government sizes of empirical relevance, 0.15 to 0.3, the indeterminacy region is roughly constant.

The explanation for the shape of the curve in Figure 3 is as follows. On the one hand, a larger government leads to more volatile gross income by propagating the income effect in rule-of-thumb labour supply. On the other hand, for a given gross income stream, a larger government smoothes disposable income by raising average taxes. The latter effect dominates when government is small, but as government grows larger the gross income stream gets exceedingly more volatile and the destabilising effect dominates.

3.3 Non-separable government purchases

Under the complete separability assumed so far, government spending destabilises the economy by making households less willing to accept swings in consumption. That is, because government size does not alter households' relative risk aversion, given by σ, it does increase households' absolute risk aversion by crowding out steady state private consumption.

Now, if households enjoy government purchases as a perfect substitute for private consumption, this effect would not be present because households then do not care if they buy such goods directly in the market or indirectly via non-distortionary taxes. Hence, the only effect of an increasing government share will run via the stabilisation of disposable income that it induces. The dotted lines in Figures 4 and 5, where the solid curve is identical to the one displayed in Figure 3 before (note that the scale of the vertical axis has changed), confirm this intuition. When substitutability is perfect ($\xi = 1$) Figure 4 shows that government consumption increases the prevalence of rule-of-thumb consumption that is required to render the Taylor principle insufficient. Even if 70 percent of aggregate steady state consumption were governed by rule-of-thumb behaviour, satisfying the Taylor principle would be sufficient to avoid equilibrium indeterminacy if government consumes 18 percent of aggregate output or more.

In general, for any positive degree of substitutability between government and private goods, government purchases reduce households' relative aversion to volatility in private consumption. This effect counteracts the increase in absolute risk aversion that occurs when government crowds out private consumption. In the same spirit, if government and private consumption are Edgeworth complements, government spending will not only tend to increase absolute risk aversion through the crowding out effect, it will also increase *relative* risk aversion, as discussed in the presentation of the general utility function (1).[28] The remaining curves in Figures 4 and 5 illustrate this point, showing that for an intermediate degree of substitutability ($\xi = 0.5$, within the range of estimates provided by Ni (1995)) government spending that substitutes well for private consumption stabilises the economy in the sense that it reduces the scope for indeterminacy. The effect of

[28] The impact of substitutability is clearly seen if (2) is solved forward, and the resulting expression for Ricardian consumption is substituted into (6) together with (5) which governs non-Ricardian consumption, to obtain

$$w_t - p_t = \frac{\sigma\lambda\gamma_c}{\xi\gamma_g + \gamma_c} c_t^r - (1-\lambda)\sum_{i=0}^{\infty}(r_{t+i} - \pi_{t+1+i}) + \psi n_t.$$

The crowding out effect of government size on wage dynamics is to raise c_t^r, i.e. to increase the *percentage* change in rule-of-thumb consumption after a sunspot shock. The effect on relative risk aversion goes through the coefficient $\frac{\sigma\lambda\gamma_c}{\xi\gamma_g+\gamma_c}$, which is increasing in γ_g if ξ is negative.

complementarity, as reflected by a negative ξ is the opposite, and quantitatively strong. For $\xi = -0.5$, a degree of complementarity that is well within the range of empirical estimates (see for instance Karras (1994)), a government that purchases 25 percent of output brings down the threshold fraction of rule-of-thumb households to below 50 percent.

A further point is worth noting here. GLVb find that rule-of-thumb consumption may render the Taylor principle misguided as policy advice. However, the prevalence of such behaviour that they require for their results to go through, close to 60 percent in their benchmark calibration, is relatively high compared to empirical evidence from developed economies (see GLVa and the references therein). One may therefore doubt its relevance for the conduct of monetary policy in actual economies. Figure 4 shows that if government expenditure is a substitute for private consumption this doubt is even more appropriate. On the other hand, in economies where government purchases complement private consumption, the indeterminacy problem that rule-of-thumb households induce is more relevant than what GLVb's results indicate. Unfortunately, as discussed in the section about how the model is calibrated, the empirical literature is inconclusive on the degree of substitutability between private and government consumption.

4 Sensitivity analysis

The key mechanisms that determine how government spending affect the scope for indeterminacy all lie in the labour market. This section therefore explores to what extent the results would differ under the assumption of a perfectly competitive labour market. Thereafter the assumption of full redistribution is relaxed, and I let rule-of-thumb households live off their net wage income alone, while the remaining households in addition receive income from renting out capital and owning firms. Finally I raise the elasticity of real wages with respect to working hours to the same level as in the determinacy analysis of GLVb.

4.1 Perfectly Competitive Labour Market

If the labour market is perfectly competitive, working hours will no longer be equal for different consumer types. The reason is that (6) does not only hold in the aggregate, but also for each household since they optimise individually:

$$w_t - p_t = \sigma c_t^h + \psi n_t^h, \tag{16}$$

$h = o, r$. Hence, Ricardian and non-Ricardian households will supply different amounts of labour when their consumption levels differ. This will generally be the case outside steady state (where transfers are set to equalise consumption across households), and clearly in the case of the sunspot shocks discussed so far.

