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Tax Cuts, Redistribution, and Borrowing Constraints

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Abstract

With perfect credit markets, any (lump-sum) tax redistribution is neutral. We study the effects of a tax redistribution in an economy with heterogenous agents and borrowing constraints. Under flexible prices, a tax redistribution that favors "the poor" (i.e., the credit constrained) is neutral, or, possibly, even mildly contractionary. When nominal prices are sticky, that result is overturned: a tax redistribution from the savers to the constrained borrowers is expansionary on output. Key to the non-neutrality result is the agents' heterogenous sensitivity to movements in the credit premium.

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1 Introduction

The fiscal stimulus package designed by the US administration in the aftermath of the financial crisis of 2007-2008 has revived a traditional debate between the advocates of a public-expenditure driven stimulus and those of a tax-cut driven stimulus. Even within the latter, however, the views have not been unanimous.

Some have argued that, in a state of the economy in which agents are unwilling to lend, tax cuts should induce private entrepreneurs to take on more risk. [1] Conversely, it has been argued that capital-gains tax cuts, that are mostly directed to high-income households, would generate a very poor stimulus, since those households are more likely to save rather than spend the additional windfall. Hence an alternative, and somewhat classical, view has argued that tax cuts should be primarily geared towards the *low-income* households, who typically feature a larger marginal propensity to consume, and would therefore be the ones most likely to provide a stimulus to consumption demand.

A case in point is the recent debate on whether or not extending the tax cuts previously enacted under President George W. Bush. According to the Congressional Budget Office, extending all of the Bush tax cuts would have a small "bang for the buck" (CBO, 2010). Once again, the classic argument goes that those tax cuts are mostly geared towards higher-income households, who have a relatively lower marginal propensity to consume. Interestingly, of eleven potential stimulus policies the CBO recently examined, an extension of *all* of the Bush tax cuts seems to imply the lowest stimulus per dollar spent.[2]
At the heart of this debate is the issue of the *compositional* effects of tax changes. This issue relates to the classical and more general question: what are the macroeconomic effects, if any, of a given redistribution of income? From a theoretical viewpoint, those ef-

[1] See for instance Alesina and Zingales (2009).
[2] See CBO (2010), Table 1.

fects cannot be analyzed within the context of standard macroeconomic models, whether neoclassical or "New-Keynesian". In those models, in fact, the assumption of perfect credit markets supports the notion of a representative agent, and any type of (lump-sum) tax redistribution across agents is neutral.

In this paper we study the effects of a tax redistribution when a fraction of agents face credit constraints. In the economy, there is a natural distinction between borrowers and savers. In fact, our model can be thought of as a simplified version of classic equilibrium models with incomplete markets, such as Bewley (1980), Aiyagari (1993), and Hugget (1998). The main difference is that we add New Keynesian features such as imperfectly competitive goods markets and price rigidity.

We study the effects of a tax redistribution that "favors the borrowers". Namely, a reduction in borrowers' taxes financed by an increase in savers' taxes, holding government spending constant. We wish to understand whether, as it is usually claimed, a reduction in taxes should be targeted to the low-income households because these are the agents that are typically credit constrained. As a result, that argument goes, those households are also the ones featuring a higher marginal propensity to consume

We first show that in a scenario with flexible prices this reasoning can be misleading. In fact, in a baseline model with perfectly competitive goods and labor markets, and despite the presence of borrowing frictions, a tax redistribution "that favors the poor" is neutral. The intuition for the neutrality result is simple. With flexible prices, exogenous borrowing limits, and in the absence of capital accumulation, the equilibrium allocations are equivalent to the ones that would obtain in a static economy. Hence, the different ability of each agent to substitute consumption intertemporally (as a result of borrowing frictions) is irrelevant for the equilibrium outcome.

