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Government Spending Shocks and Rule-of-Thumb Consumers: The Role of 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. Key to this result is a centralized labor market. I show that the ability to explain the positive consumption response as a consequence of rule-of-thumb behavior hinges on the arbitrary assumption that wealth is redistributed across households in steady state. Inequality leads to equilibrium indeterminacy and undermines the theoretical foundation of the centralized labor market.

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

JEL Classification: E32, E62

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1 Introduction

Empirical evidence, f.ex. Perotti (2005), indicates that private consumption responds positively to unanticipated increases in government spending. Conventional economic theory cannot easily account for this finding, as government expenditures ultimately require tax financing, which reduces households' wealth. Addressing this issue, Galí, López-Salido, and Vallés (2007) (GLV, hereafter) propose the following explanation: Part of the population are "rule-of-thumb" consumers who 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 a potentially important result, as it implies that fiscal policy analysis 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. This paper accounts for the steady state inequality that arises when only part of the population save, and then asks whether rule-of-thumb consumption may still explain the positive response of private consumption to government spending shocks. The answer is negative for two reasons.

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 parameterized 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.[1] 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 of consumption for leisure in steady state. Imposing equalization of hours is then to assume that these co-operating households agree to leave mutually beneficial trades unexploited. While one might argue that such outcomes can occur temporarily, they seem less feasible as a steady state arrangement.

The paper is organized as follows. Section 2 describes the model briefly. Section 3 discusses equilibrium dynamics when redistribution is absent or at the level implied by a US tax system, and the feasibility of the centralized labor market with inequality. Section 4 concludes.

2 The Model

The model presented here is the framework developed 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 $i \in (0,1)$.

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 $E_t \sum_{k=0}^{\infty} \beta^k U\left(C^o_{i,t+k}, N^o_{i,t+k}\right)$,

[1] With a perfectly competitive labor market, optimizing households would satisfy most of the increase in labor demand that higher government spending causes. Hence, the labor income and thus the consumption of rule-of-thumb households will not increase much after a positive government spending shock.

where β is their discount factor, $C^o_{i,t}$ is consumption and $N^o_{i,t+k}$ is hours worked. Their budget constraint is

$$P_t\left[C^o_{i,t}+I^o_{i,t}\right]+R_t^{-1}B^o_{i,t+1}\leq B^o_{i,t}+W_{i,t}P_tN^o_{i,t}+R^k_tP_tK^o_{i,t}+D^o_{i,t}-P_tT^o_{i,t} \tag{1}$$

and the law of motion for capital is $K^o_{i,t+1}=(1-\delta)K^o_{i,t}+\phi\left(\frac{I^o_{i,t}}{K^o_{i,t}}\right)K^o_{i,t}$. Here P_t is the time t price level, $W_{i,t}$ is the real wage for labor type i, and $B^o_{i,t+1}$ 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. $D^o_{i,t}$ denotes dividends from ownership of firms. T^o_{it} denotes lump sum real taxes levied upon each optimizing household and $K^o_{i,t}$ is the amount of capital they hold. It depreciates at a rate δ and yields a gross return R^k_t. The term $\phi\left(\frac{I^o_{i,t}}{K^o_{i,t}}\right)K^o_{i,t}$, 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:

$$C^r_{i,t}=W_{i,t}N^r_{i,t}-T^r_{i,t}, \tag{2}$$

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.

In the aggregate, consumption and labor supply per consumer of type h are given by $C^h_t=\int_0^1 C^h_{i,t}di$ and $N^h_t=\int_0^1 N^h_{i,t}di$. Total consumption is $C_t=\lambda C^r_t+(1-\lambda)C^o_t$, while aggregate labor supply follows from $N_t=\lambda N^o_t+(1-\lambda)N^r_t$. Investment, capital, bonds and dividends aggregate by $I_t=(1-\lambda)I^o_t$, $K_t=$

$(1-\lambda)K_t^o$, $B_t = (1-\lambda)\, B_t^o$ and $D_t = (1-\lambda)D_t^o$.

2.2 Firms

A representative, perfectly competitive firm combines different varieties of goods $Y_{j,t}$, $j \in [0,1]$, 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. The differentiated intermediate goods are produced by imperfectly competitive firms with the production technology $X_{j,t} = K_{j,t}^{\alpha} N_{j,t}^{1-\alpha}$, $\alpha \in (0,1)$. $K_{j,t}$ 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 $N_{j,t} = \left(\int_0^1 N_{j,i,t}^{\frac{\varepsilon_w - 1}{\varepsilon_w}}\, di\right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$, where ε_w is the elasticity of substitution between the different labor types i hired by firm j. From cost minimization and aggregation across firms it then follows that demand for labor of variety i is given by

$$N_{i,t} = \left(\frac{W_{i,t}}{W_t}\right)^{-\varepsilon_w} \widetilde{N}_t. \tag{4}$$

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

Finally, intermediate firms set prices in a staggered fashion as in Calvo (1983). Each period a firm may reset its price only with a constant probability of magnitude $1-\theta$, otherwise the price remains unchanged.

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

$$\sum_{s=0}^{\infty} E_t \beta^s \left\{ \lambda \left[U \left(C^r_{i,t+s}, N_{i,t+s} \right) \right] + (1-\lambda) \left[U \left(C^o_{i,t+s}, N_{i,t+s} \right) \right] \right\} \tag{5}$$

with respect to $W_{i,t}$, subject to (4), (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 $C^r_{i,t}$ and $C^o_{i,t}$ 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

$$W_t = \frac{\varepsilon_w}{(\varepsilon_w - 1)} \left[\frac{\lambda}{C^r_t N^{\varphi}_t} + \frac{(1-\lambda)}{C^o_t N^{\varphi}_t} \right]^{-1}. \tag{6}$$