The upper left plot of Figure 6 displays how government size affects the scope for indeterminacy with this labour market. The dashed line separates the determinacy from the indeterminacy region when tax revenues obey the acyclical rule (12), while the solid line applies to the proportional tax scheme (13). Consistently with GLVa, the figure shows that rule-of-thumb consumers generate far less of a determinacy problem here than under the imperfectly competitive labour market. The reason is that when a sunspot shock raises their disposable income they increase leisure as well as consumption. More interesting for the current analysis however, is the finding that government spending casts far less of a destabilising influence when hours are determined individually rather than collectively. The lines dividing the determinacy and indeterminacy regions from one another now have the same shapes as under the imperfectly competitive labour market, revealing that the qualitative effects are the same as before. Quantitatively, however, the difference is the large, and government size is almost irrelevant for how strongly rule-of-thumb consumers destabilise the economy.

The reason why the destabilising influence (dashed line in the figure) of government is much weaker under a perfectly competitive labour market is as follows. Instead of having to adjust wages to meet the average marginal rate of substitution between leisure and consumption in the economy, a firm that wishes to increase its production may go directly to the households who have the highest willingness to work on the margin. During a sunspot shock, these will be Ricardian households as long as monetary policy satisfies the Taylor principle. This is the case since a rise in the real interest lowers their present level of consumption in favour of the future. Thus, since employers are free to turn toward Ricardian households, the consequence of a stronger income effect in rule-of-thumb labour supply is that rule-of-thumb households increase their working hours less than Ricardian households after a sunspot shock. Consequentially, the destabilising effect of government size becomes far weaker when wages are set individually rather than collectively.

Furthermore, the potentially stabilising effect of a large government (solid line in the figure), through making tax revenues more procyclical, is also weaker under the competitive labour market. This follows since income variations matter less for real wages in a competitive labour market, as explained above, and therefore the importance of how *much* income varies is also reduced. Hence, the total effect of procyclical taxation on such households' consumption is reduced by their ability to individually choose working hours in a perfectly competitive labour market.

The lessons from this exercise are twofold. First, when rule-of-thumb households adjust to income rises by enjoying more leisure as well as consumption, government matters less for whether or not the rational expectations equilibrium is unique. Second, in order to understand how rule-of-thumb consumers affect the economy, it is necessary to study how they behave in the labour as well as in the goods market.[29]

4.2 No Steady State Redistribution

So far I have assumed that in steady state government transfers wealth so as to equalise consumption across households. When this assumption is departed from, equations (2), (5) and (6) must be adopted, since it no longer is the case that γ_g equals each household's consumption share out of output. The adjustments are derived and explained in the appendix.

The upper right plot of Figure 6 reveals the consequences of removing the steady state redistributionary transfers. As can be seen, the indeterminacy problem generated by rule-of-thumb households now kicks in at a substantially lower level than before, as now approximately a 45 percentage point share of rule-of-thumb agents will render the Taylor principle insufficient in the absense of government spending. This effect is exactly what one would expect from the discussion of how government spending generates indeterminacy. That is, when rule-of-thumb households consume less in the steady state, the income effect in their labour supply decision becomes stronger. Furthermore, the plot reveals that the destabilising effect of government size is qualitatively similar to, but quantitatively somewhat stronger than in the benchmark economy, as revealed by the dashed line. This helps to explain why the total effect of government size under proportional taxation (the solid line) is never to increase the scope for indeterminacy.[30]

[29] The point that households' labour market adjustment matters a great deal for the final effect of specific assumptions on their consumption pattern is common with a range of other studies. The closest example is GLVa who show that rule-of-thumb households contribute less to explaining the effects of government spending shocks under the competitive rather than the incompetitive labour market sturcture studied here.

[30] Although not visible in Figure 6, the solid and dotted lines cross when government becomes sufficiently large, indicating that a if government absorbes enough resources from households, a procyclical tax-scheme actually increases the scope for indeterminacy. The mechanism behind this somewhat counterintuitive result, is that when taxes raise to dampen the increase in rule-of-thumb consumption after a sunspot shock, they also dampen the response of wages. This in turn dampens inflation and thereby the reaction of the interest rate. Hence, Ricardian consumption and investment fall less after the sunspot shock when lump sum tax revenues are pro- rather than acyclical.

In order for these effects to be so strong that procyclical taxation is destabilising in the model, rule-of-thumb consumption must propagate very stongly into wages, relative to their effect on aggregate demand. Such an effect is exactly what a large γ_g delivers. When γ_g is large, rule-of-thumb households are very poor at the outset, so the income effect of a given income rise on their labour supply is gigantic. Thus, procyclical taxation is very efficient in dampening wage pressures, and thereby the response of the interest rate.

4.3 Higher Real Wage Elasticity

When GLVb investigate how rule-of-thumb households increase the scope for indeterminacy, they assume the Cobb-Douglas utility function $U(C, L) = \frac{1}{1-\sigma}(CL^{\nu})^{1-\sigma}$, where $L = 1 - N$ is leisure. The two lower plots of Figure 6 show the impact of government size on the scope for indeterminacy under these preferences, with the new parameter ν set so that $N = 1/2$ in steady state, following the benchmark calibration of GLVb. Since $\sigma = 1$, the utility function is still separable in leisure and consumption. Hence, the only difference between this model and my benchmark framework, is that the elasticity of wages with respect to hours (the inverse Frisch elasticity if the labour market is perfectly competitive) now equals $\frac{N}{1-N}$, and thereby is 5 times as elastic with respect to hours as before. For details see the appendix.

