Government Spending Shocks and Rule-of-Thumb Consumers with Steady State Inequality*

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Abstract

Galí, López-Salido, and Vallés (2007) suggest that because part of the population follow a rule-of-thumb by which they spend their entire disposable income each period, private consumption responds positively to deficit-financed increases in government spending. I show that this result hinges on the arbitrary assumption that the government fully redistributes wealth across households in steady state.

Keywords: Rule-of-thumb consumers, wealth inequality, government spending, indeterminacy.

JEL Classification: E21, E25, E32, E62

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1 Introduction

In a recent paper, Galí, López-Salido, and Vallés (2007) (GLV, hereafter) propose the following explanation for why private consumption responds positively to unanticipated increases in government spending: Part of the population are "rule-of-thumb" consumers who do not use financial markets to smooth consumption, but consume their entire disposable income each period. Capital and firms are owned by the remaining population, termed "optimizing" households. GLV find that with sufficiently many rule-of-thumb consumers, an otherwise standard New Keynesian model can account for the positive response of consumption to a deficit financed increase in government spending. This is an important result, as it implies that fiscal policy analyses should take rule-of-thumb behavior into consideration. However, in reaching their conclusion GLV assume that wealth is redistributed in steady state, and thereby abstract from the impact of heterogenous savings behavior on wealth inequality. In this note I show that accounting for such inequality has two important effects.

First, without redistribution the equilibrium of GLV's model is indeterminate under their benchmark calibration. If the equilibrium is to be determinate with no redistribution, at most 32 percent of the economy's households may be rule-of-thumb consumers, which is well below the 50 percent that GLV suggest and too low for aggregate private consumption to be stimulated by a government spending shock. This conclusion holds also when controlling for the redistributive effects of consumption, labor and capital taxes parametrized to their US counterparts.

Second, wealth inequality undermines the labor market structure that GLV show is key for their model to generate the sought consumption response. The essence of this structure is that households with different savings behavior cooperate to set a common wage and work equally much. However, if wealth is not redistributed, agents will wish to work different numbers of hours, and rule-of-thumb households are likely to push the real wage below the optimizers' marginal rate of substitution between leisure and consumption in steady state.

2 The Model

The model presented here is the same as that in GLV, generalized to a situation where government does not redistribute wealth in steady state.

2.1 Households

There are two types of households, optimizing (indexed by "o") and rule-of-thumb (indexed by "r"). A share λ of the population belongs to the latter group. All households supply a differentiated type of labor indexed by $i \epsilon (0,1)$.

Optimizing households own firms and have access to complete markets for state contingent money claims. They consume, purchase bonds and accumulate physical capital so as to maximize expected discounted lifetime utility $E_t \sum_{k=0}^{\infty} \beta^k U\left(C_{i,t+k}^o, N_{i,t+k}^o\right)$, where β is their discount factor, $C_{i,t}^o$ is consumption and $N_{i,t+k}^o$ is hours worked. Their budget constraint is

$$P_t\left[C_{i,t}^o + I_{i,t}^o\right] + R_t^{-1} B_{i,t+1}^o \leq B_{i,t}^o + W_{i,t} N_{i,t}^o + R_t^k P_t K_{i,t}^o + D_{i,t}^o - P_t T_{i,t}^o \qquad (1)$$

and the law of motion for capital is $K_{i,t+1}^o = (1-\delta) K_{i,t}^o + \phi\left(\frac{I_{i,t}^o}{K_{i,t}^o}\right) K_{i,t}^o$. Here P_t is the time t price level, $W_{i,t}$ is the nominal wage for labor type i, and $B_{i,t+1}^o$ 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 bought in period t. $D_{i,t}^o$ denotes dividends from ownership of firms. T_{it}^o denotes lump sum real taxes levied upon each optimizing household and $K_{i,t}^o$ is the amount of capital they hold. It depreciates at a rate δ and yields a gross return R_t^k. The term $\phi\left(\frac{I_{i,t}^o}{K_{i,t}^o}\right) K_{i,t}^o$, with $\phi' > 0$, $\phi'' \leq 0$, $\phi'(\delta) = 1$, $\phi(\delta) = \delta$, introduces capital adjustment costs.

Rule-of-thumb households neither borrow nor save, but consume their disposable income every period:

$$C^r_{i,t} = \frac{W^r_t}{P_t} N^r_{i,t} - T^r_{i,t}, \tag{2}$$

Here C^r_t denotes rule-of thumb households' consumption, N^r_t is their labor hours and T^r_t is their tax payments.

Intratemporal preferences are identical for all households and given by

$$U\left(C^h_{i,t}, N^h_{i,t}\right) = \log C^h_{i,t} - \frac{N^{h1+\varphi}_{i,t}}{1+\varphi}, \quad h = r, o, \tag{3}$$

where φ is the inverse of the Frisch elasticity of substitution in labor supply.