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

$$r_t = r + \phi_\pi \pi_t, \tag{7}$$

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

The government budget constraint is $P_t T_t + R_t^{-1} B_{t+1} = B_t + P_t G$, where $T_t = \lambda T^r_t + (1-\lambda) T^o_t$, and G_t is government consumption of final goods Y_t. Taxes are set according to the rule

$$t_t = \phi_b b_t + \phi_g g_t, \tag{8}$$

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

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

2.6 The Steady State with Inequality

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 display 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 any household is determined by government consumption alone, $\frac{T^r}{Y} = \frac{T^o}{Y} = \frac{G}{Y} \equiv \gamma_g$ for the government budget to be balanced in steady state. Hence, since the aggregate labor share is given by $\frac{WN}{Y} = \frac{1-\alpha}{1+\mu^p}$ (as in GLV), expression (2) implies that

$$\gamma_c^r = \frac{1-\alpha}{1+\mu^p} - \gamma_g. \tag{9}$$

The aggregate consumption share of output, γ_c, is unaffected by redistribution and given by $\gamma_c = 1 - \gamma_g - \frac{\delta\alpha}{(1+\mu^p)(\rho+\delta)}$ as in GLV, with $\rho \equiv \beta^{-1} - 1$. By combining this expression for γ_c with the aggregate relationship $C_t = \lambda C_t^r + (1-\lambda) C_t^o$, we may express optimizers' consumption share as

$$\gamma_c^o = \left[1 - \gamma_g - \delta\alpha / \left(\left(\rho + \delta\right) \mu^p\right) - \lambda\gamma_c^r\right] / \left(1 - \lambda\right). \tag{10}$$

where $\mu^p = \varepsilon_p / \left(\varepsilon_p - 1\right)$ is the steady state price markup and $\rho = 1/\beta - 1$.

3 Results

I follow GLV and consider a first order Taylor approximation of the equilibrium conditions around the steady state, with the parameter values 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 ($U_{CCC} > 0$), it will necessarily fall more the less these households consume prior to the income change.[2] 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.[3] 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 (6):

$$w_t = \varphi n_t + \frac{\lambda}{\left[\lambda + (1-\lambda)\frac{C^r}{C^o}\right]} c_t^r + \frac{(1-\lambda)}{\left[\lambda \frac{C^o}{C^r} + (1-\lambda)\right]} c_t^o, \tag{11}$$

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 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.

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.

[2]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.

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

Figure 2 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

It is natural to ask what the indeterminacy region would look like under an intermediate degree of redistribution, caused by an empirically plausible tax system. To explore this I introduce constant tax rates on consumption expenditure and labor and capital income, parameterized to their U.S. counterparts calculated by the method of Mendoza, Razin, and Tesar (1994).[4] In order, to maintain the same dynamics of total tax revenues as what GLV argue is empirically plausible, I modify the rule for lump-sum taxes in (8) to adjust for income from distortive taxes

$$t_t^{l-s} = \phi_b b_t + \phi_g g_t - t_t^{distort}, \tag{12}$$

while each single distortive tax rate is held constant.[5] Here t_t^{l-s} denotes lump sum tax income and $t_t^{distort}$ is total revenues from distortive taxation. 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 3, and the response

[4] Consumption taxes are set to 5.47%, labor income taxes are 27.73% and capital income taxes are 39.62%. These 1996 estimates for the U.S. economy are reported at Enrique Mendoza's website, www.bsos.umd.edu/econ/mendoza. Because these taxes give slightly higher tax revenues than government spending in steady state, I balance the budget by assuming that all households receive lump sum transfers. These constitute 3.28% of output in steady state.

[5] The appendix provides further details on this analysis.

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 remains approximately 0.32. This supports the previous conclusion that an empirically more plausible degree of redistribution than what GLV consider strongly reduces their model's ability to generate a positive response of private consumption to government spending shocks.

I also assess whether the determinacy-problem of inequality is driven by the existence of steady state profits. This exercise is motivated by Rotemberg and Woodford (1995), who question the existence of positive profits in steady state. However, imposing a fixed cost that removes steady state profits does not change the determinacy region by much, and the threshold value of λ for indeterminacy is now 0.35.

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 optimizing households will, due to a wealth effect, want to supply more labor when government spending increases. With a competitive labor market, this would suppress growth in rule-of-thumb households' labor income and consumption, as optimizers satisfy most of the increase in labor demand caused by higher government spending. GLV therefore 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 (6), 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 of consumption for 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 $C^o N^\varphi > W$, is

$$\varepsilon_w > 1 + \frac{(1-\lambda)\left(1-\alpha-\mu^p\gamma_g\right)}{\lambda\left(\mu^p - 1 + \frac{\alpha\rho}{(\rho+\delta)}\right)\left[1-\alpha-\mu^p\gamma_g\right]}, \tag{13}$$

where $\mu^p = \varepsilon_p / (\varepsilon_p - 1)$ is the steady state price markup. The other parameters are defined in Table 1.[6]

Figure 4 quantifies the relationship between λ and ε_w implied by inequality (13), holding the remaining parameters in (13) 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 4 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.[7] 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 exceptionally large for these agents not to desire a marginal cut in their working hours. With λ as high as 0.5, it seems a very strong assumption that rule-of-thumb and optimizing households collaborate to work equally much at identical wages. Hence, the combination of a high λ and a centralized labor market, the two central assumptions behind GLV's main results, does not seem viable as an institutional arrangement. Instead, when there are many rule of-thumb consumers, one would expect them to adjust

[6] To derive (13), combine $C^o N^\varphi > W$ with equation (6) evaluated in steady state, and apply the definition $C^h/Y = \gamma_c^h$ for $h = o, r$, 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 expression (10) for γ_c^o. On the right hand side, insert expression (9) for γ_c^r. Rearranging yields expression (13).

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

separately from optimizers in the labor market, in which case most of the increase in labor demand after a government spending shock would be met by optimizing households, and aggregate consumption would not increase.

4 Conclusion

If only part of the population save, wealth will be unequally distributed across households. This paper shows that it is not innocuous to ignore the issue of distribution when embedding rule-of-thumb consumers in a New Keynesian framework. When inequality is properly accounted for, rule-of-thumb consumption tends to render the the equilibrium indeterminate. Furthermore, inequality will motivate rule-of-thumb and optimizing households to adjust separately in the labor market. Hence, in contrast to the conclusions of Galí, López-Salido, and Vallés (2007), the extension of rule-of-thumb consumption seems insufficient for an otherwise standard New Keynesian model to explain why government spending stimulate private consumption.