As the graphs make clear, the effect of government spending on the scope for indeterminacy is no less under GLVb's specification of preferences. The indeterminacy problem hits in at a lower value of λ, the fraction of rule-of-thumb households, just as in GLVb. This is a natural consequence of the lower elasticity of labour supply. The impact of government size, however, is the same as before, both qualitatively and quantitatively.

5 Conclusion

A growing strand of literature, following Mankiw (2000), claims that in order to understand how government spending affects the economy one must take into account that some households do not use financial markets, but let their consumption level perfectly track disposable income instead. Such behaviour is of a strong Keynesian flavour. One may therefore believe that embedding it into an otherwise standard New Keynesian model by construction introduces the Keynesian idea of automatic stabilisation too. My results show that this is not generally the case. Quite to the opposite, when hand-to-mouth consumption is sufficiently prevalent, more government expenditure raises the sensitivity of real wages to consumption swings and thereby the scope for recurrent sunspot fluctuations to take place as well. This will be the case for government expenditures that complement private consumption. On the other hand, government purchases that substitute for private consumption reduce the scope for indeterminacy. A further point that follows from

In total then, if rule-of-thumb households are poor enough, a tax increase in the wake of a sunspot shock has a more contractive effect on the response of the interest rate than on the response of rule-of-thumb consumption. Hence, even though procyclical taxes dampen the destabilising spur in rule of thumb consumption following a sunspot shock, their total effect may be to increase the scope for indeterminacy by dampening the stabilising contractions of Ricardian consumption and investment even more.

my results is that redistributive government policies that favour households' whose consumption is excessively sensitive to income swings, reduces the destabilisatory influence such households have on the economy.

For monetary policy, the implications of my findings are straightforward. Government purchases that substitute well for private consumption increase the parameter range within which the satisfying Taylor principle is sufficient for monetary policy not to be a source of recurrent sunspot fluctuations. Purchases that complement private consumption have the opposite effect. In essence, my results show that the destabilising influence of rule-of-thumb households that Galí et al. (2004) emphasise is sensitive to the size and composition of government spending. Hence, for the purpose of evaluating historical monetary policy rules in the light of asset market participation, accounting for the government sector in a rather detailed way seems necessary.

A general implication of this paper is that once Ricardian equivalence does not hold, it is important to get the dynamics of government deficits right. As a crude assumption, I have assumed deficit dynamics consistent with inflexible tax rates and a tax base that varies proportionately with output. Being more detailed in this respect, as well as accounting for the distortionary nature of taxation, is a clear direction for improvement of the current analysis.

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A Appendix

A.1 The Labour Market with Unions

Assume that there exist a continuum of different worker types, indexed by i, distributed over the unit interval. Each worker type is represented by its own union. Furthermore, rule-of-thumb and Ricardian consumers are uniformly distributed across worker types.

For each producer, indexed by $j \; \epsilon \; (0,1)$, different labour types are imperfect substitutes.To any producer j, effective labour is a CES aggregate of the different workers it employs,

$$N_t(j) = \left(\int_0^1 N_t(j,i)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} di \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}},$$

where ε_w is the elasticity of substitution between different worker types. Demand for labour of type i is then given by

$$N_t(i) = \left(\frac{W_t(i)}{W_t} \right)^{-\varepsilon_w} N_t$$

Period by period the typical union i sets the wage for its members to maximise

$$\lambda \left[U_C' \left(C_t^r, N_t \right) W_t(i) N_t(i) - \frac{N_t^{1+\varphi}(i)}{1+\varphi} \right] + (1-\lambda) \left[U_C' \left(C_t^o, N_t \right) W_t(i) N_t(i) - \frac{N_t^{1+\varphi}(i)}{1+\varphi} \right]$$

subject to the labour demand schedule above. The idea behind this objective function is that since consumption may generally differ across consumer types, the union weights labour income by its members' marginal utility of consumption. Furthermore, as firms do not care about consumption behaviour, all members of a union will work equally much once their wage is set. In the aggregate it then follows that $N_t^r = N_t^o = N_t$ for all t.

Taking into account that all unions will behave identically, the first order condition for optimal real wages reads

$$\left(\frac{\lambda}{MRS_t^r} + \frac{1-\lambda}{MRS_t^o} \right) \frac{W_t}{P_t} = \mu^w, \tag{17}$$

where $\mu^w = \frac{\varepsilon_w}{\varepsilon_w - 1}$ and $MRS_t^z = U_N'(C_t^z, N_t)/U_C'(C_t^z, N_t) = (C_t^z + \xi G)^\sigma N_t^\varphi$ for $z = r, o$. I assume that the markup μ^w is large enough to ensure $W_t > MRS_t^z$ at all t, such that both consumer types are always willing to meet labour demand at the prevailing wage.

When the last expression is log-linearised around the steady state where taxes are set to equalise consumption across all households, the following expression results

$$w_t - p_t = \frac{\gamma_c \sigma}{\xi \gamma_g + \gamma_c} c_t + \psi n_t,$$

which corresponds to equation (6) in the text.

A.2 Steady State

This section shows that in steady state government size, as indicated by γ_g, does not affect factor shares or real wages, but increases hours and the ratio of labour income to consumption. As long as consumption is equalised across agents in steady state, the choice of wage structure does not matter for these relationships.

