Redistribution and the Multiplier*

Tommaso Monacelli† Roberto Perotti‡

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Abstract

Does it matter, for the size of the government spending multiplier, which category of agents bears the brunt of the necessary adjustment in taxes? In an economy with heterogeneous agents and imperfect financial markets, the answer depends on whether or not New Keynesian features, such are price rigidity, are present. If prices are flexible, the tax-financing rule is either neutral or leads to a larger multiplier when taxes are levied on the borrowing constrained agents. If prices are sticky, the multiplier is larger when taxes are levied on the unconstrained agents. We discuss the conditions under which these results hold. Furthermore, we study the real effects of fiscal expansions via pure, revenue-neutral, tax redistributions.

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†IGIER, Università Bocconi and CEPR. Email: tommaso.monacelli@unibocconi.it. URL: http://www.igier.uni-bocconi.it/monacelli.

‡IGIER, Università Bocconi, CEPR and NBER. Email: roberto.perotti@unibocconi.it. URL: http://www.igier.uni-bocconi.it/perotti.

1 Introduction

The recent literature has emphasized a series of theoretical channels that can critically affect the size the output multiplier of government spending. These channels include the presence of a zero lower bound constraint (Christiano et al., 2009, Correia et al., 2010), imperfect competition and price stickiness (Hall, 2010, Woodford, 2010), complementarity in preferences (Monacelli and Perotti, 2008, Bilbie, 2010), and alternative fiscal rules (Davig and Leeper, 2011, Corsetti et al. 2010).

In this paper we focus on a different channel: *redistribution*. We ask the following question: in implementing a fiscal expansion, does it matter, for the size of the multiplier, which category of agents in the population bears the brunt of the adjustment in taxes? Whether debt-financed or conducted under a balanced budget, in fact, any given expansion in government spending must be accompanied by a current and/or future adjustment in taxes. Tax adjustments often feature a pronounced redistributive content.[1] This dimension, however, has been largely overlooked in the recent literature, being that literature mostly based on the paradigm of a representative-agent economy with perfect financial markets.

We build a model economy featuring heterogenous agents and imperfect financial markets. Agents are heterogenous in terms of their impatience rates. This minimal form of heterogeneity gives rise, in equilibrium, to a natural distinction between borrowers and savers.[2] The impatient agents, in turn, are subject to a borrowing limit. One way to rationalize such a setup is to think of this distinction as ensuing from a recession, during which the likelihood that a fraction of the population faces constraints in borrowing is higher.

In this setup, we study whether the size of the multiplier of government spending depends on the assumed tax redistribution scheme, i.e., either pro-borrowers or pro-savers.

[1] See Monacelli and Perotti (2011) for a detailed documentation of this point.

[2] Alternatively, in the classic Bewley-Ayagari-Hugget heterogenous-agent framework, borrowing by some agents (and saving by others) is motivated by the presence of idiosyncratic shocks. In a section of Krusell and Smith (1998), idiosyncratic (as well as aggregate) uncertainty co-exists with heterogeneous impatience rates.

We first show an *irrelevance* result, which constitutes our benchmark. If prices are flexible, there are constant returns to scale in production, and the steady state distribution of wealth is degenerate, the tax financing rule is irrelevant. Put differently, the size of the output multiplier is the same irrespective of whether it is borrowers or savers that bear the brunt of the adjustment in taxes. The only case in which the tax redistribution scheme affects the size of the multiplier is when equilibrium profits are non-zero, so that the assumed ownership structure of the firms is relevant. Under the natural assumption that it is the savers that own the shares of the firm, we find that the output multiplier is larger when the increase in government spending is financed via a rise in *borrowers*' taxes.

Matters are different, however, under sticky prices. To gain intuition, consider an economy in which the real interest rate is constant, because, for instance, prices are fixed for two periods. In this scenario, consumption by the savers, who behave as permanent income agents, will be constant. Therefore, any given rise in government spending (in the absence of investment in physical capital) will generate a more than proportional rise in output if and only if consumption of the constrained agents (the borrowers) will rise. The latter outcome will in turn depend on the type of tax financing scheme put in place. When the boost in government spending is financed with taxes levied on the *savers*, the increase in disposable income of the borrowers is amplified, and hence the effect on the output multiplier is maximized. In general we show that there exists a range of alternative compositions of the tax mix (from more to less biased against the borrowers) which are compatible with a multiplier above one: the larger the degree of price stickiness, the larger the borrowers' share of the tax burden which remains consistent with a multiplier greater than unity.

Finally, we analyze the effect of a fiscal expansion undertaken via a pure tax redistribution (i.e., holding government spending constant). In other words, a revenue-neutral decrease in taxes to one group of agents financed via an increase in taxes to the other group of agents. We find that, under flexible prices, such a redistribution is neutral or quasi neutral. Under sticky prices, however, the type of tax policy matters crucially: a (lump-sum) redistribution that favors the constrained borrowers generates an expansion in output, whereas the reverse is true when the tax redistribution favors the savers.

General equilibrium borrower-saver models build on the earlier analysis of Becker (1980), Becker and Foias (1987), Krusell and Smith (1998), Kiyotaki and Moore (KM, 1997). Campbell and Hercowitz (2004) extend this category of models to a standard real business cycle framework, whereas Iacoviello (2005) extends the KM framework to include features more typical of the New Keynesian monetary policy literature. Monacelli (2009) analyzes the implications for the monetary transmission mechanism of the presence of endogenous collateral constraints. Curdia and Woodford (2009) allow agents to differ in their impatience to consume, but (differently from our framework) limit the ability to borrow by assuming that agents can have access to financial markets (in the form of purchase of state contingent securities) only randomly.

None of these models, however, have focused their analysis on the redistributive features of fiscal policy. Galí et al. (2007) and Bilbie (2008) build a model in which myopic "rule-of thumb" consumers co-exist with standard agents that perfectly smooth consumption. Our analysis is closely related to those papers, but differs in two respects: first, the borrowers in our economy remain intertemporal maximizers, although subject to a suitably specified borrowing constraint; second, the distribution of debt across agents is endogenous. One can therefore view our model as a generalization of the one of Galí et al. and Bilbie, in that it shows the quantitative implication of varying the borrowing limit, and lends itself to natural extensions such as making that limit endogenous.

More recently, Eggertson and Krugman (2011) use a borrower-saver model with New Keynesian features (and a fixed borrowing limit) to analyze the effects of financial shocks and of the zero bound for monetary policy. The focus of their analysis, however, differs from ours, in that neither fiscal expansions nor tax redistribution rules are analyzed.

2 Baseline model

The model economy features two types of agents, henceforth *borrowers* and *savers*, respectively in measure ω_b and ω_s along a continuum, and such that $\omega_b + \omega_s = 1$. Borrowing is motivated by impatience. The impatient agents face a fixed borrowing limit, in the spirit of classic equilibrium models with incomplete markets such as Bewley (1983), Aiyagari (1994), and Hugget (1998). In its essence, our model can be seen as a simplified version of those models, in that we feature only two agents (as opposed to a continuum) and we abstract from capital accumulation. On the other hand, we add features of the recent New Keynesian monetary policy literature, such as imperfectly competitive goods markets and nominal price rigidity.[3]

The baseline setup is deliberately stylized, in order to shed light on the role of redistribution and imperfect financial markets as a channel of transmission. In particular, in the baseline version of the model, we assume that (i) taxes are non-distortionary, (ii) agents cannot invest in physical capital, (iii) the government does not issue debt. We then compare the implications of flexible price economies to the ones of sticky price economies.