One interpretation of this finding, is that if government spending stimulates private consumption because of rule-of-thumb behavior, the labor market must work in a different way than considered by Galí, López-Salido, and Vallés (2007). Two important features here may be wage rigidity, which mitigates the wage response to sunspot shocks and thereby limits how strongly rule rule-of-thumb behavior increases the economy's indeterminacy region, and impediments to firms' ability to substitute between rule-of-thumb and optimizing households' labor services. In the appendix I extend the model to illustrate this, by imposing wage rigidity and imperfect substitutability between optimizing and rule-of-thumb households' labor types. This extention is similar to that of Furlanetto (2009) and Colciago (2006), who study how sticky wages alter the aggregate implications of rule-of-thumb consumption in models with full redistribution, but I do not assume any redistribution scheme. Figure 5 shows that with these modifications of the labor market, it is possible to generate a positive consumption response to government spending shocks, in the absense of redistribution. A more micro-founded explanation of imperfect substitutability might be that search and matching frictions prevent firms from substituting between the labor services of rule-of-thumb and optimizing households in the short run.

Alternatively, an interpretation of this paper's results is that other factors than rule-of-thumb behavior, such as deep habits (Ravn, Schmitt-Grohe, and Uribe (2006)), complementarity between consumption and hours worked (Monacelli and Perotti (2008)) or initial conditions (Christiano, Eichenbaum, and Rebelo (2009)), are the reason why private consumption may respond positively to government spending shocks.

References

Altig, D., L. J. Christiano, M. Eichenbaum, and J. Lindé (2005). "Firm-Specific Capital, Nominal Rigidities, and the Business Cycle," NBER Working Paper No. 11034.

Bilbiie, F. O. (2008). "Limited Asset Market Participation, Monetary Policy and (Inverted) Aggregate Demand Logic," *Journal of Economic Theory*, 140(1), 162–196.

Calvo, G. (1983). "Staggered Prices in a Utility Maximising Framework," *Journal of Monetary Economics*, 12, 383–398.

Christiano, L., M. Eichenbaum, and C. Evans (2005). "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 113(1), 1–46.

Christiano, L., M. Eichenbaum, and S. Rebelo (2009). "When is the government Spending Multiplier Large?," NBER Working Paper 15394.

Colciago, A. (2006). "Sticky Wages and Rule of Thumb Consumers," University of Milano Bicocca Working Paper no. 98.

Erceg, C., D. Henderson, and A. Levin (2000). "Optimal Monetary Policy with Staggered Wage and Price Contracts," *Journal of Monetary Economics*, 46, 281–313.

Furlanetto, F. (2009). "Fiscal Stimulus in a Credit Crunch: The Role of Wage Rigidity," Norges Bank Working Paper no. 8.

Galí, J., J. D. López-Salido, and J. Vallés (2004). "Rule-of-Thumb Consumers and the Design of Interest Rate Rules," *Journal of Money Credit and Banking*, 36, 739–763.

——— (2007). "Understanding the Effects of Government Spending on Consumption," *Journal of the European Economic Association*, 5(1), 227–270.

Mendoza, E. G., A. Razin, and L. L. Tesar (1994). "Effective tax rates in macroeconomics. Cross-country estimates of tax rates on factor incomes and consumption," *Journal of Monetary Economics*, 24, 297–323.

Monacelli, T., and R. Perotti (2008). "Fiscal Policy, Wealth Effects, and Markups," NBER Working Paper 14584.

Natvik, G. J. (2009). "Government Spending and the Taylor Principle," *Journal of Money,Credit and Banking*, 41(1), 57–78.

Perotti, R. (2005). "Estimating the Effects of Fiscal Policy in OECD Countries," CEPR Working Paper no. 4842.

Ravn, M., S. Schmitt-Grohe, and M. Uribe (2006). "Deep Habits," *Review of Economic Studies*, 73(1), 195–218.

Rotemberg, J., and M. Woodford (1995). "Dynamic General Equilibrium Models with Imperfectly Competitive Product Markets," in *Frontiers in Business Cycle Research*, ed. by T. F. Cooley. Princeton University Press.

Schmitt-Grohé, S., and M. Uribe (2004). "Optimal Operational Monetary Policy in the Christiano-Eichenbaum-Evans Model of the U.S. Business Cycle," NBER Working Paper No. 10724.

——— (2006). "Comparing two Variants of Calvo-type Wage Stickiness," NBER Working Paper No. 12740.

Smets, F., and R. Wouters (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review*, 97(3), 586–606.

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.