A.2.1 Factor Shares

From firms' price setting and the expressions for marginal costs, it follows that the steady state capital to output ratio is

$$\frac{K}{Y} = (1+\mu^p)^{-1} \alpha \left(\rho + \delta\right)^{-1}$$

and that the wage share is

$$\frac{WN}{PY} = \frac{1-\alpha}{(1+\mu^p)}, \tag{18}$$

where $1+\mu^p$ is the optimal markup $\frac{\varepsilon}{\varepsilon-1}$. Equation (14) in the text follows straightforwardly from this expression. Furthermore, when the capital to output ratio is combined with the production function, the labour to output ratio may be expressed as

$$\frac{N}{Y} = \left((1+\mu^p)\alpha^{-1} \left(\rho+\delta\right)\right)^{\frac{\alpha}{1-\alpha}}.$$

Hence, it follows that the capital labour ratio $\frac{K}{N}$ is independent of government size.

A.2.2 Real Wages

Combining the expressions for the wage share and the labour to output ratio, it follows that

$$\frac{W}{P} = \frac{1-\alpha}{(1+\mu^p)^{\frac{1}{1-\alpha}} \left[\alpha^{-1} \left(\rho+\delta\right)\right]^{\frac{\alpha}{1-\alpha}}}.$$

Hence, in the steady state real wages are independent of government size.

A.2.3 The Consumption Share

The aggregate resource constraint and the capital output ratio, together with the fact that $\frac{I}{K}=\delta$, implies that the consumption share of output is

$$\gamma_c = 1-\gamma_g - \frac{\delta\alpha}{(1+\mu^p)(\rho+\delta)}. \tag{19}$$

A.2.4 Steady State Hours

From the expressions for real wages (17) and the wage share with $C^r = C^o = C$, it follows that

$$(1+\mu^w)(C+\xi G)^\sigma N^\varphi = \frac{W}{P} = \frac{1-\alpha}{(1+\mu^p)}\frac{Y}{N}.$$

Assuming that $\sigma = 1$, it then follows that

$$\begin{aligned} N^{\varphi+1}\left(\gamma_c+\xi\gamma_g\right)(1+\mu^w) &= \frac{1-\alpha}{(1+\mu^p)} \\ N &= \left[\frac{1-\alpha}{\left(\gamma_c+\xi\gamma_g\right)(1+\mu^w)(1+\mu^p)}\right]^{\frac{1}{\varphi+1}} \end{aligned}$$

Together with (19) this implies that steady state hours are given by

$$N = \left[\frac{1-\alpha}{\left[1-(1-\xi)\gamma_g-\delta(1+\mu^p)^{-1}\alpha\left(\rho+\delta\right)^{-1}\right](1+\mu^w)(1+\mu^p)}\right]^{\frac{1}{\varphi+1}}$$

which is increasing in γ_g as long as $\xi<1$. When $\xi=1$, hours are independent of government size.

Furthermore, since $\frac{K}{Y}$ is independent of γ_g it follows that the steady state levels of capital and output also increase with γ_g when $\xi<1$, and are independent of γ_g when $\xi=1$.

A.3 The Proportional Tax Scheme

To see the rationale behind the modified tax scheme (13), note that total tax revenues T_t may be written as

$$T_t = \Gamma_t Y_t$$

This says that net tax revenues are proportional to output, where the factor of proportionality, i.e. the average net tax rate, is Γ_t . Furthermore, because steady state government debt is zero, $\Gamma=\gamma_g$. Next, I assume that the average net tax rate does not respond on impact to variations in output. I still allow it, however, to respond on impact to changes in the level of government debt. Thus, taxes are set according to the rule

$$P_t \Gamma_t Y = \phi_b B_t$$

Note that had not the output measure on the left hand side of this expression been evaluated in steady state, this tax rule would be equivalent to (12). Log-linearised around the steady state with neither inflation nor govenment debt, the tax rule then reads

$$t_t = \phi_b b_t + \gamma_g y_t.$$

A.4 Calibration

Parameter	Value	Parameter	Value	Parameter	Value
σ	1	ε	6	η	1
β	0.99	δ	0.025	θ	0.75
φ	0.2	α	0.33	ϕ_b	0.3

(20)

For a discussion of this calibration, see GLVa.

A.5 The Real Wage Elasticity with Cobb-Douglas Preferences

This section shows that when households have the utility function $U(C, L) = \frac{1}{1-\sigma}(CL^{\nu})^{1-\sigma}$, where $L = 1 - N$ is leisure, the elasticity of real wages with respect to hours is $\frac{N}{1-N}$.

Each households' marginal rate of substitution between consumption and leisure is given by

$$\frac{U'_{L_t^z}}{U'_{C_t^z}} = \nu \frac{C_t^z}{L_t^z} \tag{21}$$

With a perfectly competitive labour market, each household adjusts to equate this ratio to the real wage. Hence, in the aggregate

$$\nu \frac{C_t}{L_t} = W_t - P_t,$$

which may be log-linearised to obtain

$$w_t - p_t = c_t + \frac{N}{1-N} n_{t.}$$

This expression confirms the claim that with the assumed Cobb-Douglas preferences, the elasticity of real wages with respect to hours (the inverse Frisch elasticity) equals $\frac{N}{1-N}$.