2.1 Households

There are two types of agents, indexed by $j = s, b$, who differ in their degree of (im)patience β_j,

$$\beta_s > \beta_b.$$

A generic agent of type j solves the following problem:

$$\max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta_j^t \left[\log c_{j,t} - \frac{\chi_j n_{j,t}^{1+\varphi}}{1+\varphi} \right] \right\}$$

subject to the period-by-period budget constraint (expressed in units of consumption):

$$c_{j,t} + r_{t-1} d_{j,t-1} \leq d_{j,t} + w_t^r n_{j,t} - \tau_{j,t} + \sigma_j \mathcal{P}_t \qquad (1)$$

[3] Another key difference with respect to the Bewley-Aiyagari-Hugget type of model is that we solve the model under certainty equivalence, and therefore analyze bounded dynamics in the neighborhood of the deterministic steady state. As a result, we rule out any role for uncertainty and for precautionary saving. Those elements, however, *could* in principle be analyzed also in our model, conditional on implementing a fully non-linear solution and on allowing the borrowing constraint to be only occasionally binding.

where $c_{j,t}$ is consumption, $r_{t-1}d_{j,t-1}$ is the service cost on a real one-period loan contract signed in $t-1$ and maturing in time t, $d_{j,t}$ is new borrowing of agent j at time t, $n_{j,t}$ is labor hours, , w_t^r is the real wage, $\tau_{j,t}$ are lump-sum taxes on agent j, χ_j is a parameter governing the disutility of labor, and σ_j is the per capita share of aggregate profits $\mathcal{P}_t$ that accrues to agent j (because of equity holdings).

The impatient agents (in equilibrium, the borrowers, $j = b$) face also the following constraint on borrowing:

$$d_{b,t} \leq \overline{d} \tag{2}$$

where $\overline{d} > 0$ is an exogenous upward limit. Notice that this borrowing limit is more stringent than a so called "natural" debt limit (Aiyagari 1994).

Let $\{\lambda_{j,t}\}$ and $\{\psi_t\}$ denote sequences of Lagrange multipliers on constraints (1) and (2) respectively. First order conditions of the above problem read:

$$\lambda_{j,t} = c_{j,t}^{-1} \tag{3}$$

$$\chi_j n_{j,t}^{\varphi} = w_t^r \lambda_{j,t} \tag{4}$$

$$\lambda_{j,t} = \beta_j \mathbb{E}_t \left\{ r_t \lambda_{j,t+1} \right\} + \mathcal{I}_j \lambda_{j,t} \psi_t, \tag{5}$$

for $j = s, b$, where $\mathcal{I}_j$ is an index variable that takes the values $\mathcal{I}_s = 0$ and $\mathcal{I}_b = 1$.

In the case $j = s$, equation (5) is a standard consumption Euler equation; for $j = b$, however, and if the borrowing constraint is binding ($\psi_t > 0$), that condition states that the marginal utility of consumption exceeds the (expected) marginal utility of saving.

2.2 Firms

A perfectly competitive firm employs labor to produce a homogenous final good with the following production function:

$$y_t = F(n_t), \tag{6}$$

with $F^{'}(n_t) > 0$, and $F^{''}(n_t) \leq 0$. Notice that n_t denotes the firm's *total demand* for labor.[4]

Hence, in equilibrium, the real wage equals

$$w_t^r = F^{'}(n_t), \tag{7}$$

and, using (7), aggregate profits are equal to

$$\mathcal{P}_t = F(n_t) - F^{'}(n_t)n_t \equiv \mathcal{P}(n_t).$$

Notice that in the case $F^{''} = 0$, i.e., of a constant return to scale (in this case linear) production function, we have $F(n_t) = F^{'}(n_t)n_t$, and therefore $\mathcal{P}_t = 0$.

2.3 Government and tax financing rule

The government needs to finance an exogenous stream of government spending. It collects lump-sum taxes and redistribute them across the agents. Hence its budget constraint reads

$$g_t = \sum \omega_j \tau_{j,t} \tag{8}$$

We assume that government spending follows the autoregressive stochastic process (in logs):

$$\log(g_t) = (1 - \rho_g) \log(g) + \rho_g \log(g_{t-1}) + \varepsilon_{g,t}, \tag{9}$$

where $\varepsilon_{g,t}$ is an iid innovation.

We will in general compare two extreme cases of tax financing rules, depending on whether variations in spending are respectively financed with taxes entirely levied on borrowers (τ_b *rule*) as opposed to savers (τ_s *rule*).

[4] Equivalently one can reinterpret the present model as isomorphic to one where the capital stock is fixed.

2.4 Equilibrium

An equilibrium with a binding borrowing constraint (i.e., $\psi_t > 0$ for all t) requires the following conditions to hold, for all t and $j = b, s$:

$$d_{b,t} = \overline{d} \tag{10}$$

$$n_t = \sum_j \omega_j n_{j,t} \tag{11}$$

$$\sum_j \omega_j d_{j,t} = 0 \tag{12}$$

Combining (1) with (8) one obtains the aggregate resource constraint:

$$y_t = \sum_j \omega_j c_{j,t} + g_t. \tag{13}$$

Hence an equilibrium is a collection of processes for $\{c_{j,t}, n_{j,t}, d_{j,t}, w_t^r, \psi_t\}$ satisfying (1), (4), (5), (2), (13), for $j = b, s$ and for any given evolution of the government spending process $\{g_t\}$.

3 Steady state

In the steady state, the assumption $\beta_s > \beta_b$, guarantees that the borrowing constraint is always binding. From the steady state version of (5), in fact, we have (in the case $j = b$):

$$\psi = 1 - \frac{\beta_b}{\beta_s} > 0$$

For $j = s$, (5) implies $r = 1/\beta_s$. By combining (1) and (2) we can write the following non-linear expression that pins down steady-state consumption for the borrower:

$$c_b - c_b^{-\frac{1}{\varphi}} \left[1 - \delta_b \left(\frac{1}{\beta_s} - 1 \right) \right] - \tau_b = 0, \tag{14}$$

where $\delta_b \equiv \overline{d}/n_b \geq 0$ is the borrower's steady-state debt-to-income ratio.

Following similar steps, the expression for the savers' steady state consumption reads:

$$c_s - c_s^{-\frac{1}{\varphi}} \left[1 - \delta_s \left(\frac{1}{\beta_s} - 1\right)\right] - \tau_s = 0, \tag{15}$$

where $\delta_s \equiv -\overline{d}/n_s \leq 0$.