Aggregation Consumption and labor supply per consumer of type $h = o, r$ are given by $C^h_t = \int_0^1 C^h_{i,t} di$ and $N^h_t = \int_0^1 N^h_{i,t} di$. Aggregate consumption and labor supply are given by

$$C_t = \lambda C^r_t + (1-\lambda) C^o_t \tag{4}$$

and

$$N_t = \lambda N^o_t + (1-\lambda) N^r_t. \tag{5}$$

Investment, capital, bonds and dividends aggregate by $I_t = (1-\lambda) I^o_t$, $K_t = (1-\lambda) K^o_t$, $B_t = (1-\lambda) B^o_t$ and $D_t = (1-\lambda) D^o_t$.

2.2 Firms

A representative, perfectly competitive firm combines different varieties of goods $Y_{j,t}$, $j \,\epsilon\, [0,1]$, to produce a final good Y_t with the CES-technology $Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\varepsilon_p - 1}{\varepsilon_p}} dj\right)^{\frac{\varepsilon_p}{\varepsilon_p - 1}}$, where ε_p is the elasticity of substitution between the varieties indexed by j. Profit maximization implies the demand schedules $Y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\varepsilon_p} Y_t$, where P_t is the price of the final good. The zero profit condition that price equals minimized unit costs is $P_t = \left(\int_0^1 P_{j,t}^{1-\varepsilon_p} dj\right)^{\frac{1}{1-\varepsilon_p}}$, where $P_{j,t}$ is the price of intermediate good j.

The differentiated intermediate goods are produced by imperfectly competitive firms indexed by j with the production technology $X_{j,t} = K_{j,t}^{\alpha} N_{j,t}^{1-\alpha}$, $\alpha \epsilon (0,1)$. $K_{j,t}$ is the capital used by firm j in period t and $N_{j,t}$ is an aggregate of the different labor types it uses. Firms only care about the labor type i of the workers they hire, not how consumption decisions are made. The labor aggregate is defined by the CES-function

$$N_{j,t} = \left(\int_0^1 N_{j,t}^{\frac{\varepsilon_w - 1}{\varepsilon_w}} di \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \tag{6}$$

where ε_w is the elasticity of substitution between the different labor types.

Cost minimization and aggregation across firms then imply that demand for labor of variety i is given by

$$N_{i,t} = \left(\frac{W_{i,t}}{W_t} \right)^{-\varepsilon_w} \widetilde{N}_t. \tag{7}$$

where $\widetilde{N}_t = \left(\int_0^1 N_{i,t}^{\frac{\varepsilon_w - 1}{\varepsilon_w}} di \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$.

Finally, intermediate firms set prices. As in Calvo (1983), each period a firm may reset its price only with a constant probability, denoted by $(1-\theta)$. Otherwise the price remains unchanged. Firms that reset their price in period t will then choose it so as to maximize $\sum_{s=0}^{\infty} \theta^s E_t \left\{ Q_{t,t+s} X_{j,t} \left[P_{j,t}^* / P_{t+s} - MC_{t+s} \right] \right\}$ subject to the demand constraints $X_{j,t+s} = Y_{j,t+s} = \left(\frac{P_{j,t}^*}{P_{t+s}} \right)^{-\varepsilon_p} Y_{t+s}$. Here $P_{j,t}^*$ and MC_{t+s} denote the price chosen by the resetting firm j and its real marginal cost, respectively. $Q_{t,t+s}$ is firm owners' stochastic discount factor for real profits s periods ahead, given by $Q_{t,t+s} \equiv \beta^k \left(\frac{C_t^o}{C_{t+s}^o} \right)$.

2.3 Unions

For each labor type i there exists a union which sets one wage on behalf of all its members, and requires them all to work equally much so as to satisfy labor demand at the posted wage, i.e. $N_{i,t}^r = N_{i,t}^o = N_{i,t}$. Each union places equal weight on each of their members, and thus maximizes

$$\sum_{s=0}^{\infty} E_t \beta^s \left\{ \lambda \left[U \left(C_{i,t+s}^r, N_{i,t+s} \right) \right] + (1-\lambda) \left[U \left(C_{i,t+s}^o, N_{i,t+s} \right) \right] \right\} \tag{8}$$

with respect to $W_{i,t}$, subject to (7), (1), and (2). Because all unions solve the same problem, $W_{i,t} = W_t$ for all i. Hence, labor demand $N_{i,t}$ and consumptions $C_{i,t}^r$ and $C_{i,t}^o$ are the same for all i as well. Taking this and the utility functions in (3) into account, the first-order condition for the optimal real wages may be written as

$$W_t = \frac{\varepsilon_w}{(\varepsilon_w - 1)} N_t^{\varphi} \left[\frac{\lambda}{C_t^r} + \frac{(1-\lambda)}{C_t^o} \right]^{-1}. \tag{9}$$

2.4 Fiscal and monetary policy

The nominal interest rate $r_t \equiv R_t - 1$ is set according to the simple interest rate rule

$$r_t = r + \phi_\pi \pi_t \tag{10}$$

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

The government budget constraint is

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

where $T_t = \lambda T_t^r + (1-\lambda) T_t^o$, and G_t is government consumption of final goods Y_t.