The wage elasticity in the incompetitive labour market framework, follows from (21) and (17)

$$\begin{aligned}\left(\frac{\lambda}{\nu\frac{C_t^r}{L_t^r}}+\frac{1-\lambda}{\nu\frac{C_t^o}{L_t^o}}\right)\frac{W_t}{P_t} &= \mu^w \\ (1-N_t)\left(\frac{\lambda}{\nu C_t^r}+\frac{1-\lambda}{\nu C_t^o}\right)\frac{W_t}{P_t} &= \mu^w,\end{aligned}$$

Log-linearisation then yields

$$\begin{aligned}\frac{1}{\nu C}\frac{W}{P}(1-N)\left[-n_t\frac{N}{1-N}+(w_t-p_t)-\lambda c_t^r-(1-\lambda)c_t^o\right] &= 0 \\ w_t-p_t &= c_t+n_t\frac{N}{1-N},\end{aligned}$$

since $c_t=\lambda c_t^r+(1-\lambda)c_t^o$. Hence, the elasticity if real wages with respect to hours is $\frac{N}{1-N}$ in the imperfectly competitive labour market too.

A.6 The Model Without Redistribution in Steady State

A.6.1 The Steady State Without Redistribution

When there is no redistribution in the steady state, C^r will not be equal to C^o. Hence the ratios $\frac{C^z}{C}$ will no longer equal γ_c. Denote instead $\frac{C^r}{Y}=\gamma_c^r$ and $\frac{C^o}{Y}=\gamma_c^o$.

The consumption equation of rule-of-thumb households $C^r=\frac{W}{P}N^r-T^r$ implies that

$$\frac{C^r}{Y}=\frac{WN^r}{PY}-\frac{T^r}{Y}.$$

Since $T^r=T^o=T$, it must be the case that $\frac{T}{Y}=\frac{G}{Y}=\gamma_g$ if the government budget is to be balanced in steady state. Combining this with the assumption that $N^r=N$ and the wage share given by (18), it then follows that

$$\gamma_c^r=\frac{1-\alpha}{1+\mu^p}-\gamma_g$$

γ_o then follows from the aggregate relationship $C_t=\lambda C_t^r+(1-\lambda)C_t^o$:

$$\gamma_c^o=\frac{\gamma_c-\lambda\gamma_c^r}{1-\lambda}$$

where the aggregate consumption share of output γ_c is given by (19) as before.

A.6.2 Log-Linearised Equilibrium Without Redistribution

The log-linearised wage scheme will be somewhat different when there is no redistribution in steady state. The equation (17) still holds, so that

$$\left(\frac{\lambda}{(C_t^r+\xi G)^{\sigma} N_t^{\varphi}}+\frac{1-\lambda}{(C_t^o+\xi G)^{\sigma} N_t^{\varphi}}\right)\frac{W_t}{P_t}=\mu^w.$$

Log-linearised around the steady state without redistribution, but still with $N^r = N^o$, this relationship yields

$$c_t^r\left[\frac{\lambda\sigma\gamma_c^r}{\left(\gamma_c^r+\xi\gamma_g\right)^{\sigma+1}}\right]+c_t^o\left[\frac{(1-\lambda)\sigma\gamma_c^o}{\left(\gamma_c^o+\xi\gamma_g\right)^{\sigma+1}}\right]+n_t\left[\frac{\lambda\varphi}{\left(\gamma_c^r+\xi\gamma_g\right)^{\sigma}}+\frac{(1-\lambda)\varphi}{\left(\gamma_c^o+\xi\gamma_g\right)^{\sigma}}\right]$$
$$-(w_t-p_t)\left[\frac{\lambda}{\left(\gamma_c^r+\xi\gamma_g\right)^{\sigma}}+\frac{(1-\lambda)}{\left(\gamma_c^o+\xi\gamma_g\right)^{\sigma}}\right]=0 \qquad (22)$$

Without redistribution in the steady state, this expression replaces equation (6) as the log-linearised wage equation.

The only two other adjustments that must be made to the model are the relationships governing households' consumption. The euler equation for optimising households' consumption profile now reads

$$c_t^o=E_t c_{t+1}^o-\frac{\xi\gamma_g+\gamma_c^o}{\sigma\gamma_c^o}\left(r_t-E_t\pi_{t+1}\right),$$

in stead of (2) in the text. Rule-of-thumb households now obey the equation

$$c_t^r=\frac{1-\alpha}{(1+\mu^p)}\frac{1}{\gamma_c^r}(n_t^r+w_t-p_t)-\frac{1}{\gamma_c^r}t_t^r.$$

The log-linearised relationship for aggregate consumption is

$$c_t=\lambda\frac{\gamma_c^r}{\gamma_c}c_t^r+(1-\lambda)\frac{\gamma_c^o}{\gamma_c}c_t^o$$

The remainder of the model does not change.