We then show that the neutrality result breaks down in an economy where prices are sticky. The main implication of price stickiness, in fact, is that it renders the economy dynamic. As a result, the agents' different ability to smooth consumption determines their heterogenous consumption and labor supply choices. In this context, and as conventional wisdom would dictate, a tax redistribution that "favors the poor" (i.e., a tax rise on savers coupled by a tax cut of equivalent size on borrowers) indeed has an expansionary effect on output.

The intuition for the non-neutrality result lies in the different sensitivity of each agent's consumption to movements in their *effective* real interest rate. Whereas savers substitute consumption intertemporally as a function of the riskless real interest rate (as it is standard for permanent income consumers), consumption of the constrained agents depends also on the shadow price of borrowing, the equivalent of a(n) (endogenous) finance premium (or credit spread).

Tax redistributions are then non-neutral exactly because variations in the finance premium induce heterogeneous responses in each agent's consumption. When a tax redistribution favors the borrowers, it also induces a loosening of the financing conditions, in the sense of making the current shadow value of borrowing lower. This channel induces an expansion in borrowers' consumption in absolute value larger than the contraction in savers' consumption. Since government spending is held constant, the resulting expansion in aggregate spending also boosts aggregate output.

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). Iacoviello (2005) extends the KM framework to include features more typical of the New Keynesian monetary policy literature, whereas Campbell and Hercowitz (2004) extend this category of models to a standard real business cycle framework. Monacelli (2009) analyzes the implications for the monetary transmission mechanism of the presence of durable goods and endogenous collateral constraints.

None of these models, however, have focused their analysis on the redistributional features of fiscal policy. Galí et al. (2007) build a model in which myopic "rule-of thumb" consumers co-exist with standard agents that perfectly smooth consumption. Our analysis differs from Galí et al. in two respects: first, the borrowers in our economy remain intertemporal maximizers, although subject to a suitably specified (either exogenous or endogenous) borrowing constraint; second, the distribution of debt across agents is endogenously determined.

More recently, Eggertson and Krugman (2011) use a borrower-saver model with New Keynesian features to analyze the effects of financial shocks and of the zero bound for monetary policy. Our analysis differs from theirs in two respects: first, we analyze the distributional aspects of fiscal policy; second, our model features also a distinction between endogenous and exogenous borrowing constraints. Hyunseung and Reis (2011) study targeted transfers in an economy with imperfect credit markets, imperfect information, and nominal rigidities. Although their work is similar in spirit to ours, their model differs from ours in several respects, including the specification of the borrowing frictions and the type of policies studied.

2 Baseline Model

The model economy features two types of agents, henceforth *borrowers* and *savers*. Borrowing is motivated by impatience.[3] The impatient agents face a fixed borrowing limit, in the spirit of classic equilibrium models with incomplete markets such as Bewley (1980), Aiyagari (1993), and Hugget (1998). In its essence, our model can be seen as a simplified

[3] 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.

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.

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 for their degree of (im)patience β_j:

$$\beta_s > \beta_b$$

A generic agent of type j solves the following problem:

$$\max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta_j^t \left[u(c_{j,t}) - v(n_{j,t}) \right] \right\}$$

where $u^{'} > 0$, $u^{''} < 0$, $v^{'} > 0$, $v^{''} > 0$, subject to the period-by-period budget constraint (expressed in units of consumption):

$$c_{j,t} + r_{t-1} d_{j,t-1} \leq d_{j,t} + w_t n_{j,t} - \tau_{j,t} \tag{1}$$

where $c_{j,t}$ is consumption, $n_{j,t}$ is labor hours, $d_{j,t}$ is borrowing of agent j (in real terms), w_t is the real wage, $\tau_{j,t}$ are lump-sum taxes on agent j.

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:

$$\lambda_{j,t} = u^{'}(c_{j,t}) \tag{3}$$

$$\frac{v^{'}(n_{j,t})}{\lambda_{j,t}} = w_t \tag{4}$$

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

for $j = s, b$, where $\mathcal{I}_j$ is an index variable, with $\mathcal{I}_s = 0$ 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.