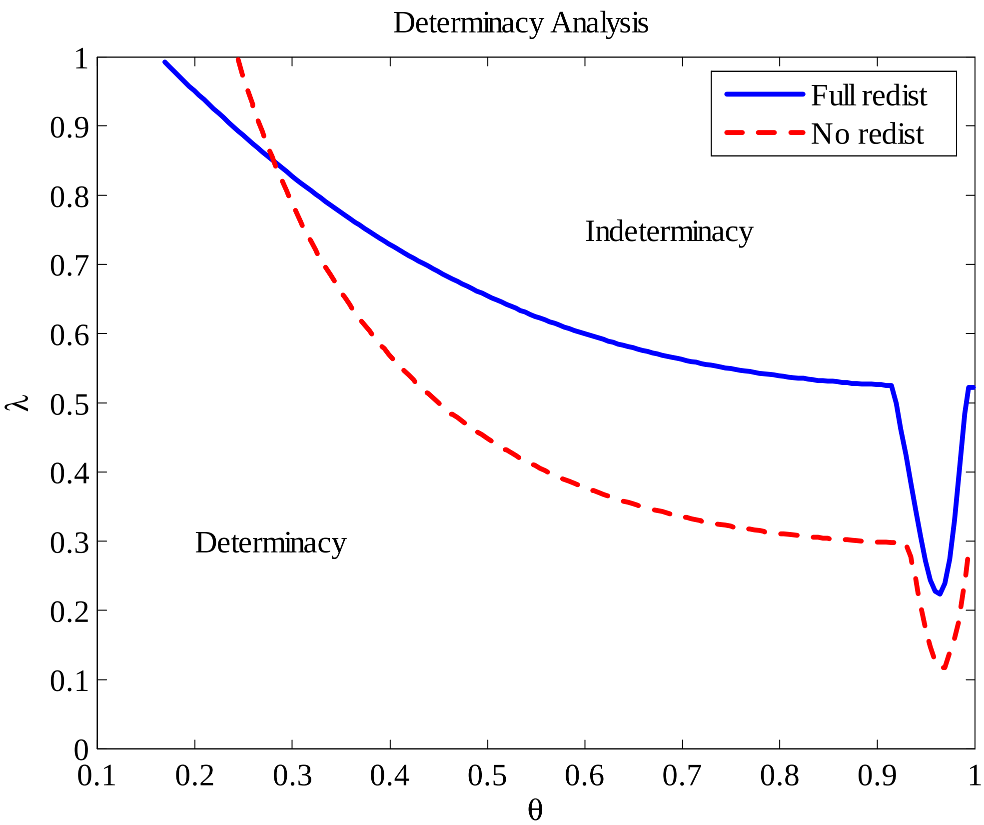

Figure 1: Equilibrium indeterminacy with and without steady state redistribution. The equilibrium is determinate below the curves and indeterminate above them.

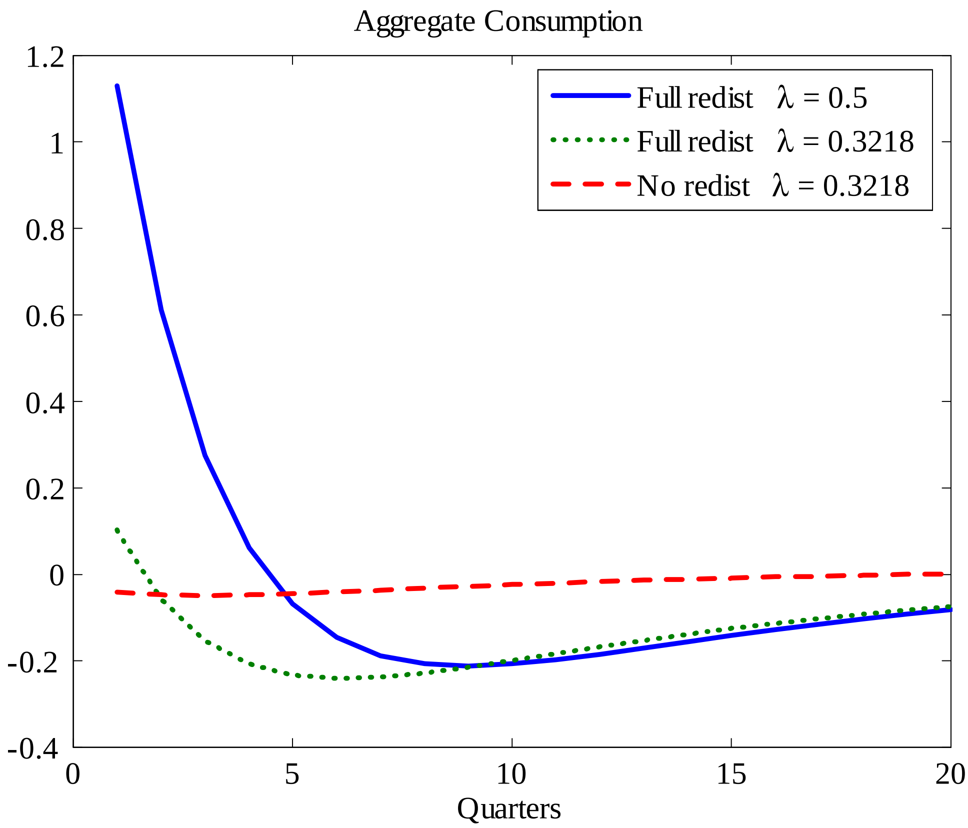

Figure 2: The response of private consumption to a 1 % unexpected increase in government spending. GLV's model with and without redistribution.

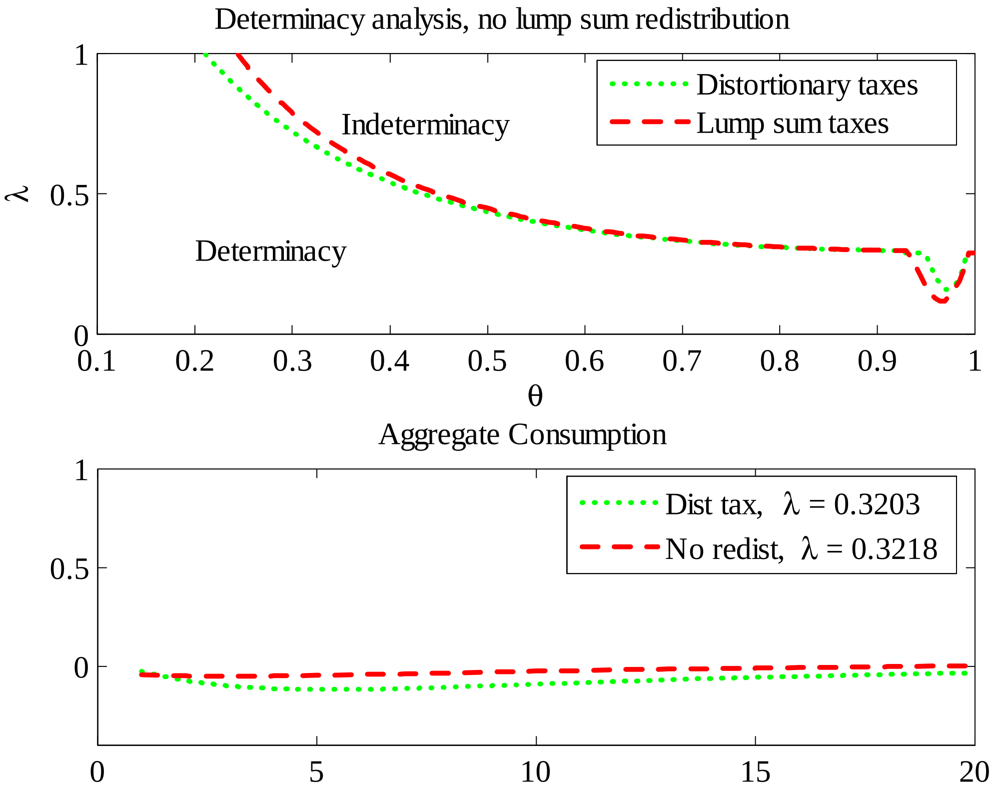

Figure 3: Equilibrium indeterminacy (upper panel) and the consumption response to a government spending shock (lower panel) with redistribution through distortive taxation (upper panel). The dashed curves refer to the case with lump sum taxes, but without redistribution. The consumption responses in the lower panel are obtained with λ set to its maximum level consistent with equilibrium determinacy.