Taxes are set according to the rule

$$t_t = \phi_b b_t + \phi_g g_t, \tag{11}$$

where $b_t = \frac{B_t/P_{t-1} - B/P}{Y}$, $t_t = \frac{T_t - T}{Y}$, $g_t = \frac{G_t - G}{Y}$, and ϕ_b and ϕ_g are positive constants.

Government expenditures evolve exogenously by the process

$$g_t = \rho_g g_{t-1} + \varepsilon_t$$

2.5 Market clearing

The markets for labor and capital clear when $N_t = \int_0^1 \int_0^1 N_{i,j,t} di dj$ and $K_t = \int_0^1 K_{j,t}(j)\, dj$. The goods markets clear when $Y_{j,t} = X_{j,t}$ for all j and $Y_t = C_t + I_t + G_t$.

2.6 Steady state

Unless government transfers are set so as to equalize income across households, optimizing and rule-of-thumb agents will consume different amounts in steady state. Here I only emphasize those aspects of the steady state that are affected by this heterogeneity.

Rule-of-thumb and optimizing households' consumption shares are denoted by $\frac{C^r}{Y} = \gamma_c^r$ and $\frac{C^o}{Y} = \gamma_c^o$, respectively.

Without steady state redistribution, the tax burden upon rule-of-thumb households is determined by government consumption alone, and $\frac{T^r}{Y} = \frac{G}{Y} \equiv \gamma_g$ for the government budget to be balanced in steady state. Hence, from (2) it follows that

$$\gamma_c^r = \frac{WN}{PY} - \gamma_g. \tag{12}$$

As in GLV the aggregate labor share is given by $\frac{WN}{PY} = \frac{1-\alpha}{1+\mu^p}$.

Optimizing households' consumption share, then follows from the aggregate relationship $C_t = \lambda C_t^r + (1-\lambda) C_t^o$:

$$\gamma_c^o = \frac{\gamma_c - \lambda \gamma_c^r}{1-\lambda} \tag{13}$$

where the aggregate consumption share of output, γ_c, is unaffected by redistribution and given by $\gamma_c = 1 - \gamma_g - \frac{\delta\alpha}{\mu^p(\rho+\delta)}$ as in GLV, where $\rho \equiv \beta^{-1} - 1$

The steady state wage equation is

$$\frac{W}{P} = \frac{\varepsilon_w}{(\varepsilon_w - 1)} N^{\varphi} \left[\frac{\lambda}{C^r} + \frac{(1-\lambda)}{C^o} \right]^{-1}. \tag{14}$$

3 Results

The model's dynamics are analyzed by considering a first order Taylor approximation of the equilibrium conditions around the steady state. The parameter values of GLV are given in Table 1.

3.1 Inequality and Determinacy

It is well known that the presence of rule-of-thumb consumers may render the equilibrium of a New Keynesian economy indeterminate, even though monetary policy satisfies the Taylor principle (Galí, López-Salido, and Vallés (2004) and Bilbiie (2008)). To see why, consider the following thought experiment described in Galí, López-Salido, and Vallés (2004). Assume that without fundamentals to justify it, firms increase production. As consequence, labor demand rises too, pushing wages and marginal costs up. The latter motivates firms to charge higher prices, and inflation increases. Now, if monetary policy satisfies the Taylor principle and raises the nominal interest rate by more than the increase in inflation, the real interest rate goes up. This induces optimizing households to consume less, which in itself reduces demand and renders the initial burst in activity non-sustainable. However, rule-of-thumb households consume their entire rise in labor income. Hence, if a sufficiently large fraction of the households obey the rule-of-thumb, an expansionary sunspot shock will generate its own demand even though monetary policy satisfies the Taylor principle.

The quantitative strength of this mechanism depends on how much wages increase when activity rises. If a non-fundamental rise in activity is associated with a larger increase in labor income, the equilibrium becomes indeterminate for a lower share of rule-of-thumb households in the economy. Here the steady state income distribution plays a role: The poorer the rule-of-thumb households are in steady state, and the wealthier the optimizing households are, the stronger is the wage response to a non-fundamentally motivated rise in activity. The intuition behind is as follows.