Notice that conditional on the borrowing constraint being binding (so that $\psi_t > 0$ for all t), the above equilibrium conditions imply:

$$\lambda_{b,t} > \lambda_{s,t} \tag{6}$$

for all equilibrium values of $c_{b,t}$ and $c_{s,t}$.

Hence the "impatience to consume" manifests itself in two ways. First, and regardless of borrowing restrictions being in place, via the assumption $\beta_s > \beta_b$. Second, in an equilibrium where the borrowing constraint is binding, via equation (6). Since constraint (2) is always binding in the steady state (to the extent that agents have different discount rates), condition (6) is verified also in the steady state.

In a standard intertemporal model of consumption (with no labor supply choice and no borrowing constraints), under logarithmic utility, each agent would consume a constant fraction $(1-\beta_j)$ of her income. Hence the assumption $\beta_s > \beta_b$ would directly imply that borrowers feature a higher marginal propensity to consume out of income.[4] In our model, however, such mapping is less straightforward, since (some) agents face borrowing constraints. Condition (6) is the model-based counterpart to the notion of "low-income households having a higher marginal propensity to consume". That notion manifests itself as the implication that constrained agents feature a higher shadow value of wealth and, therefore, via the equilibrium condition (3), also a higher marginal utility of consumption.[5]

Extensive micro-based empirical evidence suggests that the marginal propensity to consume differs across agents with different levels of income. Parker (1999) uses data from the Consumer Expenditure Survey and finds that the marginal propensity to consume out of transitory income at low levels of resources (which corresponds to current income for most low-income households) is much higher than the marginal propensity to consume out of transitory income for very high-income households. McCarthy (1995) find a similar evidence using the Panel Survey of Income Dynamics. Dynan, Skinner and Zeldes (2001)

[4] A simpler version of the model featuring only heterogeneity in discount factors, but no borrowing constraints, would imply a degenerate distribution of consumption (see Becker 1980).

[5] This differs, for instance, from Curdia and Woodford (2010), who assume that the marginal *utility* of consumption differs across agents as a result of the two agents having different utility functions. In our model, such an implication follows in equilibrium. In fact, simply combining the first order conditions (3) and (6) one obtains:

$$u^{'}(c_{b,t}) > u^{'}(c_{s,t})$$

The key difference is that in Curdia and Woodford the agents do not face an explicit period-by-period borrowing limit, but only a random inability to access a market for state contingent securities.

show that, in several different data sets, average propensities to consume out of current and permanent income fall at higher levels of income.

2.2 Firms

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

$$y_t = n_t, \tag{7}$$

with $F^{'}(n_t) > 0$, and $F^{''}(n_t) \leq 0$. Notice that n_t denotes the firm's demand for labor.[6]

Hence, in equilibrium, the real wage equals

$$w_t = 1, \tag{8}$$

2.3 Government

The government needs to finance a constant exogenous stream of government expenditures. Hence it collects lump-sum taxes and redistribute them across the agents. Its budget constraint reads:

$$\sum_j \tau_{j,t} = g \tag{9}$$

where g is the steady-state level of government spending.

We assume that lump-sum taxes obey an exogenous stochastic process $\{\tau_{j,t}\}$. In what follows we will specify this process to be autoregressive:

$$\tau_{j,t} - \tau_j = (1 - \rho_\tau)\tau_j + \rho_\tau(\tau_{j,t-1} - \tau_j) + \varepsilon_{\tau,t}$$

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

[6] Equivalently one can view the present production function as isomorphic to one employing an input in fixed supply.

2.4 Equilibrium

An equilibrium with a binding borrowing constraint requires

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

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

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

Hence an equilibrium is a collection of processes for $\{c_{j,t}, n_{j,t}, d_t, w_t, \psi_t\}$ satisfying (1), (4), (5), (2), (13), for $j = b, s$ and for any given evolution of $\{\tau_{j,t}\}$.