Notice that if $\overline{d} > 0$, even if steady state taxes are the same across agents ($\tau_b = \tau_s$), we have:

$$c_b < c_s. \tag{16}$$

Since the labor market is perfectly competitive, implying that both agents are paid the same wage, the steady state version of (4) implies

$$n_b > n_s. \tag{17}$$

As a result, a steady state with a non-degenerate wealth distribution ($\overline{d} > 0$) is also one in which the borrowers consume less and work more than the savers. However, in the special case of (i) a degenerate distribution of wealth, i.e., $\overline{d} = 0$, and (ii) $\tau_b = \tau_s$, consumption and labor supply will be equalized across agents:

$$c_b = c_s \tag{18}$$

$$n_b = n_s. \tag{19}$$

3.1 An irrelevance result

Combining the above conditions, the equilibrium under flexible prices and binding borrowing constraint can be rewritten in a more compact form as a set of equations in the five variables $\{c_{b,t},\ c_{s,t}, n_{b,t},\ n_{s,t},\ r_t\}$, for $j = b, s$:

$$c_{s,t} + \tau_{s,t} - (r_{t-1} - 1)\overline{d} = F^{'}(n_t)n_{s,t} + \sigma_s \mathcal{P}(n_t) \tag{20}$$

$$c_{b,t} + \tau_{b,t} + (r_{t-1} - 1)\overline{d} = F^{'}(n_t)n_{b,t} + (1 - \sigma_s)\mathcal{P}(n_t) \tag{21}$$

$$c_{s,t}n_{s,t}^{\varphi} = F^{'}(n_t) \tag{22}$$

$$c_{b,t}n_{b,t}^{\varphi} = F^{'}(n_t) \tag{23}$$

$$c_{s,t}^{-1} = \beta_s \mathbb{E}_t \left\{ r_t c_{s,t+1}^{-1} \right\}, \tag{24}$$

and where it should be recalled that, in equilibrium, $n_t = \sum_j \omega_j n_{j,t}$.

Suppose, further, that production features constant returns to scale. In that case, $F^{'}(n_t) = 1$ and $\mathcal{P}_t = 0$ for all t. Combining the equilibrium conditions above, and log-linearizing around the deterministic steady-state, we obtain:

$$\widehat{c}_{b,t} = -\frac{\tau_b}{\kappa_b}\widehat{\tau}_{s,t} - \frac{\overline{d}}{\gamma}\widehat{r}_{t-1} \tag{25}$$

$$\widehat{c}_{s,t} = -\frac{\tau_s}{\kappa_s}\widehat{\tau}_{s,t} + \frac{\overline{d}}{\gamma}\widehat{r}_{t-1}, \tag{26}$$

where $\kappa_j \equiv c_j + \left(c_j^{-\frac{1}{\varphi}} / \varphi \right)$, for $j = b, s$.

Equations (25) and (26) show how each agent's consumption responds, respectively, to tax changes and to past values of the real interest rate. Notice that three are the possible elements of asymmetry in the dynamics of consumption across agents: first, the steady state level of taxes; second, the coefficient κ_j (which depends on the level of consumption of agent j in the steady state); third, if $\overline{d} > 0$ (non-degenerate distribution of wealth), the elasticity $(\overline{d}/\gamma)$ of consumption to the past level of the real interest rate.

In the particular case of equal lump-sum taxation in the steady state $(\tau_b = \tau_s)$ and degenerate wealth distribution $(\overline{d} = 0)$, we also have (using (14) and (15)) that $\kappa_s = \kappa_b$. Armed with this observation, we can state the following lemma:

Lemma 1 *In the economy with flexible prices and constant returns to scale in production, if the deterministic steady state is such that the agents are equally taxed ($\tau_b = \tau_s$), and the distribution of wealth is degenerate ($\overline{d} = 0$), then the tax financing rule is irrelevant.*

More precisely, irrelevance of the tax rule means the following: for any given variation in government spending, it is immaterial for the equilibrium allocations of consumption and labor whether a balanced government budget is achieved via an adjustment in savers' taxes as opposed to borrowers' taxes.

Decreasing returns Matters differ when we assume that the production function exhibits decreasing returns to scale. In that case firms generate profits in equilibrium, and how these profits are redistributed among agents can be relevant for the implications of alternative tax financing schemes.

Figure 1 illustrates the effects of a temporary expansion of government spending on aggregate output and consumption for alternative tax financing rules and under the assumption that $\sigma_s = 1$ and $\sigma_b = 0$: i.e., the savers own the shares of the firm, and receive the profits in a lump-sum transfer. The calibration adopted in this exercise is presented in Table 1. In this experiment we assume that the share of impatient agents ω_b is $1/2$ (as in the baseline calibration of Galí et al. 2007, in turn based on the evidence reported by Campbell and Mankiw, 1989), the production function is $F(n_t) = n_t^{\alpha}$, and the debt limit is $\overline{d} = 0$. We assume $\alpha = 0.9$.

Table 1. Calibration in Simulation Exercise		
Parameter	**Description**	**Value**
ρ_g	autoregressive parameter of g process	0.7
β_s	savers discount factor	0.99
β_b	borrowers discount factor	0.98
ϕ_π	coefficient on inflation in monetary policy rule	1.5
$\overline{d}$	steady state debt limit	0
σ	inverse of elasticity of substitution in consumption	1
φ	inverse Frisch elasticity of labor supply	1
χ_j	parameter governing disutility of labor	match labor supply = 1/3
ω_b	share of impatient agents in the population	1/2
g	steady state share of govt. spending	0.2

Clearly, in this case, the irrelevance result breaks down. Output expands more sharply when taxes are levied on the *borrowers* (dashed line) as opposed to the case in which taxes are levied on the savers (solid line). The smaller expansion in output when taxes are levied on the savers depends on a corresponding larger contraction of aggregate consumption under that scenario. In turn this depends on the different response of labor supply by the two agents in the two scenarios. When government spending rises, the agent whose taxes are increased correspondingly expands his/her labor supply. But under the assumed profit redistribution scheme, the savers increase their labor supply *by less,* since they simultaneously face also an increase in the rebated profits. A symmetric effect would emerge in the opposite polar case of $\sigma_b = 1$ and $\sigma_s = 0$.

Overall, the analysis so far conveys two main messages. First, under flexible prices, the *(ir)relevance* of the tax rule during a fiscal expansion, and the corresponding size of the multiplier, depends essentially on the assumed profits redistribution scheme (which in turn relates to the assumed property structure of firms). Although this is a feature that it is usually overlooked in the analysis of fiscal multipliers in standard representative-agent models, it does not genuinely relates to the presence of financial imperfections. Second, regardless of the type of tax financing rule assumed, an expansion in government spending leads to a *crowding-out* of private consumption (although of different intensity depending on the type of tax redistribution scheme adopted). The latter is also a typical result in

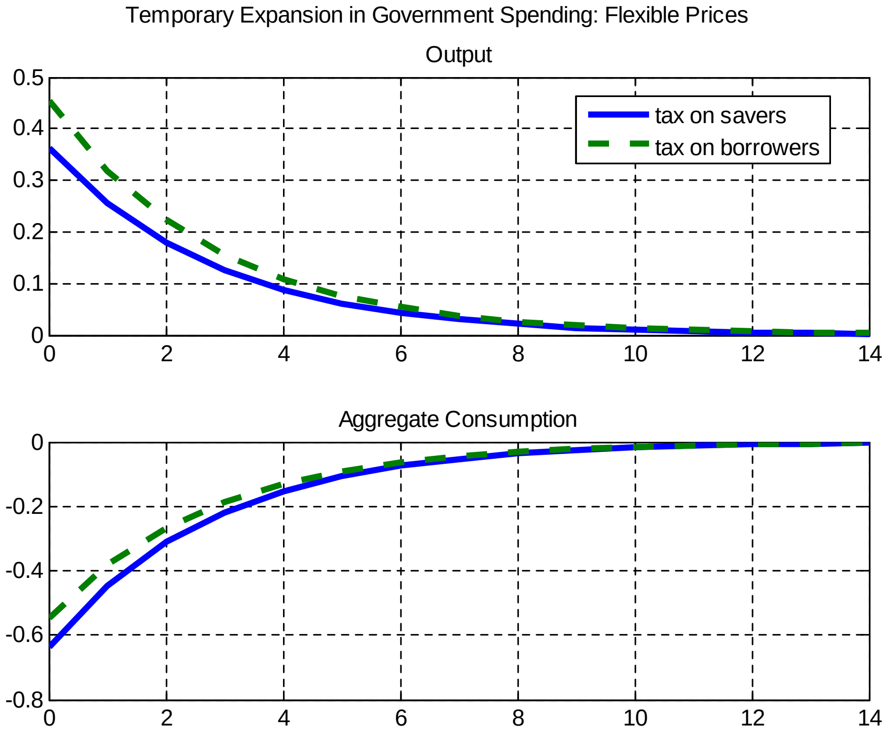

Figure 1: Effects on aggregate output and consumption of a rise in government spending under flexible prices.

a standard neoclassical representative-agent type of economies (Baxter and King, 1993). We show below, however, that both results can radically change once we introduce New Keynesian features such as monopolistic competition and price stickiness.