A given rise in rule-of-thumb households' income reduces their willingness to work through the conventional income effect. The strength of this effect depends on how much their marginal utility of consumption falls as they consume more. Since the marginal utility of consumption is convex ($U_{CCC} > 0$),[1] it will necessarily fall more the less these households consume prior to the income change. Hence, the poorer rule-of-thumb households are, the more will their marginal willingness to exchange leisure for consumption drop if their income increases. Because wages are driven by households' willingness to work, it follows that the wage pressure induced by higher labor demand is negatively related to rule-of-thumb households' steady state wealth.[2] Furthermore, the same logic implies that a change in optimizing households' consumption affects real wages more, the less they consume initially. Thus, when these housholds cut consumption in response to higher interest rates, the moderating effect on wages is weaker if they have high wealth in steady state.

These effects are reflected in a first order approximation of equation (9):

$$w_t = \varphi n_t + \frac{\lambda}{\left[\lambda + (1-\lambda)\frac{C^r}{C^o}\right]} c_t^r + \frac{(1-\lambda)}{\left[\lambda\frac{C^o}{C^r} + (1-\lambda)\right]} c_t^o, \tag{15}$$

where w_t, n_t, c_t^r and c_t^o denote the real wage, hours worked and consumption by rule-of-thumb and optimizing households, in log deviations from their steady state levels. C^r and C^o denote the steady state consumption of the two consumer

[1] The assumption of a positive third derivative is not very restrictive. It holds for most utility functions used in the macro literature, such as all CARA and CRRA utility functions.

[2] Natvik (2009) explores how this effect may imply that a larger government, by absorbing private wealth, increases the scope for indeterminacy.

types. We see that by increasing C^r/C^o, a redistributive transfer scheme dampens the impact of rule-of-thumb consumption and stimulates impact of optimizers' consumption on wages.

The upper panel of Figure 1 shows how wealth inequality affects the economy's determinacy region. The figure shows the combinations of price rigidity (θ) and rule-of-thumb consumption share (λ) that lead to indeterminacy in GLV's model with and without redistribution, with all other parameters held constant. We see that under GLV's parametrization, where $\lambda = 0.5$ and prices are reset on average every 4 quarters ($\theta = 0.75$), the equilibrium is indeterminate if income is not redistributed between households in steady state.

The bottom panel of Figure 1 compares the consumption response to a government spending shock in GLV (the solid curve) to the response when the prevalence of rule-of-thumb consumption behavior is at its highest level consistent with equilibrium determinacy (the dotted curve). This threshold value of λ is 0.32, and we see that now the consumption response is very close to zero. Hence, it seems that if income is not redistributed, rule-of-thumb consumption cannot generate the positive response of private consumption to government spending shocks found in the data, without also rendering the equilibrium indeterminate.

3.1.1 Sensitivity Analysis

Redistribution through Distortive Taxation It is natural to ask what the indeterminacy region would look like under an intermediate degree of redistribution, caused by an empirically relevant tax system. I explore this by introducing constant tax rates on labor and capital income as well as on consumption expenditure, parametrized to their 1996 U.S. counterparts calculated by the method of Mendoza, Razin, and Tesar (1994).[3] In order for the government budget to

[3] Consumption taxes were set to 5.47%, labor income taxes were set to 27.73% and capital income taxes to 39.62%. These 1996 estimates for the U.S. economy are reported at Enrique Mendoza's website, www.bsos.umd.edu/econ/mendoza.

be balanced in the steady state, I assume that the difference between revenues from distortive taxation and government spending G is reimbursed uniformly to all households in a lump-sum manor. These lump-sum transfers amount to 3.28% out of steady state output. Finally, to maintain the same dynamics of total tax revenues as what GLV argue is empirically plausible, I assume that lump-sum taxation vary by the tax rule

$$t_t^{l-s} = \phi_b b_t + \phi_g g_t - t_t^{distort}, \tag{16}$$

while each single distortive tax rate is held constant. The remaining parameters of the model are left unchanged.

The impact of redistribution through distortive taxation is negligible. Both the indeterminacy region, displayed in the upper panel of Figure 2, and the response of consumption to government spending shocks are almost identical to the case without any redistribution at all. The threshold value of λ above which the equilibrium is indeterminate changes from 0.3218 to 0.3203. This supports the previous conclusion that a more empirically plausible degree of redistribution than what GLV consider, reduces their model's ability to generate a positive response of private consumption to government spending shocks.[4]

Zero Steady State Profits Optimizing households own firms. Because these firms have monopoly power, they operate with profits and hence increase optimizers' income in steady state. However, as argued in Rotemberg and Woodford (1995), steady state profits are both difficult to reconcile with the concept of a steady state, since they should motivate firm entry, and they are counterfactual. Thus, a common assumption in frameworks with monopolistic competition is that operating a firm involves the payment of a fixed cost each period. This cost may then be parametrized so as to remove steady state profits.

[4] The appendix provides further details of this analysis.