Combining (1) with (9) one obtains the aggregate resource constraint condition

$$y_t = n_t = \sum_j c_{j,t} + g \tag{13}$$

3 Neutrality of redistribution under flexible prices

Consider an exogenous decision to temporarily redistribute resources from the savers to the borrowers:

$$\Delta\tau_{s,t} = -\Delta\tau_{b,t} > 0$$

In other words, an unanticipated reduction in borrowers' taxes financed by a simultaneous rise in savers' taxes of equal size, holding government spending constant.

We show below that in our setup, despite the presence of financial imperfections and agents' heterogeneity, such redistribution is neutral. Our meaning of neutral is twofold.

For one, a tax redistribution that favors the borrowers (to savers' detriment) will produce identical effects on aggregate output to a symmetric policy of redistributing in favor of the savers (to borrowers' detriment). Furthermore, neither policy will produce any effect on aggregate output.

In order to illustrate this point, it is useful to consider a more compact representation of the equilibrium. Using (3) and (8), and inverting conditions (4) we can express each agent's consumption as:

$$c_{s,t} = u^{-1}\left(v^{'}(n_{s,t})\right) \equiv \Phi(n_{s,t})$$

$$c_{b,t} = u^{-1}\left(v^{'}(n_{b,t})\right) \equiv \Phi(n_{b,t})$$

with $\Phi^{'}(n_{j,t}) < 0$, for $j = b, s$.

Substituting into conditions (1), normalizing the borrowing limit $\overline{d} = 0$, and using the government budget constraint we can then solve for each agent's level of employment as a function of the respective tax rate:

$$n_{j,t} = \Theta^{-1}(\tau_{j,t}) \tag{14}$$

where $\Theta(n_{j,t}) \equiv n_{j,t} - \Phi(n_{j,t})$.

A few observations are in order. First, notice that the borrower's consumption Euler condition can be used to pin down the multiplier on the borrowing constraint residually. Hence, the different ability of each agent to substitute consumption intertemporally is irrelevant for the equilibrium outcome. This feature is important, for it is via the reduced ability to smooth consumption over time that the effects of borrowing constraints play out in the model.

Second, employment of agent j depends positively on agent j's tax rate:

$$\frac{\partial n_{j,t}}{\partial \tau_{j,t}} = \left(1 - \Phi'(n_{j,t})\right)^{-1} > 0 \tag{15}$$

This is the typical wealth effect that induces each agent to increase her labor supply (and reduce consumption, via equation (4)) in response to a rise in taxes (reduction in transfers). More importantly, it is clear that this effect is symmetric across agents. Hence, a reduction in borrowers' taxes financed by a rise in savers' taxes of equal amount will produce effects on labor supply and consumption exactly symmetric across agents. Aggregate output and consumption, then, will be unaffected both by the tax measure per se as well as by its composition.

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 ceases to be neutral . The main implication of price stickiness is to turn the model from static into dynamic. As a result, the agents' (in)ability to substitute consumption intertemporally is crucial in determining the behavior of private consumption in response to the redistribution of income.

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:

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

where $n_t(z)$ is total demand of labor by firm z, $F^{'} > 0$ and $F^{''} \leq 0$.

The households' budget constraint, once expressed in real consumption units, is modified to include profits rebated lump-sum from monopolistic competitive firms:

$$c_{j,t} + \frac{(1+i_{t-1})d_{j,t-1}}{\pi_t} \leq d_{j,t} + w_t n_{j,t} - \tau_{j,t} + \sigma_j \mathcal{P}_t, \tag{16}$$

where $1 + i_t$ is the gross nominal interest rate on one-period debt, $d_{j,t}$ is debt expressed in real units, and σ_j is the share of aggregate profits $\mathcal{P}_t$ that accrues to agent j (because of equity holdings), with $\sum_j \sigma_j = 1$.