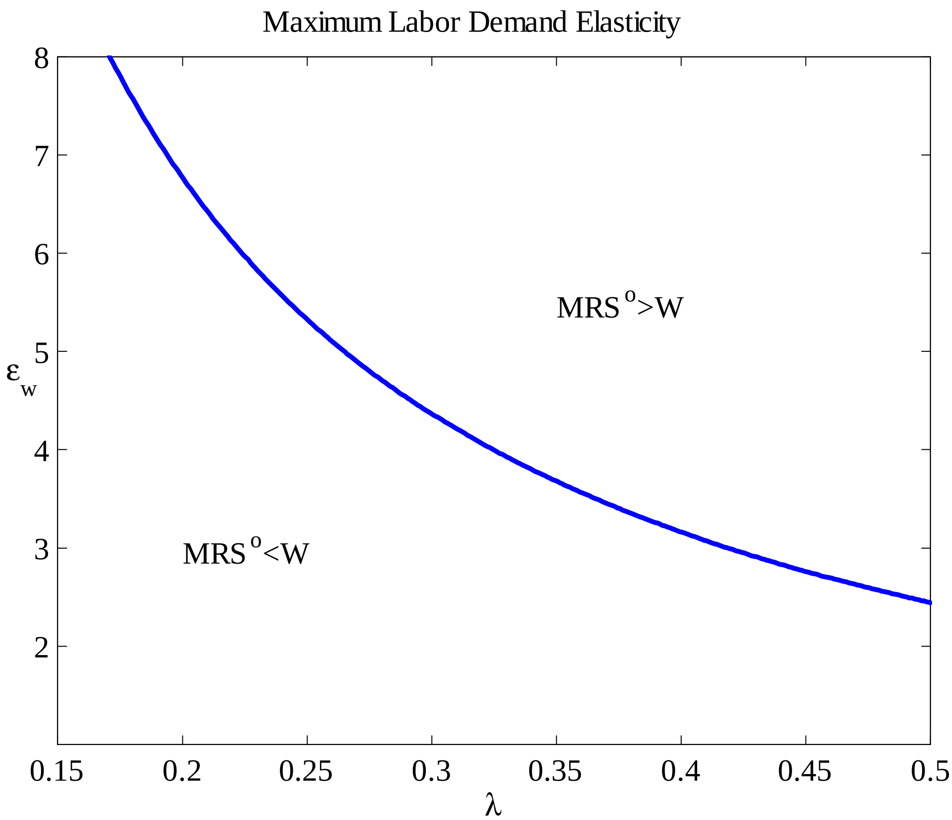

Figure 4: The curve displays the maximum elasticity of labor demand (ε_w) for the real wage to be larger than optimizing households' marginal rate of substitution of consumption for leisure (MRS^o) in steady state.

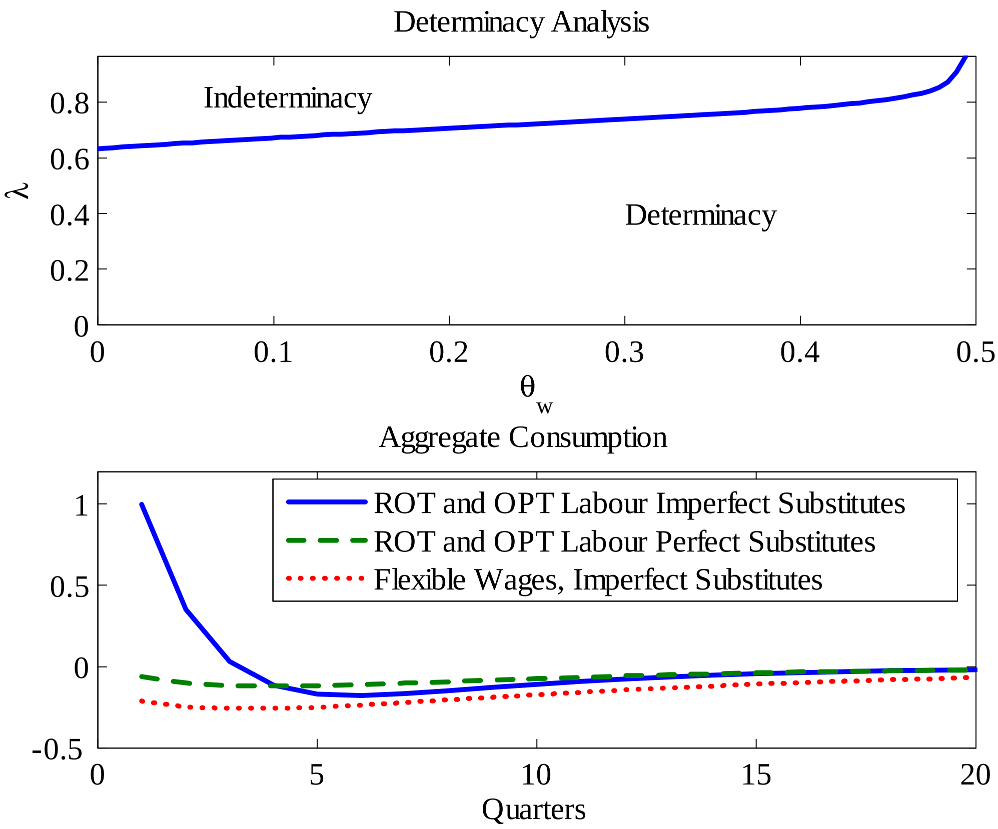

Figure 5: The upper panel plots the indeterminacy region when wages are sticky and rule-of-thumb and optimizing households' labor services are imperfect substitutes. θ_w denotes the probability that a wage cannot be reset in a given period. Determinacy below the line, indeterminacy below. The lower panel plots the response of private consumption to a 1% positive shock to government spending. The solid curve displays the response when the elasticity of substitution, ε_w, is set to 21. The dashed curve displays the response when the labor of rule-of-thumb and optimizing households are perfect substitutes ($\varepsilon_w \to \infty$). The dotted line displays the response when wages are fully flexible ($\theta_w = 0$).