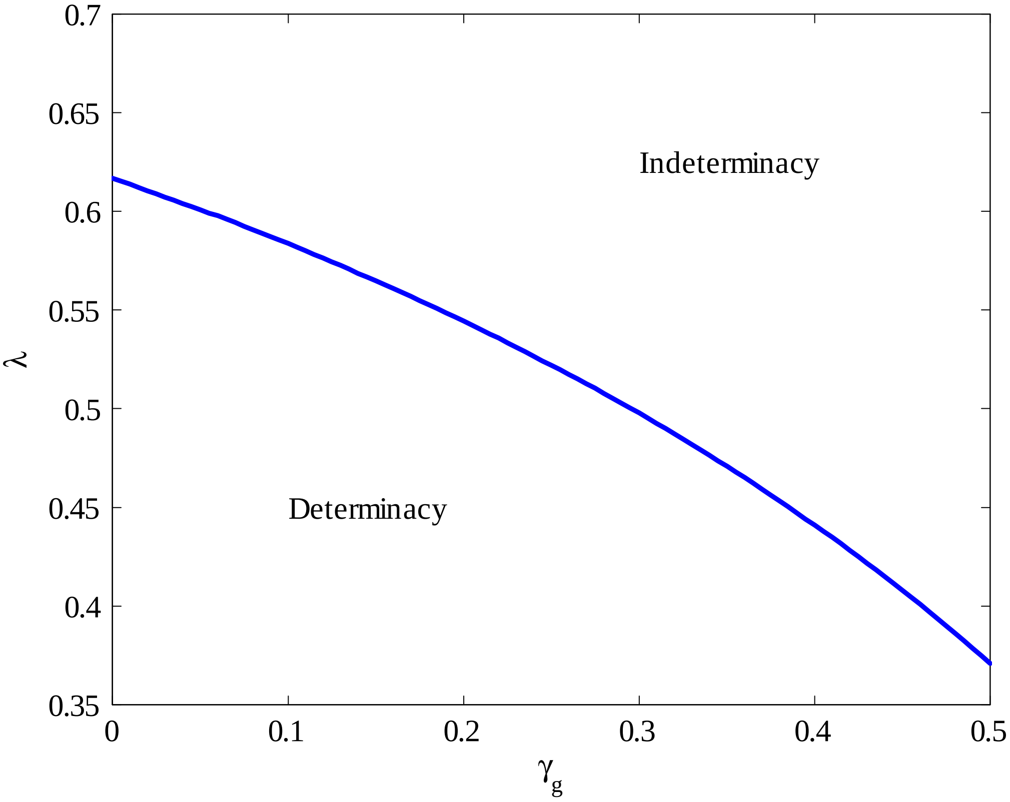

Figure 1: Government size, rule-of-thumb consumption and indeterminacy when tax revenues are acyclical. $\phi_\pi = 1.0001$. Utility is separable in private and government consumption. The rational expectations equilibrium is indeterminate above the plotted curve, and determinate below it.

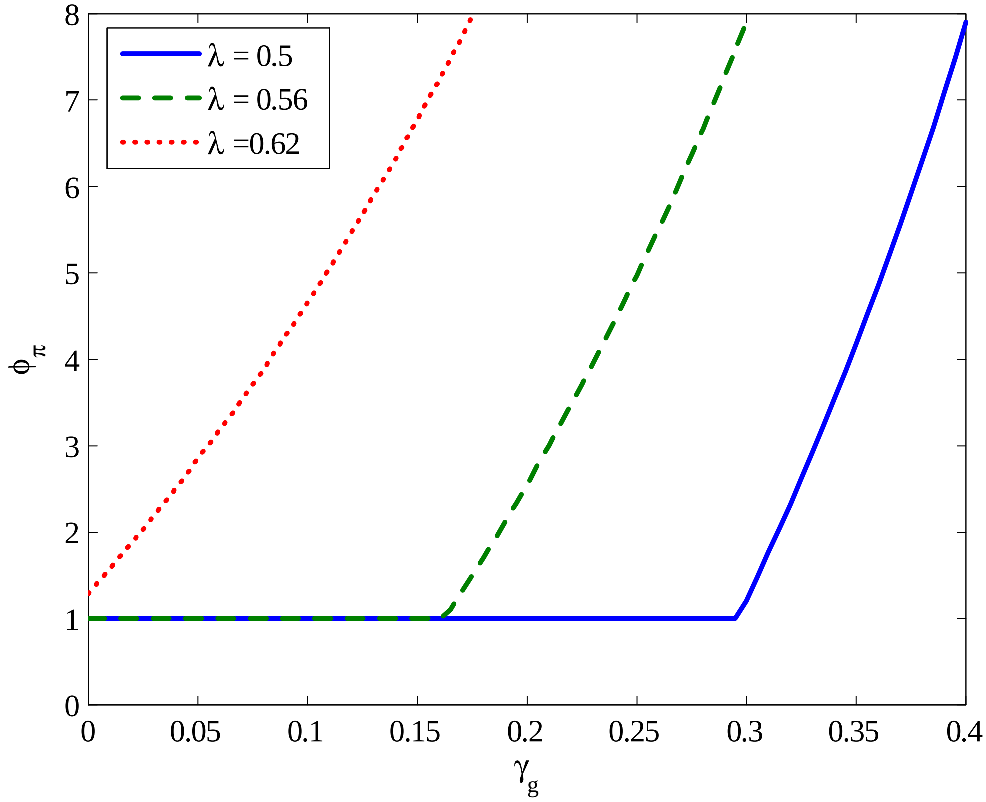

Figure 2: Government size and the threshold inflation coefficient that yields determinacy for three different values of λ. Tax revenues are acyclical. Utility is separable in private and government consumption. The rational expectations equilibrium is determinate above the plotted curves, and indeterminate below them.