From the determinacy analysis above and the log-linearized wage equation (15), it follows that by omitting such a fixed cost, my preceding analysis may exaggerate the indeterminacy problem by exaggerating consumption inequality as measured by $\frac{\gamma_c^o}{\gamma_c^r}$. I therefore introduce a fixed cost that removes steady state profits.

It turns out that the quantitative significance of removing steady state profits on the model's indeterminacy region without redistribution is small, as shown in the lower panel of Figure 2. For the benchmark parametrization of the model with $\theta = 0.75$, the maximum share of rule-of-thumb households consistent with a determinate equilibrium of the economy increases from 0.3218 to 0.3477. Similarly, the response of private consumption to a positive government spending shock remains close to zero, increasing with approximately 0.2 percent on impact, when λ is set at its maximum value consistent with equilibrium determinacy.

3.2 Inequality and The Distribution of Working Hours

GLV show that to generate a positive response of private consumption to government spending in their model, it is crucial that the labor market is not perfectly competitive. The reason is that in a competitive labor market optimizing households would, due to a wealth effect, supply more labor when government spending increases. This would suppress growth in rule-of-thumb households' labor income and consumption. Hence, GLV impose a labor market structure where all households work equally much.

However, when wealth varies across households, their willingness to work for a given wage will vary as well. This is reflected in equation (9), which implies that the households with lowest consumption push their union's wage claims downward, while those who consume most push it up. Thus, under GLV's assumption that hours are always equalized across workers, a potential consequence of steady state wealth inequality is that rule-of-thumb households push the wage below optimizing households' marginal rate of substitution between consumption and leisure. If this occurs, there will exist mutually beneficial trades in hours that are left unexploited, between agents who by assumption are collaborating through unions. All that is required for every agent to be better off is that optimizing households work less, while rule-of-thumb households work more. The condition for this to be the situation in steady state, i.e. for $C^o N > W$, is

$$\varepsilon_w > 1 + \frac{(1-\lambda)\left(1-\alpha-\mu^p\gamma_g\right)}{\lambda\left(\mu^p - 1 + \frac{\alpha\rho}{(\rho+\delta)}\right)\left[1-\alpha-\mu^p\gamma_g\right]}, \tag{17}$$

where $\mu^p = \varepsilon_p/\left(\varepsilon_p - 1\right)$ is the steady state price markup, $\rho = 1/\beta - 1$ is the time preference rate. The other parameters are defined in Table (1).[5]

Figure 3 quantifies the relationship between λ and ε_w implied by inequality (17), holding the remaining parameters in (17) fixed. Studies in the New Keynesian literature largely argue for a labor demand elasticity above 3, or a wage markup below 1.5, and Figure 3 shows that as long as λ is relatively low these values are consistent with capital owners being willing to work as much as rule-of-thumb households in the steady state.[6] However, when λ is large, few optimizers receive all capital and dividend income, and therefore are relatively wealthy. The steady state wage markup, inversely related to ε_w, must then be unreasonably large for these agents not to desire a marginal cut in their working hours. With λ as high as 0.5, the value used by GLV, the elasticity of substitution between labor types must be extremely low for the labor market specification to make sense without redistribution.

[5] To derive (17), combine $C^o N^\varphi > W$ with equation (9) evaluated in steady state, and apply the definition $C^h/Y = \gamma_c^h$ for $h = o, r$, where Y denotes steady state output, to obtain $\gamma_c^o > \gamma_c^r\left[\frac{\varepsilon_w}{(\varepsilon_w-1)} - (1-\lambda)\right]/\lambda$. On the left hand side of this inequality, insert $\gamma_c^o = \left[1-\gamma_g - \delta\alpha/\left((\rho+\delta)\,\mu^p\right) - \lambda\gamma_c^r\right]/(1-\lambda)$, which follows from the aggregate relationship $C = \lambda C^r + (1-\lambda)C^o$ and $\gamma_c = C/Y = 1-\gamma_g - \delta\alpha/\left((\rho+\delta)\,\mu^p\right)$, as in GLV. On the right hand side, insert $\gamma_c^r = (1-\alpha)/\mu^p - \gamma_g$, which follows from $C^r = WN - T$, where T denotes per capita taxes, and $WN/Y = (1-\alpha)/\mu^p$. Rearranging yields expression (17).

[6] Smets and Wouters (2007) set ε_w to 3, while Christiano, Eichenbaum, and Evans (2005) set ε_w to 21.

4 Conclusion

Galí, López-Salido, and Vallés (2007) provide a framework where rule-of-thumb behavior explains why government spending stimulates private consumption. This note has given two separate arguments which indicate that this result hinges on the assumption that wealth is fully redistributed between households in steady state.