A Appendix

A.1 Redistribution through Distortive Taxation

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

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

$$P_t\left[(1+\tau^c)\,C_t^o+I_t^o\right]+R_t^{-1}B_{t+1}^o\leq B_t^o+(1-\tau^w)\,W_t^oP_tN_t^o+\left[R_t^k-\tau^k\left(R_t-\delta Q_t\right)\right]P_tK_t^o+D_t-P_tT_t \tag{14}$$

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.

Rule-of-thumb consumption now evolves by

$$C_t^r=\left[(1-\tau^w)\,W_tN_t^r-T_t\right]\frac{1}{(1+\tau^c)}. \tag{15}$$

As before, unions require all households to work equal hours (i.e. $N_t^r=N_t^o=N_t$) maximize the objective (5). The constraints are now (4), (14) and (15), and the solution to the problem is the following wage equation

$$W_t=\frac{\varepsilon_w}{(\varepsilon_w-1)}\frac{1+\tau^c}{1-\tau^w}\left[\frac{\lambda}{MRS_t^r}+\frac{(1-\lambda)}{MRS_t^o}\left(\frac{N_t^o}{N_t^r}\right)^{1+\varphi}\right]^{-1} \tag{16}$$

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 expression (12) for lum-sum taxes, where $t_t^{distort}=\tau^c\gamma_c c_t+\tau^w\frac{1-\alpha}{(1+\mu^p)}\left(w_t+n_t\right)+\tau^k\frac{\alpha\rho}{(1+\mu^p)\left(\rho+(1-\tau^k)\delta\right)}\left[k_t+\left(r_t^k-\delta q_t\right)\right]+\tau^k\delta\frac{\alpha(1-\tau^k)}{(1+\mu^p)\left(\rho+(1-\tau^k)\delta\right)}\left(r_t^k-\delta q_t\right)$ denotes tax revenues from distortive taxation, in terms of log deviations from steady state.

In the steady state, rule-of-thumb households' consumption share now 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:

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

These two expressions may be combined to get the following expression

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

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

Optimizing households' consumption share of output is given by (10) as before.

A.2 Sticky Wages and Imperfect Substitutability Between Optimizing and Rule-of-Thumb Labor

In this section I develop the model by embedding sticky wages and imperfect substitutability between labor types. This extension builds on Furlanetto (2009), who studies the interaction between rule-of-thumb consumers and wage rigidity in an economy with full redistribution, and it serves to illustrate that by modifying the labor market, it is possible to generate a positive aggregate consumption response to government spending shocks as a consequence of rule-of-thumb consumer behavior, even without full redistribution.

A.2.1 Model

Firms hire labor from a continuum of labor markets of mass 1, indexed by $i \epsilon [0,1]$. A fraction $1-\lambda$ of these labor types are supplied by optimizing households only, and the remaining fraction λ is supplied by rule-of-thumb households only. Furthermore, in the spirit of Schmitt-Grohé and Uribe (2004) each optimizing household supplies all labor type in their segment of the labor market, i.e. each $i \in [0, 1-\lambda]$ and each rule-of-thumb household supplies all labor types in their segment of the labor market, i.e. each $i \in [1-\lambda, 1]$. In each labor market i wages are set by a monopolistically competitive union, and every period any union resets its wage with probability $1-\theta_w$. Unions that do not re-optimize their wage leave it unchanged. When resetting wages, unions do so to maximize their members utility, subject to the constraints given by labor demand, their members' behavior and budget constraints, and that they may not be able to reset their wage again for some time.

Labor Demand Each firm, indexed by j, aggregates labor by

$$N_t(j) = \left[\lambda^{\frac{1}{\varepsilon_w}} N_t^r(j)^{1-\frac{1}{\varepsilon_w}} + (1-\lambda)^{\frac{1}{\varepsilon_w}} N_t^o(j)^{1-\frac{1}{\varepsilon_w}}\right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \tag{17}$$

where $N_t^h(j)$ is a bundle of different labor services provided by households of consumer type h.

There is a mass λ of imperfectly substitutable rule-of-thumb labor types, and a mass $1-\lambda$ of optimizing labor types. Firm j's labor bundles of each consumer type are defined by

$$N_t^r(j) = \left[\left(\frac{1}{\lambda}\right)^{\frac{1}{\varepsilon_w}} \int_{(1-\lambda)}^{1} N_t^r(j,i)^{1-\frac{1}{\varepsilon_w}} \, di\right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}} \tag{18}$$

$$N_t^o(j) = \left[\left(\frac{1}{1-\lambda}\right)^{\frac{1}{\varepsilon_w}} \int_{0}^{(1-\lambda)} N_t^o(j,i)^{1-\frac{1}{\varepsilon_w}} \, di\right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}} \tag{19}$$

where $N^h(j,i)$ denoting hours worked per individual of consumer type h in firm j. Hence, ε_w is not only the elasticity of substitution between labor bundles o and r, but also between the different varieties of labor types i on each labor segment

h.

Each firm takes wages as given and chooses its demand for each labor type thereafter. Hence, the labor demand schedules for each type of labor will be

$$N_t^r(j,i) = \frac{1}{\lambda}\left(\frac{W_t^r(i)}{W_t^r}\right)^{-\varepsilon_w} N_t^r(j) \tag{20}$$

$$N_t^o(j,i) = \frac{1}{(1-\lambda)}\left(\frac{W_t^o(i)}{W_t^o}\right)^{-\varepsilon_w} N_t^o(j) \tag{21}$$

where $W_t^h(i)$ is the hourly wage paid to household i for $h = o, r$, and W_t^h are defined by $W_t^r = \left[\frac{1}{\lambda}\int_{(1-\lambda)}^{1} W_t^r(i)^{1-\varepsilon_w}\, di\right]^{\frac{1}{1-\varepsilon_w}}$ and $W_t^o = \left[\frac{1}{1-\lambda}\int_{0}^{(1-\lambda)} W_t^o(i)^{1-\varepsilon_w}\, di\right]^{\frac{1}{1-\varepsilon_w}}$. When all unions operating on behalf of rule-of-thumb households set the same wage, $W_t^r(i) = W_t^r$. When all unions operating on behalf of optimizing households set the same wage, $W_t^o(i) = W_t^o$.