4 Nominal rigidities

We next proceed to analyze the implications of nominal rigidities. We wish to show that in this case the tax financing rule is not irrelevant, and for reasons independent of the maintained assumption on the redistribution of profits. The main implication of nominal price stickiness is that it renders the model genuinely dynamic. As a result, the (in)ability to substitute consumption intertemporally is crucial in determining the behavior of private spending in response to a contraction in government spending.

We assume a standard New Keynesian setting with monopolistic competition and price rigidity. A perfectly competitive firm purchases intermediate differentiated goods to produce a final homogenous good via the production function

$$y_t = \left(\int_0^1 y_t(z)^{(\varepsilon-1)/\varepsilon} dz \right)^{\varepsilon/(\varepsilon-1)},$$

where $\varepsilon > 1$ is the elasticity of substitution across varieties.

A continuum of mass one of firms (indexed by z) produce the differentiated varieties employing labor according to the production function:

$$y_t(z) = F(n_t(z)) \quad z \in [0,1],$$

where $n_t(z)$ is total demand of labor by firm z.

The monetary authority is assumed to set the short-term nominal interest rate i_t according to the feed-back rule

$$i_t = r\pi_t^{\phi_\pi}, \tag{27}$$

where r is the steady-state real interest rate, π_t is the rate of inflation, and $\phi_\pi > 1$.

In a symmetric equilibrium each firm z employs the same amount of labor and pays the same nominal wage, both to borrowers and savers. In the same equilibrium it must hold:

$$\sum_j \omega_j n_{j,t} = n_t(z) = n_t, \tag{28}$$

for $j = b, s$ and $z \in [0,1]$.

The first order conditions of the household's problem can be written:

$$\chi_j c_{j,t} n_{j,t}^{\varphi} = \frac{w_t}{p_t}, \tag{29}$$

$$c_{j,t}^{-1} = \beta_j \mathbb{E}_t \left\{ \frac{i_t}{\pi_{t+1}} c_{j,t+1}^{-1} \right\} + \mathcal{I}_j c_{j,t}^{-1} \psi_t, \tag{30}$$

where w_t denotes the *nominal* wage. In the following we assume that the shares of firms are owned by the savers, so that the profit redistribution rule is such that $\sigma_s = 1$ and $\sigma_b = 0$.

4.1 A fiscal expansion under rigid prices

In order to analyze the implications of nominal price rigidity, let's assume, for the sake illustration, that prices are fixed for at least two periods, between time t and $t+1$. From (27) this implies (since p_{t-1} is predetermined as of time t) that i_t is fixed , and, in turn, that also the ex-ante *real* interest rate $r_t \equiv \mathbb{E}_t \{i_t/\pi_{t+1}\}$ is constant. Alternatively, as in Woodford (2010), we could think of constructing an equilibrium in which the central bank, via (27), keeps the real interest rate fixed at a level $r_t = \overline{r} > 1$. Notice that the latter scenario, like ours of temporarily fixed prices, would not be feasible under flexible prices.

Under a fixed real interest rate, (30) implies, for agents of type $j = s$,

$$c_{s,t} = \overline{c}_s \ \text{ for all } t.$$

The same, however, does not hold for agents of type $j = b$. For those agents, in fact, it will hold

$$\overline{r} \beta_b \mathbb{E}_t \left\{ \frac{c_{b,t}}{c_{b,t+1}} \right\} = 1 - \psi_t. \tag{31}$$

To the extent that the borrowing constraint is binding for the impatient agents, the shadow value of borrowing, ψ_t, will be non-zero and time-varying. Thus the above equation shows that consumption of the borrowers *cannot* be constant in equilibrium, even though the *riskless* real interest rate remains unchanged.

If current prices are fixed, the symmetric equilibrium price level of variety z reads:

$$p_t(z) = \overline{p} = \mu_t \frac{w_t}{F'(n_t)}, \tag{32}$$

where μ_t is the possibly time-varying markup of prices over the nominal marginal cost of production, which corresponds to $w_t/F^{'}(n_t)$. In the case of flexible prices, $p_t(z)$ can vary in response to current economic conditions, thereby allowing firms to keep the markup aligned with the optimal level $\mu_t = \mu^* \equiv \varepsilon/(\varepsilon - 1) > 1$, which is constant. But under rigid prices, movements in the nominal marginal cost will force the markup to deviate from its optimal desired value.

Condition (32) allows to derive an implicit aggregate labor demand schedule:

$$n_t = N^D \left(\frac{w_t \mu_t}{\overline{p}} \right), \tag{33}$$

where $N^D(\cdot) = F^{-1}\left(F^{'}\left(\frac{w_t \mu_t}{\overline{p}}\right)\right)$, with $\partial N^D / \partial \mu < 0$.

The *aggregate* labor supply schedule can then be derived by combining the conditions in (29):

$$n_t = \sum_j \omega_j n_{j,t} = \left(\frac{w_t}{\overline{p}} \right)^{\frac{1}{\varphi}} \left(\omega_s \overline{c}_s^{-\frac{1}{\varphi}} + \omega_b c_{b,t}^{-\frac{1}{\varphi}} \right) = N^S \left(\overline{c}_{s,t}, c_{b,t} \right). \tag{34}$$

Under our assumed fixed-price equilibrium, the aggregate market clearing condition (13) reads:

$$y_t = \omega_s \overline{c}_s + \omega_b c_{b,t} + g_t. \tag{35}$$

Equation (35) suggests that both the sign and the size of the output multiplier of government spending depend crucially on the behavior of *borrowers*' consumption under any given tax financing rule.

Equivalently, one can assess the role of borrowers' consumption for aggregate labor market quantities (and hence aggregate output) by evaluating the equilibrium described by the schedules (33) and (34). This is illustrated in Figure 2. Notice that the position of the aggregate labor supply schedule (34) depends on the value of borrowers' consumption c_b, whereas savers' consumption is considered as constant.

Under fixed prices, and since firms are assumed to meet all the available demand at that given price, the rise in government spending will induce firms to decrease their markups, and therefore increase their demand for labor at any given real wage.