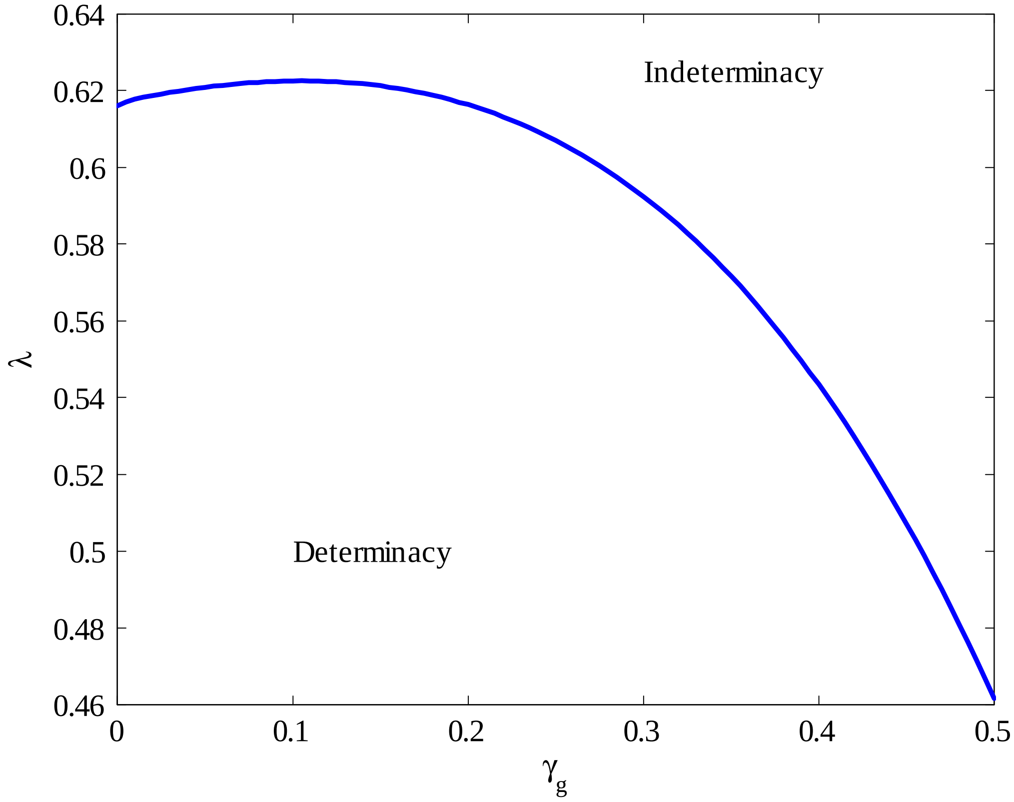

Figure 3: Government size, rule-of-thumb consumption and indeterminacy when tax revenues are procyclical. $\phi_\pi = 1.0001$. Utility is separable in private and government consumption. The rational expectations equilibrium is indeterminate above the plotted curve, and determinate below it.

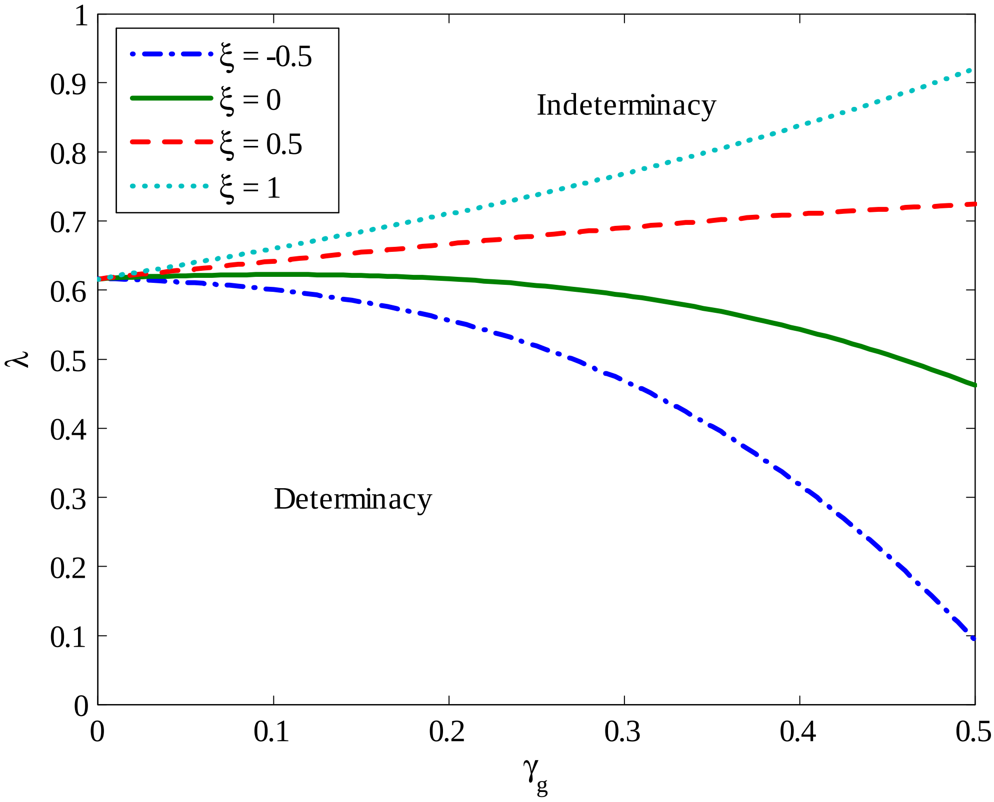

Figure 4: Government size, rule-of-thumb consumption and indeterminacy for four different degrees of substitutability (ξ) between private and government consumption. Tax revenues are procyclical. The rational expectations equilibrium is indeterminate above the plotted curves, and determinate below them.