Both problems discussed arise in the labor market. Hence, if rule-of-thumb consumers do lie behind the expansive effects of government spending in the data, this is likely due to aspects of the labor market that are not considered in Galí, López-Salido, and Vallés (2007). Two such features could be wage rigidity, which will mitigate the wage response to sunspot shocks and thereby contain how strongly rule rule-of-thumb behavior increases the economy's indeterminacy region, and search and matching frictions, which may limit firms' ability to substitute between rule-of-thumb and optimizing households' labor services after a government spending shock.[7]

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A Appendix

A.1 Distortive Taxation

This section describes in detail how distortive taxes on consumption, labor and capital income affect the model economy.

With the three distortive taxes, the budget constraint of an optimizing household becomes

$$P_t\left[(1+\tau^c)\,C_t^o+I_t^o\right]+R_t^{-1}B_{t+1}^o\leq B_t^o+(1-\tau^w)\,W_t^oN_t^o+\left[R_t^k-\tau^k\,(R_t-\delta Q_t)\right]P_tK_t^o+D_t-P_tT_t \tag{18}$$

where τ^c, $\tau^w$and τ^k are the average tax rates on consumption, labor income and capital income, respectively, while T denotes lump-sum taxes which are uniform across households. P and W are the producer prices of goods and labor.

Rule-of-thumb consumption now evolves by

$$C_t^r=\left[(1-\tau^w)\,\frac{W_t}{P_t}N_t^r-T_t\right]\frac{1}{(1+\tau^c)}. \tag{19}$$

As before, unions require all households to work equal hours (i.e. $N_t^r=N_t^o=N_t$) maximize the objective (8). The constraints are now (7), (18) and (19), and the solution to the problem is the following wage equation

$$\frac{W_t}{P_t}=\frac{\varepsilon_w}{(\varepsilon_w-1)}\frac{1+\tau^c}{1-\tau^w}\left[\frac{\lambda}{MRS_t^r}+\frac{(1-\lambda)}{MRS_t^o}\left(\frac{N_t^o}{N_t^r}\right)^{1+\varphi}\right]^{-1} \tag{20}$$

which reflects how labor and consumption taxes increase the gap between unions' valuation of their members' leisure and the real wage.

Fiscal policy is given by

$$t_t^{l-s}=\phi_b b_t+\phi_g g_t-t_t^{distort},$$

where t_t^{l-s} denotes lump-sum tax revenues while $t_t^{distort}=\tau^c\gamma_c c_t+\tau^w\frac{1-\alpha}{\mu^p}\left(w_t+n_t\right)+\tau^k\frac{\alpha\rho}{\mu^p\left(\rho+(1-\tau^k)\delta\right)}\left[k_t+\left(r_t^k-\delta q_t\right)\right]+\tau^k\delta\frac{\alpha(1-\tau^k)}{\mu^p\left(\rho+(1-\tau^k)\delta\right)}\left(r_t^k-\delta q_t\right)$ denotes tax revenues from distortive taxation, in terms of log deviations from steady state.

In steady state, rule-of-thumb households' consumption share is

$$\gamma_c^r = \left[\frac{WN}{PY}(1-\tau^w) - \frac{T}{Y}\right]\frac{1}{(1+\tau^c)}.$$

Where the lump-sum tax share $\frac{T}{Y}$ is determined residually as the difference between government expenditures G and the tax revenues from distortive taxes:

$$\frac{T}{Y} = \gamma_g - \left[\tau^c\gamma_c + \tau^w\frac{WN}{PY} + \tau^k\frac{R^kK}{Y}\right]$$

The two last equations may be combined to get the following expression

$$\gamma_c^r = \left[\frac{(1-\alpha)}{\mu^p} + \tau^c\left[1 - \frac{\alpha(1-\tau^k)}{\mu^p(\rho+(1-\tau^k)\delta)}\delta\right] + \frac{\tau^k\alpha\rho}{\mu^p(\rho+(1-\tau^k)\delta)}\right]\frac{1}{(1+\tau^c)} - \gamma_g$$

where use has been made of the relationships $\frac{WN}{PY} = \frac{1-\alpha}{\mu^p}$ and $\gamma_i = \frac{\alpha(1-\tau^k)}{\mu^p\left(\rho+(1-\tau^k)\delta\right)}\delta$.

Optimizing households' consumption share of output is given by (13) as before.

In summary, the log-linear equilibrium conditions that are altered due to distortive taxation are those governing the value of physical capital, rule-of-thumb consumption

$$q_t = \beta E_t\{q_{t+1}\} - E_t\{r_t - \pi_{t+1}\} + \left[1 - \beta\left(1 - \left(1-\tau^k\right)\delta\right)\right]r_{t+1}^k$$

$$c_t^r = \left(\frac{1}{1+\tau^c}\right)\frac{1}{\gamma_c^r}\left[\frac{WN}{PY}(1-\tau^w)(w_t+n_t) - t_t^{l-s}\right]$$

in addition to the tax-rule (16) which is explained in the main text.