The outward shift in labor demand can in turn be decomposed in two steps. First, an initial increase in labor demand (and therefore a rise in the marginal cost and a fall in the markup) *holding borrowers' consumption constant* (point B in the figure). This initial effect, which is common to both tax rules scenarios, corresponds to an outward shift of the aggregate labor demand schedule from $N^S(\mu, c_b)$ to $N^S(\mu', c_b)$, with $\mu' < \mu$. The final position of the aggregate labor demand curve, however, depends on the equilibrium behavior of borrowers' consumption. If borrowers' consumption rises (as illustrated in the figure) this produces a further shift in the labor demand schedule to $N^S(\mu', c_b')$, and therefore a further contraction in the markup to $\mu'' < \mu'$. To the extent that rising markups generate a higher real wage and therefore labor income, borrowers' consumption will rise. But the effect will crucially depend on the type of tax financing scheme. If taxes are levied on the borrowers, this will tend to counteract the increase in borrowers' disposable income and consumption, whereas if taxes are levied on the savers, the borrowers will be able to ease his/her financial conditions fully.

The final equilibrium level of aggregate employment, and therefore output, will depend on the position of the aggregate labor supply schedule, $N^S(\overline{c}_s, c_b)$, which also depends on the behavior of borrowers' consumption. In the case in which borrowers' consumption rises ($c_b' > c_b$), the aggregate labor supply schedule shifts inwards, thereby positioning the system at point C.

4.1.1 Dynamics under staggered prices

Our analysis so far has been based on the limit assumption that prices remain fixed for (at least) two periods. In the standard Calvo model of pricing, however, it is assumed that intermediate goods producers get the opportunity to reset their price only randomly, and

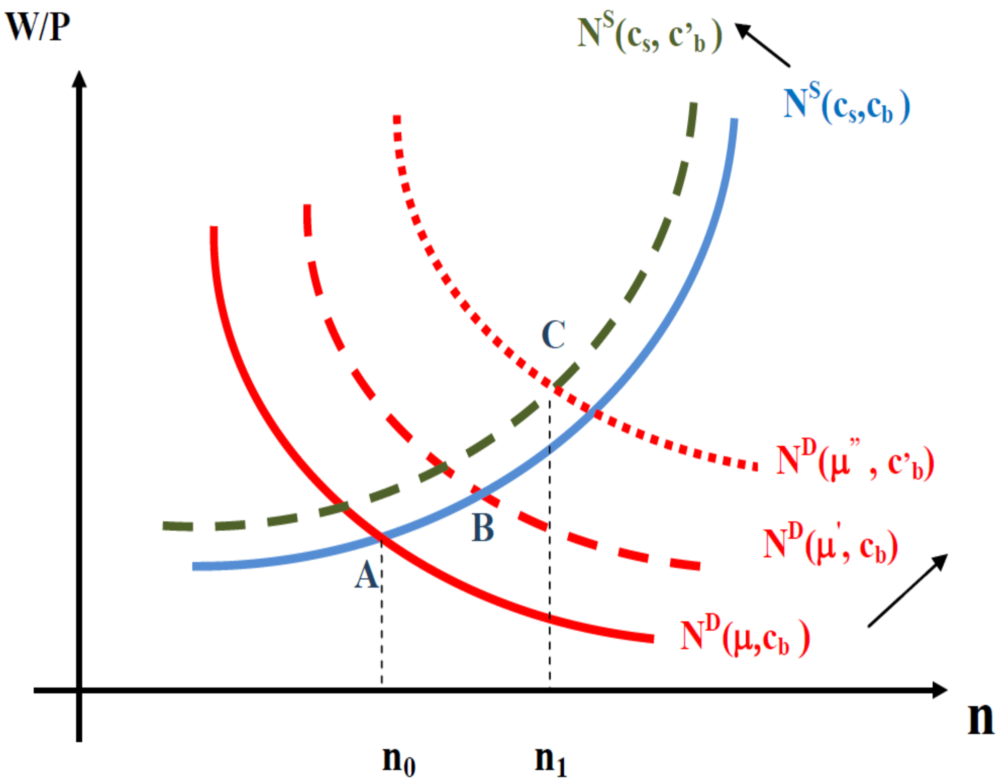

Figure 2: Effect on the aggregate labor market equilibrium of a rise in government spending under rigid prices.

with a constant probability. We assume that the probability of resetting prices is equal to $(1-\vartheta)$. In this scenario, the aggregate price level will adjust slowly, and the monetary authority will implement a certain path of the real interest rate via the policy rule (27). As a result, savers' consumption will no longer be exactly constant.

When the point of approximation is the zero-inflation steady state, the optimal price-setting strategy for the typical firm choosing its price in period t can be written in terms of the (log-linear) rule :

$$\widetilde{p}_t^* = \log\left(\frac{\varepsilon}{\varepsilon-1}\right) + (1-\beta\vartheta)\sum_{k=0}^{\infty}(\beta\vartheta)^k \ \mathbb{E}_t\{\widetilde{mc}_{t+k} + \widetilde{p}_{t+k}\} \tag{36}$$

where $\widetilde{p}_t^*$denotes the (log) of newly set prices, which is identical across reoptimizing firms, and mc_t denotes the (log) real marginal cost of production,

$$\widetilde{mc}_t = -\log(\mu_t).$$

The evolution of the aggregate price level, in log-linear terms, reads:

$$\widetilde{p}_t = \vartheta\widetilde{p}_{t-1} + (1-\vartheta)\widetilde{p}_t^*. \tag{37}$$

Equations (36) and (37) constitute the pricing block of the model.

Figure 3 displays the responses of aggregate output and consumption to a balanced-budget temporary expansion in government spending under the two alternative tax financing rules. The probability of not resetting prices in any given quarter, ϑ, is chosen in order to match a frequency of price changes of four quarters, and the price elasticity of demand ε is set equal to 8.[5] The production function is assumed to be linear, $y_t(z) = N_t(z)$, and the ownership structure is such that all profits are rebated to the savers.

As we can see, and in line with our previous reasoning under the limit case of fixed prices, output expands more sharply when taxes are increased to the savers relative to the case in which taxes are increased to the borrowers. This result is in stark contrast with the one obtained under flexible prices. Under flexible prices and profits rebated to

[5]The remaining parameters are set as in Table 1 above.

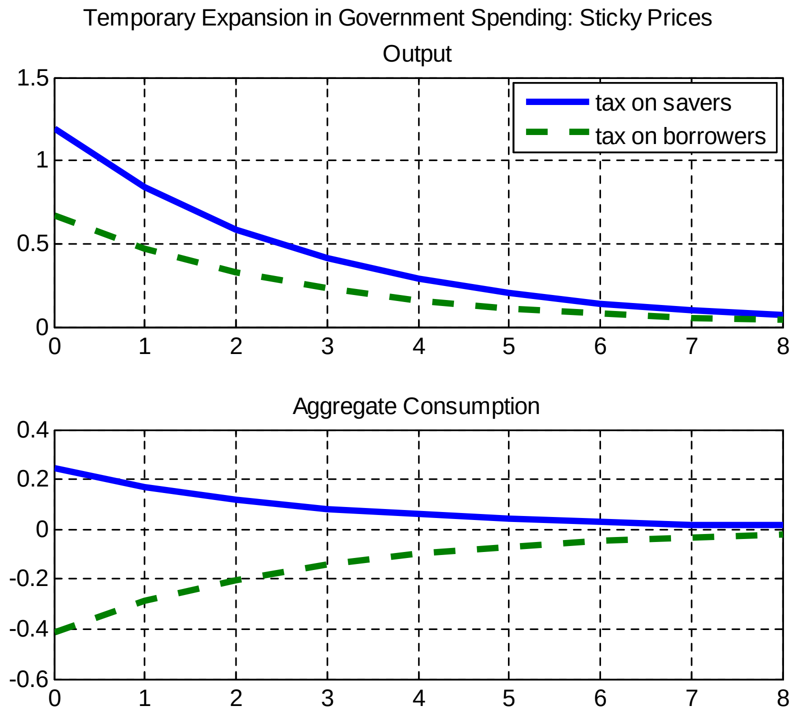

Figure 3: Effects on aggregate output and consumption of a rise in government spending under sticky prices.

the savers, in fact, the output multiplier was dampened when taxes were increased to the savers.