We assume that the savers hold the equity shares of monopolistic competitive firms, thus we have:

$$\sigma_s = 1 \text{ and } \sigma_b = 0.$$

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:

$$\sum_j n_{j,t} = n_t(z) = n_t, \tag{17}$$

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

Denoting henceforth by w_t the *nominal* wage, the first order conditions of the household's problem can be written:

$$n_{j,t} = v^{'-1}\left(u^{'}(c_{j,t})\frac{w_t}{p_t}\right) \equiv l\left(c_{j,t}, \frac{w_t}{p_t}\right) \tag{18}$$

$$u^{'}(c_{j,t}) = \beta_j \mathbb{E}_t \left\{ \frac{1+i_t}{\pi_{t+1}} u^{'}(c_{j,t+1}) \right\} + \mathcal{I}_j u^{'}(c_{j,t}) \psi_t, \tag{19}$$

with $L_1^{'} < 0$, and $L_2^{'} > 0$.

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

$$1 + i_t = r \pi_t^{\phi_\pi} \tag{20}$$

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

4.1 A Temporary redistribution 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 (20) this implies (since p_{t-1} is predetermined as of time t) that i_t is fixed , and, in turn, that the ex-ante real interest rate $r_t \equiv \mathbb{E}_t \{(1+i_t)/\pi_{t+1}\}$ is also fixed. Alternatively, as in Woodford (2010), we could think of constructing an equilibrium in which the central bank, via (20), 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, (19) implies, for agents of type $j = s$,

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

The same, however, does not hold for agents of type $j = b$, due to the shadow value ψ_t being time-varying. For those agents, in fact, it will hold

$$\overline{r} \beta_b \mathbb{E}_t \left\{ \frac{c_{b,t}}{c_{b,t+1}} \right\} = 1 - \psi_t \tag{21}$$

Thus, borrowers' ability to substitute consumption intertemporally depends on the shadow value ψ_t even though movements in the *riskless* real interest rate do not take place in equilibrium. Variations in the multiplier ψ_t are in fact akin to variations in the borrowers' finance premium on consumption.

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

$$p_t(z) = \overline{p} = \mu_t \frac{w_t}{F'(n_t)}, \tag{22}$$

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 (22) allows to derive an implicit aggregate labor demand schedule

$$n_t = \mathcal{N}\left(\frac{w_t \mu_t}{\overline{p}}\right) \tag{23}$$

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

The *aggregate* labor supply schedule can then be derived by combining the conditions in (18):

$$n_t = \sum_j n_{j,t} = \sum_j l\left(c_{j,t}, \frac{w_t}{p_t}\right) \equiv L\left(c_{b,t}, \overline{c}_s, \frac{w_t}{\overline{p}}\right) \tag{24}$$

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

$$y_t = \bar{c}_s + c_{b,t} + g \tag{25}$$

Equation (25) suggests that both the sign and the size of the response of output will depend crucially on the behavior of borrowers' consumption under any given tax financing rule.

One can equivalently assess the role of borrowers' consumption for aggregate labor market quantities (and hence aggregate output) by evaluating the equilibrium described by the schedules (23) and (24). This is illustrated in Figure 1. Notice that the position of the aggregate labor supply schedule (24) depends on the value of borrowers' consumption c_b, whereas savers' consumption is considered as constant.

Consider, once again, a temporary "pro-borrower" tax redistribution:

$$\Delta\tau_{s,t} = -\Delta\tau_{b,t} > 0.$$

For agents of type b, the fall in taxes will induce a relaxation of the borrowing constraint, and therefore a fall in the finance premium ψ_t. In turn, via (19), consumption $c_{b,t}$ will rise. In equilibrium, equation (13) implies a *rise* in equilibrium output.

Under fixed prices, and since firms are assumed to meet all the available demand at that given price, the rise in output will induce firms to lower their markups, and therefore increase their demand for labor at any given real wage. This effect corresponds to an outward shift of the aggregate labor demand schedule from $N(\mu)$ to $N(\mu^{'})$, with $\mu^{'} > \mu$.