Firms choose their demand for the bundles $N_t^r(j)$ and $N_t^o(j)$ in order to minimize total labor costs subject to (17). This yields the labor demands $N_t^o(j) = (1-\lambda)\left(\frac{W_t^o}{W_t}\right)^{-\varepsilon_w} N_t(j)$ and $N_t^r(j) = \lambda\left(\frac{W_t^r}{W_t}\right)^{-\varepsilon_w} N_t(j)$, where W_t is the aggregate wage index defined by

$$W_t = \left[\lambda W_t^{r1-\varepsilon_w} + (1-\lambda) W_t^{o1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}} \tag{22}$$

From aggregating across firms it follows that

$$N_t^{od} = (1-\lambda)\left(\frac{W_t^o}{W_t}\right)^{-\varepsilon_w} N_t \tag{23}$$

$$N_t^{rd} = \lambda\left(\frac{W_t^r}{W_t}\right)^{-\varepsilon_w} N_t, \tag{24}$$

where the superscript d is included to distinguish between the aggregate demand for each bundle, and actual hours worked per household.

Optimizing Households' Wage Setting If the wage set at time t, $\widetilde{W}_t^o(i)$, is left unchanged s periods into the future, total hours worked per optimizing household at time $t+s$ will be given by $N_{t+s}^o = \int_0^1 \int_0^{1-\lambda} N_{t+s}^o(j,i)\, di dj = \frac{N_{t+s}^{od}}{(1-\lambda)} \int_0^{1-\lambda} \left(\frac{\widetilde{W}_t^o(i)}{W_{t+s}^o} \right)^{-\varepsilon_w} di.$

Each union representing optimizing households will, when given the opportunity, set its wage rate $\widetilde{W}_t^o(i)$ so as to solve the problem

$$\max_{\widetilde{W}_t^o} E_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left\{ \left[U\left(C_{t+s}^o, \frac{N_{t+s}^{od}}{(1-\lambda)} \int_0^{1-\lambda} \left(\frac{\widetilde{W}_t^o(i)}{W_{t+s}^o} \right)^{-\varepsilon_w} di \right) \right] \right\}$$

subject to (1):

$$P_t\left[C_t^o + I_t^o\right] + R_t^{-1} B_{t+1}^o \leq B_t^o + \frac{N_t^{od}}{(1-\lambda)} \int_0^{1-\lambda} \widetilde{W}_t^o(i) \left(\frac{\widetilde{W}_t^o(i)}{W_t^o} \right)^{-\varepsilon_w} di + R_t^k P_t K_t^o + D_t^o - P_t T_t^o$$

Here θ_w denotes the probability that a wage is not readjusted in a given period. Since all these unions solve the same problem, and by symmetry of the demand for different labor types, it follows that $\widetilde{W}_t^o(i) = \widetilde{W}_t^o$.

The first-order condition for the solution w.r.t. $\widetilde{W}_t^o$ is

$$E_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left(-U'_{N_{t+s}^o} \right) W_{t+s}^{\varepsilon_w} N_{t+s}^{od} \left\{ \frac{U'_{C_{t+s}^o}}{-U'_{N_{t+s}^o}} \frac{\widetilde{W}_t^o}{P_{t+s}} - \frac{\varepsilon_w}{(\varepsilon_w - 1)} \right\} = 0 \qquad (25)$$

A log-linear approximation of this condition is

$$E_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left\{ \widetilde{w}_{t+s}^o - (c_t^o + \varphi n_t^o) \right\} = 0 \qquad (26)$$

Because the aggregate wage index is $W_t^o = \left[\frac{1}{1-\lambda} \int_0^{(1-\lambda)} W_t^o(i)^{1-\varepsilon_w} di \right]^{\frac{1}{1-\varepsilon_w}}$ and the average wage of unions that do not re-optimize in period t equals W_{t-1}^o, it follows that

$$\left(\frac{W_t^o}{P_t} \right)^{1-\varepsilon_w} = (1-\theta_w) \left(\frac{\widetilde{W}_t^o}{P_t} \right)^{1-\varepsilon_w} + \theta_w \left(\frac{W_{t-1}^o}{P_t} \right)^{1-\varepsilon_w},$$

which implies the log-linear relation

$$w_t^o = (1 - \theta_w)\, \widetilde{w}_t^o + \theta_w \left(w_{t-1}^o - \pi_t \right) \tag{27}$$

where w_t^o is the optimizers' real wage in deviation from steady state.

Together with $w_t^o = w_{t-1}^h + \pi_t^{w,o} - \pi_t$ and $\widetilde{w}_{t+s}^o = \widetilde{w}_t^o + \pi_t^{w,o} - \sum_{j=0}^{s} \pi_{t+j}^{w,o}$, the last equation can be combined with (26) to obtain the following expression for wage inflation

$$\pi_t^{w,o} = \beta E_t \pi_{t+1}^{w,o} + \kappa_w \left\{ c_t^o + \varphi n_t^o - w_t^o \right\} \tag{28}$$

Here $\pi_t^{w,o}$ denotes period t inflation in optimizers' wage rate, $\kappa_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w}$, and n_t^o denotes the numbers of hours worked per optimizing household.

Rule-of-Thumb Households' Wage Setting Total hours worked per rule-of-thumb household will be given by $N_t^r = \int_0^1 \int_{1-\lambda}^1 N_t^r(j,i)\, di dj = \frac{N_{t+s}^{rd}}{(1-\lambda)} \int_0^{1-\lambda} \left(\frac{\widetilde{W}_t^r(i)}{W_{t+s}^r} \right)^{-\varepsilon_w} di$

.