Noticeably, aggregate consumption behaves very differently in the two scenarios. In the case in which taxes are increased to the borrowers, consumption falls, thereby dampening the expansion in output. However, when taxes are increased to the savers, the rise in government spending produces a *crowding-in* of aggregate consumption, in turn magnifying the expansion in output, and leading to a multiplier that exceeds one.

The intuition for the sharply different behavior of aggregate consumption in the two alternative scenarios of tax rules lies in our previous discussion, and can be supported by inspecting Figure 4 below. As it is clear, when taxes are increased to the savers, their consumption falls, due to the combined effect of a higher real interest rate and higher

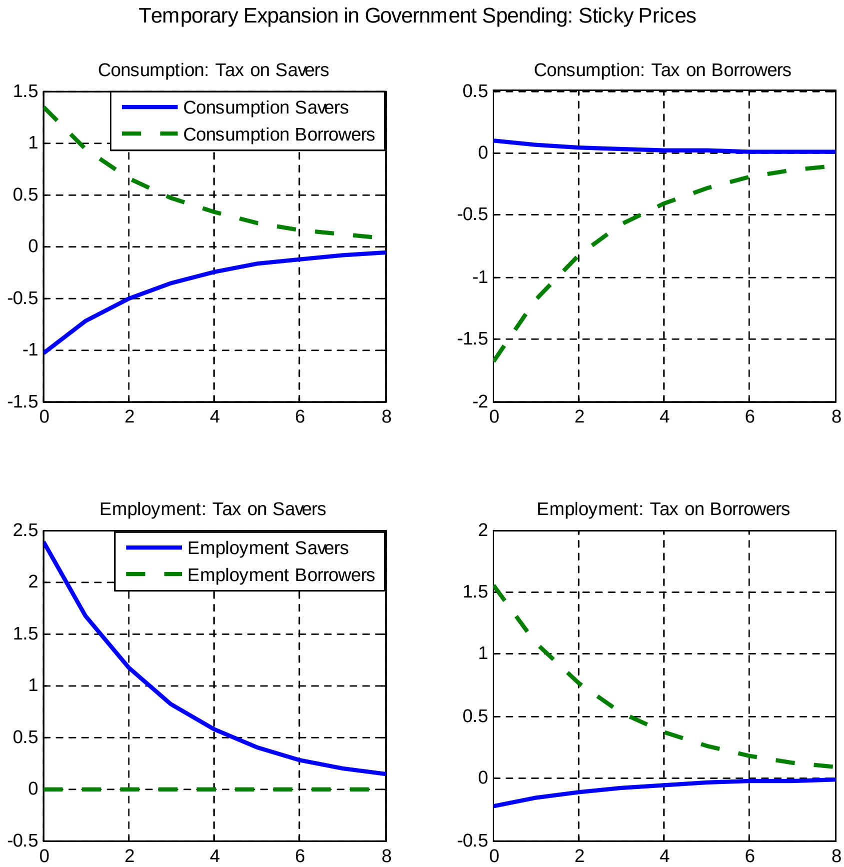

Figure 4: Responses of individual consumption and employment to a rise in government spending under sticky prices.

taxes. But, in contrast, borrowers' consumption *rises.* The net effect is a moderate expansion in aggregate consumption (*crowding-in*). In contrast, in the scenario in which taxes are increased to the borrowers, their consumption falls, but savers' consumption barely reacts. The result is a typical crowding-out effect of (aggregate) consumption.

Figure (5) illustrates the role of the fixed *borrowing limit* in affecting the size of the multiplier. In this experiment we keep the degree of nominal rigidity equal to four quarters and the share of borrowers equal to 1/2. All remaining parameters are as in Table 1. We compute the output multiplier of government spending under alternative values of the borrowing limit $\overline{d}$. The values of the multiplier are plotted against the implied steady state debt-to-ncome ratio for the borrowers. That ratio varies between zero (our baseline case) and one hundred percent. There are two cases, corresponding to whether, respectively, taxes are levied on the savers (solid line) as opposed to the borrowers (dashed line). The figure shows that the quantitative impact of changing the borrowing limit is substantial. But, most importantly, the effect strongly depends on the tax financing rule. When taxes are levied on the savers, whether or not the impatient agent is allowed to borrow at all makes a substantial impact on the multiplier. In that scenario, moving from the autarky case of $\overline{d} = 0$ to a debt-to-income ratio of one hundred percent implies that the size of multiplier more than doubles. On the contrary, when the burden of taxation lies on the borrowers, increasing the debt limit has a small, even negative, effect on the multiplier.

Figure (6) illustrates the effect on the output multiplier of varying the *share of constrained agents* in the population. The underlying calibration is identical to the one of the previous figure, except that we keep the borrowing limit $\overline{d} = 0$. Similarly to above, we compare two alternative tax financing rules. Two results stand out. First, varying the share of constrained borrowers has a quantitatively significant impact on the size of multiplier. However, the *sign* of this impact depends crucially on the tax financing rule. When taxes are levied on the savers, a higher share of borrowers in the population makes the multiplier larger, whereas the opposite holds in the case of taxes levied on the borrowers.

Usually output multipliers are particularly enhanced by the persistence of govern-

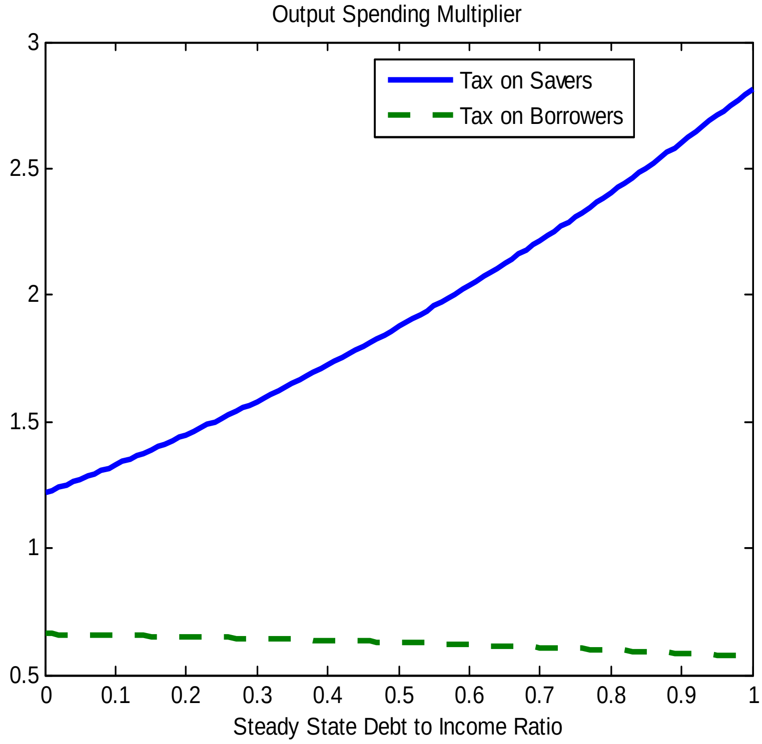

Figure 5: Effect on the output multiplier of varying the borrowing limit.