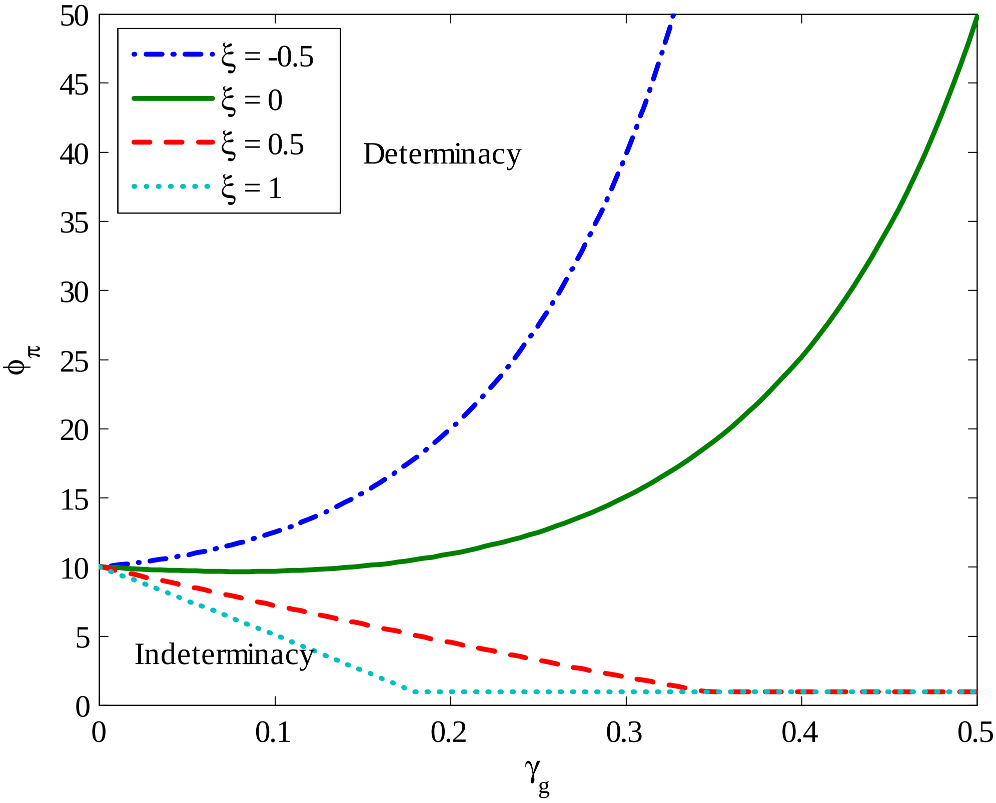

Figure 5: Government size and the threshold inflation coefficient that yields determinacy for four different degrees of substitutability (ξ) between private and government consumption. $\lambda = 0.7$ for all three curves. Tax revenues are procyclical. The rational expectations equilibrium is determinate above the plotted curves, and indeterminate below them.

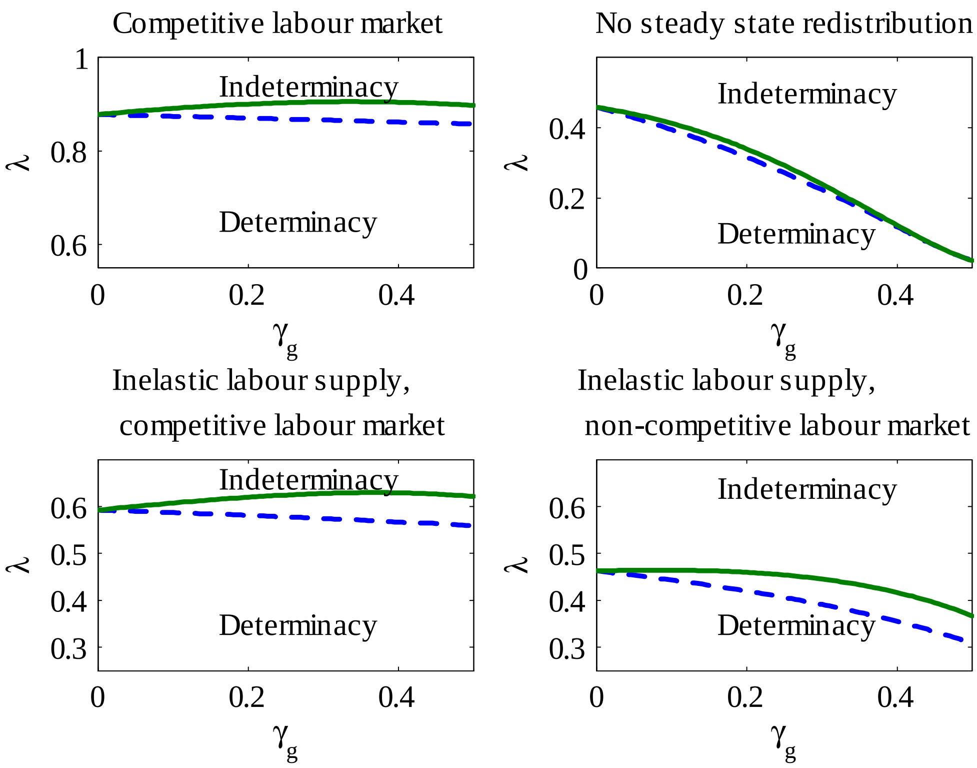

Figure 6: Government size, rule-of-thumb consumption and indeterminacy when $\phi_\pi = 1.0001$. Solid curves are the cases with acyclical tax revenues. Dotted curves are the cases when tax revenues are automatically acyclical. Utility is separable in private and government consumption. Above the plotted curves the rational expectations equilibrium is indeterminate. Below the curves it is determinate.

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