Table 1: Parameter Values

Parameter	Value	Parameter	Value	Parameter	Value
φ	0.2	θ	0.75	ϕ_π	1.5
β	0.99	δ	0.025	ϕ_b	0.33
λ	0.5	α	0.33	ϕ_g	0.1
ε_p	6	ρ_g	0.9	γ_g	0.2

Notes: φ is the inverse Frisch elasticity of labor supply. λ is the share of rule-of-thumb consumers in the population. β is the discount factor. ε_p is elasticity of substitution between goods. δ is the depreciation rate of capital. α is the share of capital in production. ρ_g is the coefficient of autocorrelation in government spending. ϕ_π is the coefficient on inflation in the interest rate rule. ϕ_b and ϕ_g are the coefficients on public debt and government spending in the tax rule. γ_g is the steady state share of output consumed by government.

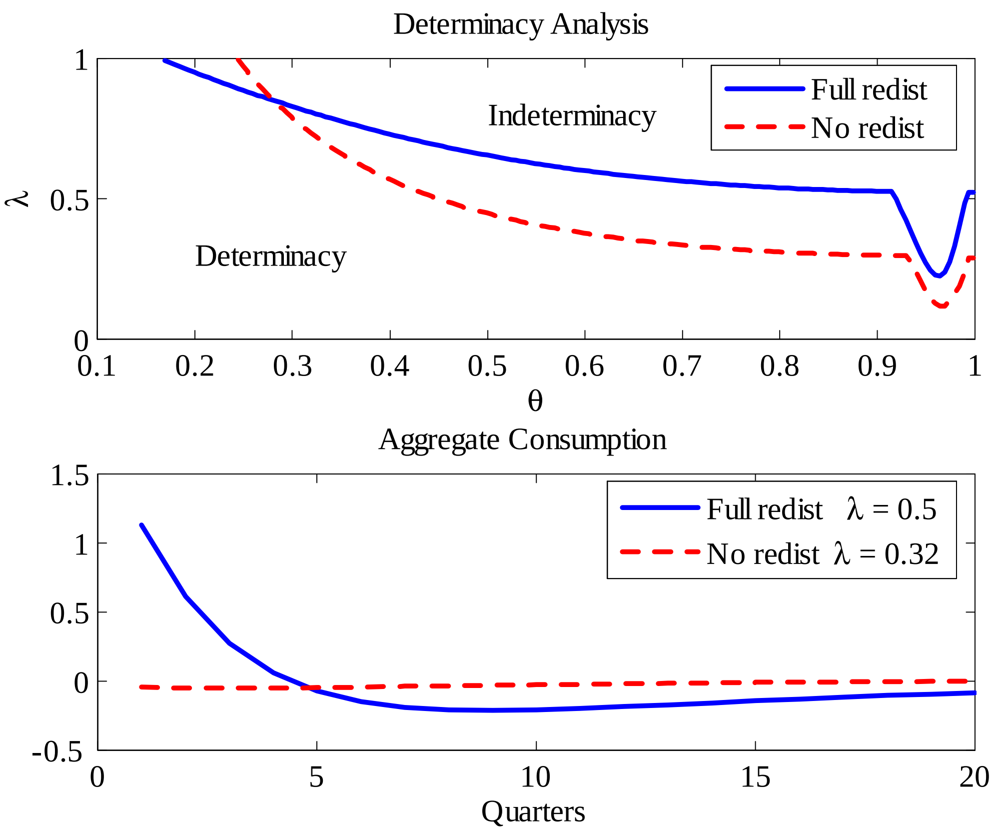

Figure 1: The upper panel plots the determinacy region as the rule-of-thumb share (λ) and the degree of price stickiness (θ) vary. The equilibrium is determinate below the curves and indeterminate above them. The lower panel plots the response of private consumption to a 1 % unexpected increase in government spending. The solid and dashed curves refer to the model with and without redistribution, respectively.