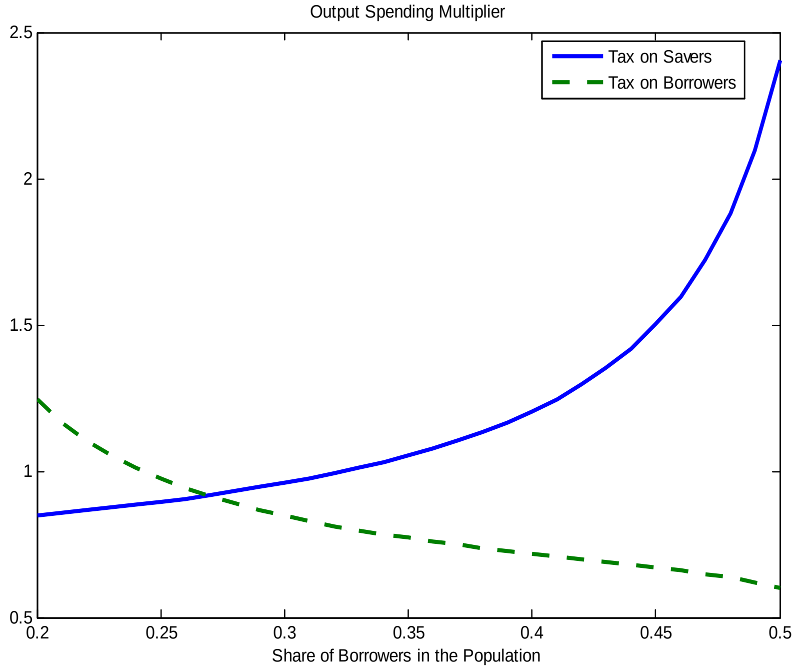

Figure 6: Effect on the output multiplier of varying the share ω of constrained agents in the population.

ment spending shocks. This holds, for instance, in the seminal analysis of Baxter and King (1993), which is based on a representative-agent, perfect financial market neoclassical model. Intuitively, relatively more persistent shocks to government spending exert a stronger impact on permanent income, thereby enhancing the wealth effect on labor supply. In our economy with sticky prices and borrowing frictions, however, the implications of persistence are somehow the opposite.

Figure 7 displays the effect on the size of the multiplier of varying the degree of *persistence* of the government spending innovation, under the two types of tax rules respectively.[6] Notice that the lower the persistence of the government spending innovation, the larger the *gap* between the multiplier obtained under the savers' tax financing rule and the one obtained under the borrowers' tax financing rule. This almost entirely depends on the multiplier being much more sensitive to persistence when the savers, rather than the borrowers, are taxed. Intuitively, more persistence in the government spending process means a stronger wealth effect on labor supply, and therefore a stronger negative effect on consumption. But this effect plays out only when the agents that are taxed are the savers. If the government taxes the borrowers, instead, expected future taxes matter only to a very limited extent, for the response of consumption and labor supply depends entirely on current disposable income.

4.1.2 How much pro-savers can the tax mix be?

The above observation raises the following question: how sensitive is the multiplier to the composition of the tax adjustment? In other words: to what extent can the tax scheme be skewed against the borrowers without sacrificing too much in terms of the size of the multiplier? Figure 8 displays the effects on the size of the (impact) output multiplier

[6]Notice that, strictly speaking, the picture is not informative about the impact of unanticipated *permanent* rises in government spending (i.e., the effect of a permanent shock to spending is not the limit effect of a temporary, but highly persistent shock, as $\rho_g \to 1$). A permanent variation in government spending implies a permanent change in the steady state, and therefore standard local log-linearization techniques (as the ones employed so far) cannot be applied to solve for the transitional dynamics. In unreported results, however, we obtain that the insights of our analysis survive also in the case of purely permanent shocks.

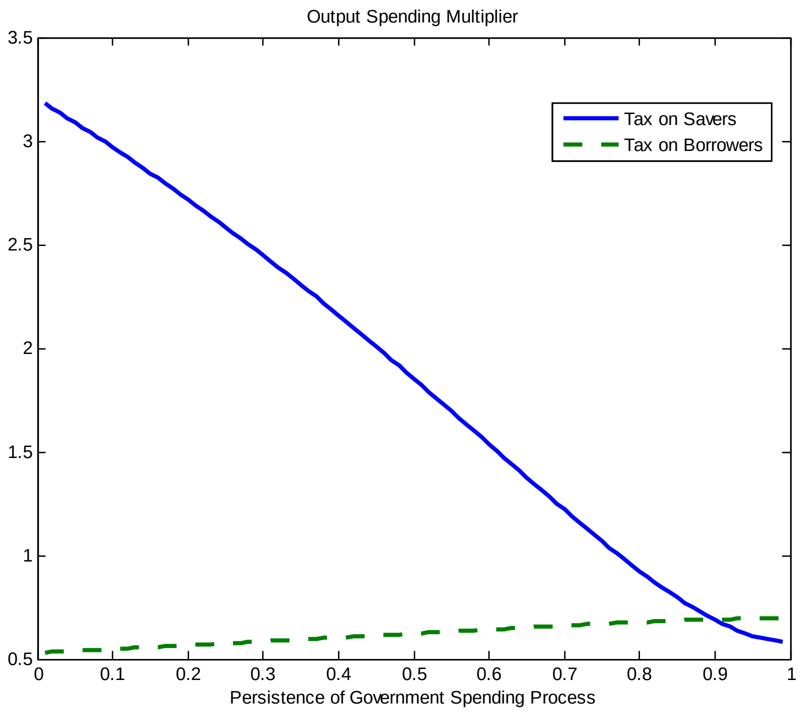

Figure 7: Effect on the output multiplier of varying the degree of persistence ρ_g of the government spending process.

of varying the share of taxes levied on the borrowers, under alternative degrees of price stickiness (measured in quarters of duration). The calibration is the one from Table 1, except that we set the debt limit ratio $\overline{d}$ such that the debt to income ratio is 30 percent.

Several results stand out. First, in all cases considered, the larger the share of taxes levied on the constrained agents, the smaller the multiplier. Second, unless the degree of price stickiness exceeds two quarters, the multiplier never exceeds one, regardless of the assumed tax redistribution scheme. Third, in the baseline case of four-quarter price stickiness, the output multiplier exceeds one for a share of taxes on the borrowers that can reach up to 25 percent. Fourth, increasing the degree of price stickiness produces a twofold effect on the relationship between the multiplier and the tax mix: that relationship simultaneously shifts outward and becomes steeper. As a result, for a share of borrowers' taxes equal to zero, the multiplier can reach a value as high as two; and for degrees of price stickiness that exceed four quarters, the tax mix can become severely biased against the borrowers (i.e., being strongly regressive) and still a fiscal expansion produce output multipliers that exceed one. For instance, in a scenario with a degree of price stickiness equal to four quarters, the borrowers' share of the tax burden can reach up to 70 percent and the multiplier still exceed one.

5 Fiscal expansion with pure redistribution

So far we have studied fiscal expansions based on government spending, and analyzed alternative tax rules to finance that expenditure. In this section we analyze fiscal expansions based on pure lump-sum tax redistribution. In other words, we study under what conditions a reduction in taxes to one category of agents (financed via an increase in taxes to the other group of agents) can lead to an expansion in output. Hence this is a revenue neutral redistribution with a constant level of government spending.[7]

[7] There are of course several alternative channels through which a tax redistribution might be implemented. If the savers are the owners of firms and collect profits, a tax redistribution could be implemented via a combination of labor income taxes (on all agents) and capital income taxes. here we focus simply on redistribution via lump-sum taxes.