I assume that although rule-of-thumb households' do not solve a forward-looking problem when choosing how much to consume, their unions do look forward when setting wages. Hence the typical union operating in the rule-of-thumb labor segment solves the problem

$$\max_{\widetilde{W}_t^r} E_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left\{ \left[U \left(C_{t+s}^r, \frac{N_{t+s}^{rd}}{\lambda} \int_{1-\lambda}^1 \left(\frac{\widetilde{W}_t^r(i)}{W_{t+s}^r} \right)^{-\varepsilon_w} di \right) \right] \right\}$$

subject to

$$C_{t+s}^r = \frac{1}{P_t} \frac{N_{t+s}^{rd}}{\lambda} \int_{1-\lambda}^1 \widetilde{W}_t^r(i) \left(\frac{\widetilde{W}_t^r(i)}{W_{t+s}^r} \right)^{-\varepsilon_w} dj - T_t^r$$

Because all wage setting unions solve the same problem, $\widetilde{W}_t^r(i) = \widetilde{W}_t^r$. The first order condition for $\widetilde{W}_t^r$ is then

$$E_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left(-U'_{N_{t+s}^r} \right) W_{t+s}^{\varepsilon_w} N_{t+s}^{rd} \left[\frac{U'_{C_{t+s}^r}}{-U'_{N_{t+s}^r}} \frac{\widetilde{W}_t^r}{P_{t+s}} - \frac{\varepsilon_w}{(\varepsilon_w - 1)} \right] = 0 \tag{29}$$

Hence, rule-thumb wage inflation is given by

$$\pi_t^{w,r} = \beta E_t \pi_{t+1}^{w,r} + \kappa_w \left[c_t^r + \varphi n_t^r - w_t^r \right] \tag{30}$$

where n_t^r denotes the hours worked per household. Note that if rule-of-thumb unions were assumed to be myopic, this would not change any of the conclusions in the main text.

Steady State Since in this economy steady state wages and hours differ between rule-of-thumb and optimizing households, we now need six equations for the six unknowns (ω^r, ω^o, η^r, η^o, γ_c^r, γ_c^o).

Combining the steady state implications of (25) and (29) gives

$$\frac{\omega^o}{\omega^r} = \frac{\gamma_c^o}{\gamma_c^r} \left(\frac{\eta^o}{\eta^r} \right)^{\varphi},$$

where $\omega^h = \frac{W^h}{W}$, and $\eta^h \equiv \frac{N^h(i)}{N}$. Because all labor varieties supplied by household types $h = \{r, o\}$ are paid the same wage in steady state, (20) and (21) imply that $N^r(i) = \frac{1}{\lambda} N^r$ and $N^o(i) = \frac{1}{(1-\lambda)} N^o$. Hence $\frac{N^r}{N} = \lambda \eta^r$, and $\frac{N^o}{N} = (1-\lambda)\eta^o$. Using these definitional relationships, it follows from labor demands (23) and (24) that the wage shares are given by

$$\omega^o = \eta^{o - \frac{1}{\varepsilon_w}}$$

$$\omega^r = \eta^{r - \frac{1}{\varepsilon_w}}$$

As before the optimizing consumption share is

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

Rule-of-thumb consumption share, however, is now

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

The sixth equation is the aggregation of labor demands (17)

$$1 = \lambda \eta^{r 1-\frac{1}{\varepsilon_w}} + (1-\lambda)\,\eta^{o 1-\frac{1}{\varepsilon_w}}$$

Parameterization The wage stickiness parameter θ_w, is set to match empirical evidence on κ_w, as argued in Schmitt-Grohé and Uribe (2006). The reason is that several theories of staggered wage setting give rise to the same reduced form as (28) and (30), which is the equation for which relevant empirical evidence on θ_w exists.[8] By this logic, a reasonable parametrization of θ_w is 0.9. This value is based on a consideration of the point estimate of κ_w provided by Altig, Christiano, Eichenbaum, and Lindé (2005) (which implies $\theta_w = 0.93$) and the calibration by Erceg, Henderson, and Levin (2000) (which implies $\theta_w = 0.89$).[9] Furthermore, the elasticity of substitution between labor types ε_w, which now influences both equilibrium dynamics and the steady state, is set to 21, as in Altig, Christiano, Eichenbaum, and Lindé (2005).

A.2.2 Results

Figure 5 displays how sticky wages and imperfect substitutability influence the model's indeterminacy region and its implied response of consumption to a government spending shock. The upper panel shows that the more rigid are wages, as measured by the probability that a given labor type is not allowed to adjust its wage in a given period (θ_w in the figure), the larger is the determinacy region.[10] This happens because wage rigidity dampens the response of wages to sunspot

[8] Schmitt-Grohé and Uribe (2006) argue that since different theories produce the same reduced form for wage dynamics, a unique value of wage stickiness θ_w, applicable to any theory for wage formation, cannot be inferred from empirical evidence on aggregate wage inflation. Thus θ_w should be parametrized so as to get the value of κ_w supported by data.

[9] The reason for reducing the κ_w relative to the empirical estimate in ACEL is that the latter assume an indexation scheme where wages that are not reoptimized are indexed to past inflation. Since this implies that past and future price inflation enters the wage phillips curve, in addition to the terms in (28) and (30), setting θ_w only based on their evidence is likely to be misguided

[10] Colciago (2006) shows that within a model with full redistribution, wage rigidity reduces the indeterminacy region caused by rule-of-thumb behavior.

shocks. Furthermore, even when wages are flexible ($\theta_w = 0$), indeterminacy is relatively unlikely. This holds because a sunspot-driven increase in labor demand now would be satisfied by optimizing rather than rule-of-thumb households, and hence less likely to be self-fulfilling.

The lower panel in Figure 5 shows that the extended framework is able to generate a positive response of aggregate consumption to a government spending shock. Note that both the two additional assumptions are required for this to hold. If substitutability is perfect, most of the rise in labor demand due to higher government spending is met by optimizing households who experience higher government spending as a drop in their private wealth. Their willingness to work increases, whereas rule-of-thumb households do not consider such wealth effects and therefore let the optimizers satisfy most of the increase in labor demand. As consequence the labor income of rule-of-thumb households increases by a small amount, and the aggregate consumption response is negative, as shown by the dashed curve. Wage rigidity is required because it enables rule-of-thumb households to both work and consume more, without that feeding into an immediate wage increase which makes employers substitute away from them. The dotted line shows that if wages are flexible, aggregate consumption drops after a government spending shock.