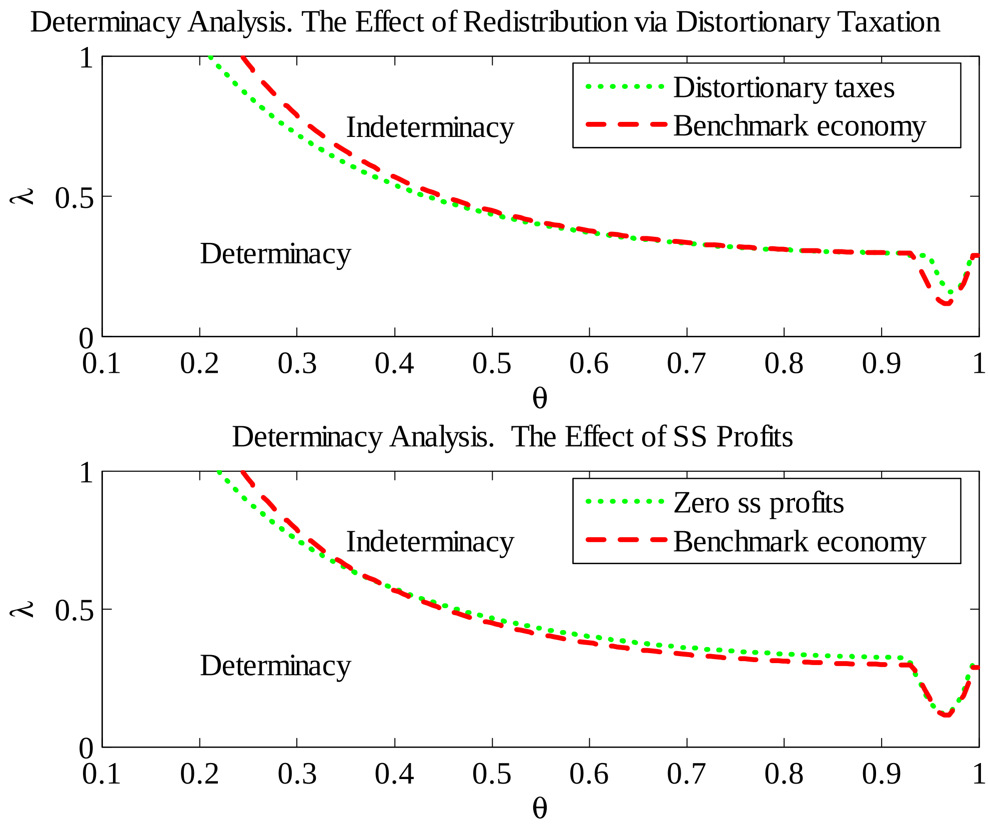

Figure 2: Equilibrium indeterminacy and the effects of distortive taxes (upper panel) and zero steady state profits (lower panel). The benchmark economy is GLV's model with lump sum taxes and positive profits, but without redistribution. The equilibrium is determinate below the curves and indeterminate above them.

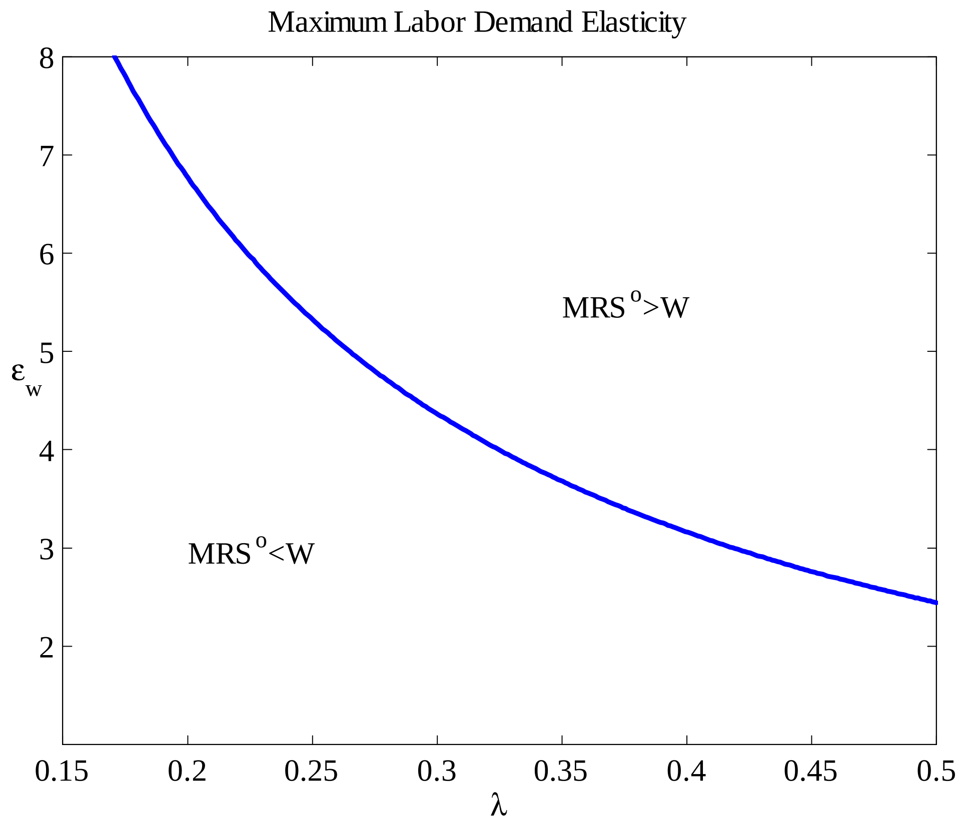

Figure 3: The curve displays the maximum elasticity of labor demand (ε_w) for the real wage to be larger than optimizing households' marginal rate of substitution between leisure and consumption (MRS^o) in steady state.