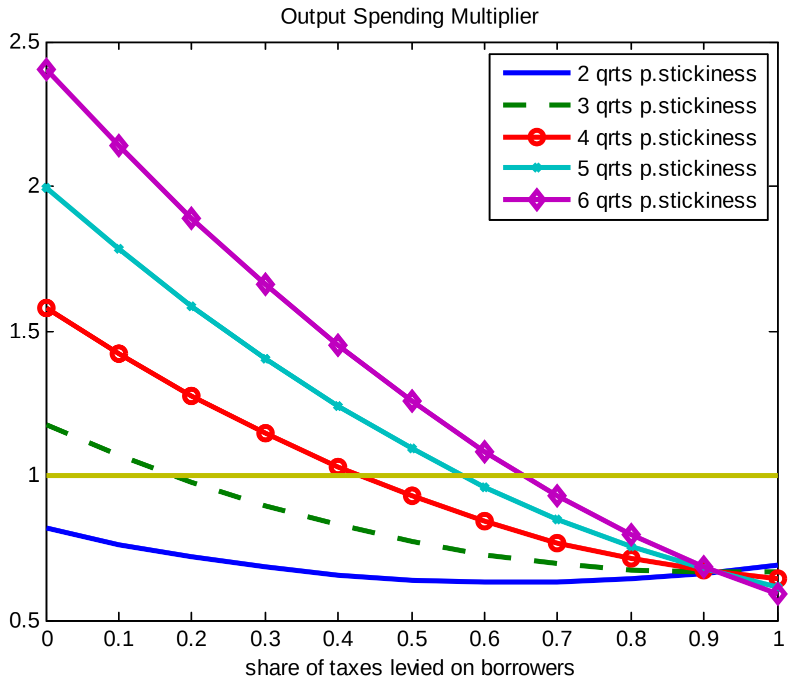

Figure 8: Effect on the output multiplier of varying the share of constrained borrowers' taxes for alternative degrees of price stickiness.

Our previous irrelevance result already suggests that under flexible prices any type of redistribution (either pro-savers of pro-borrowers) will be neutral or quasi neutral. To understand this point, consider equations (26) and (25). Under the assumption of equal lump-sum taxation in the steady state ($\tau_b = \tau_s$) and degenerate wealth distribution ($\overline{d} = 0$), those equations imply that any tax redistribution of the type $\Delta\tau_{s,t} = -\Delta\tau_{b,t}$, with $\Delta\tau_j >< 0$, will produce symmetric effects on the consumption of each agent, and therefore a neutral impact on aggregate consumption (output).

Matters are significantly different, however, with sticky prices, even under the assumptions $\tau_b = \tau_s$ (in the steady state) and $\overline{d} = 0$. Figure 9 displays the effects on aggregate output, consumption and hours worked of a temporary redistribution *from the savers to the borrowers* (i.e., a tax cut to the borrowers financed via an increase in taxes to the savers). Government spending is kept constant at its steady state level, and all remaining parameters are calibrated as in Table 1.

The key point to notice is that such redistribution is non-neutral and, most importantly, *expansionary* on output. The intuition for the result is simple. Since government spending is held constant, the only driver of the expansion in output is the underlying expansion in aggregate consumption. The Figure shows that the rise in aggregate consumption results from an expansion in *borrowers*' consumption which more than compensates the contraction in *savers*' consumption.

The reason why the borrowers increase their consumption is twofold. For one, their disposable income rises, for any given level of the real wage. But the resulting increase in demand induces the firms, under sticky prices, to lower their markups, inducing the real wage to rise, thereby further boosting available income. Since in equilibrium the impatient agents do not save any of this additional income, all the increase in disposable income translates into higher consumption.

Conversely, a tax redistribution that favors the savers would produce the symmetric opposite effect, i.e., in that case output would fall. Consumption by the savers would rise (due to the reduction in taxes), but significantly less relative to borrowers' consumption in the previous case. The reason is that the patient agents save part of the newly available

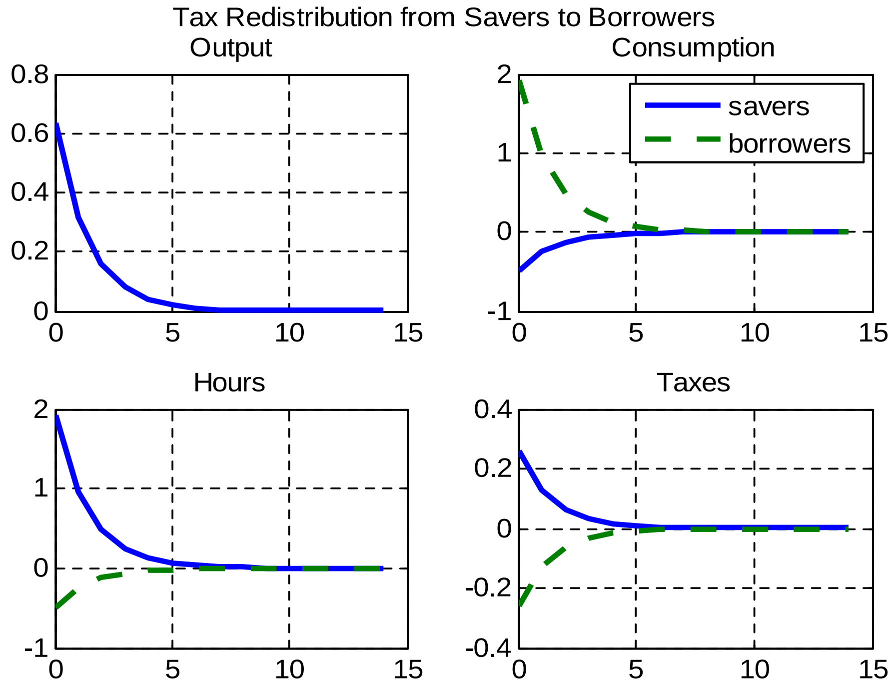

Figure 9: Tax Redistribution from Savers to Borrowers.

income. The fall income for the impatient agents, however, cannot be smoothed by borrowing more (given their constraint), so their consumption would fall sharply. The net effect would be a contraction in both aggregate consumption and output.

6 Conclusions

In the standard analysis of the multiplier of government spending, whether based on a neoclassical or New Keynesian model, any given rise in government spending must be financed with a rise in taxes. When these taxes are lump-sum (as it is often assumed), the same rise in taxes generates, at most, a wealth effect. In our framework with heterogenous agents and borrowing constraints, a given change in lump-sum taxes triggers rich redistribution effects. For any given degree of price stickiness, the multiplier is larger (i) the more skewed the tax redistribution is in favor of the borrowers, and (ii) the higher is the borrowing limit for impatient agents. For a sufficiently high degree of price stickiness, however, even tax redistribution schemes that are heavily biased against the borrowers can be consistent with multipliers that exceed one.

Our analysis aims at highlighting the role of tax redistribution as a determinant of the multiplier of government spending. For the sake of illustration, however, the focus has remained deliberately simplified. Features that have remained outside the analysis include the role of distortionary taxation, capital accumulation, and debt-financed fiscal expansions, possibly with an endogenous determination of a risk premium on government debt. The development of these features will be the subject of future related research.

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