The final equilibrium level of aggregate employment, and therefore output, will depend on the position of the aggregate labor supply schedule, $N(\bar{c}_s, c_b)$, which in turn will depend on the behavior of borrowers' consumption. Since borrowers' consumption rises ($c_b^{+} > c_b$), the aggregate labor supply schedule shifts inwards, with the final equilibrium being

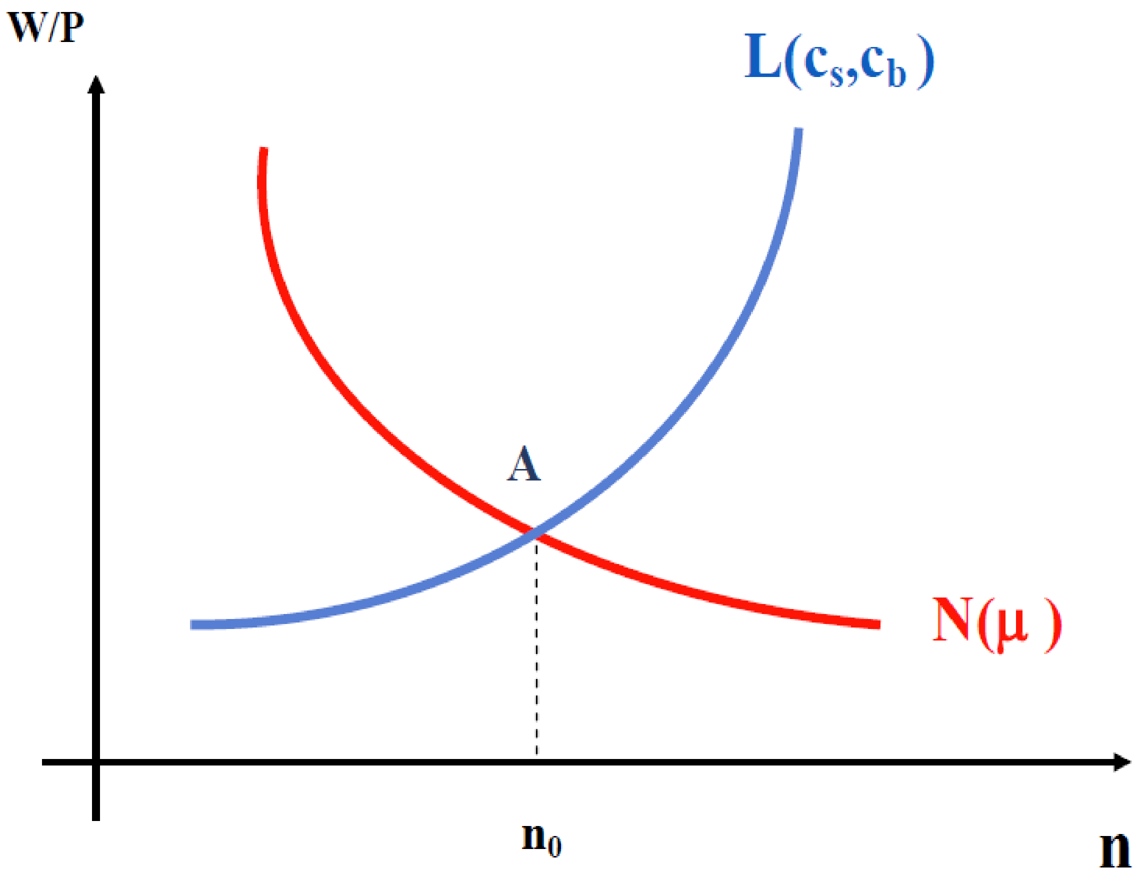

Figure 1: Aggregate labor market equilibrium

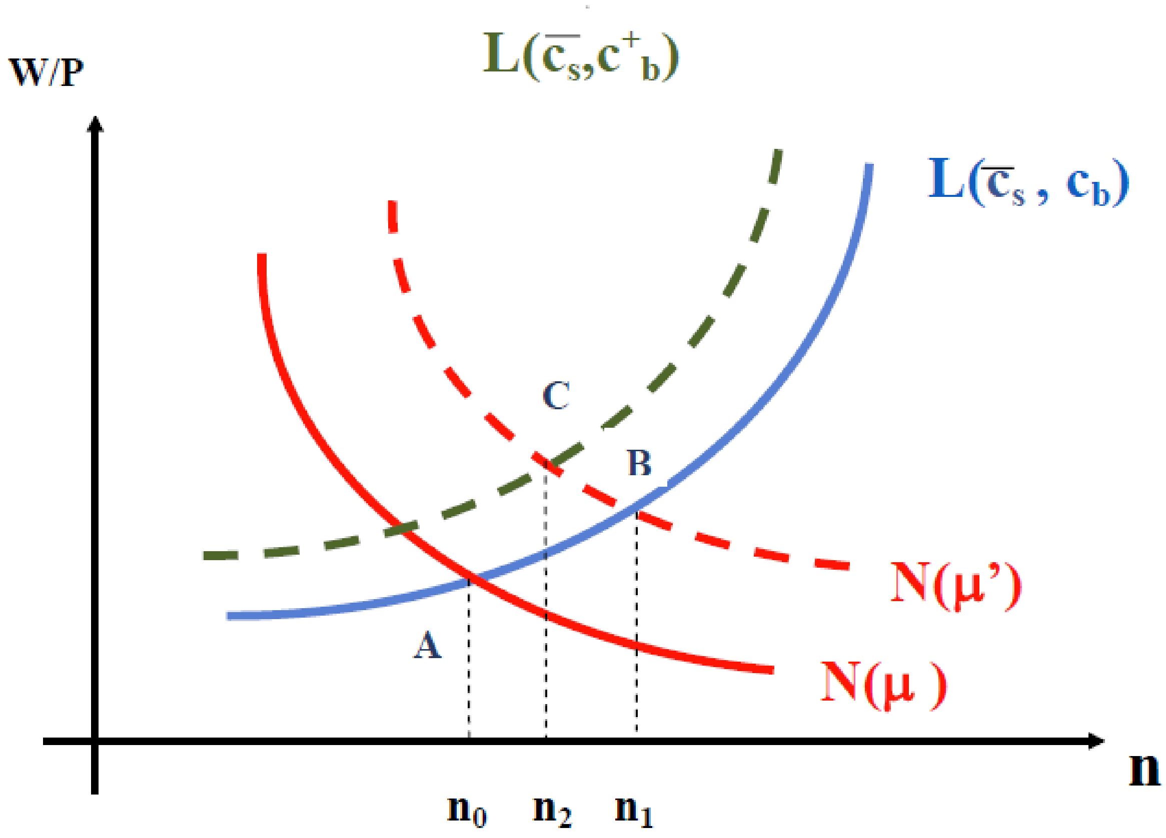

Figure 2: Aggregate labor market effects of a pro-borrower tax redistribution under rigid prices.

located in *point* C in the figure, corresponding to an aggregate level of employment (and therefore output) $n_2 > n_0$.

Interestingly, in this version of the equilibrium, the change in borrowers' consumption affects, either directly or indirectly, the position of both the aggregate labor demand and labor supply schedules. Directly, via a wealth effect on labor supply (the borrowers are less constrained, so their labor supply is reduced at the margin); indirectly, via a relaxation of the borrowing constraint, which stimulates borrowers' consumption, and induces sticky-price firms to reduce their markups. In particular, the strength of the labor demand effect will depend on the slope of the aggregate labor supply schedule, which depends on the inverse of the Frisch elasticity of labor supply. The lower that elasticity (i.e., the higher the Frisch elasticity), the flatter the labor supply schedule, and therefore the larger the employment (output) effect of a rightward shift in the labor demand schedule.

4.2 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 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 (20). 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 :

$$\widetilde{p}_t^* = \log\left(\frac{\varepsilon}{\varepsilon-1}\right) + (1-\beta\vartheta)\sum_{k=0}^{\infty}(\beta\vartheta)^k \ \mathbb{E}_t\{\widetilde{mc}_{t+k} + \widetilde{p}_{t+k}\} \tag{26}$$

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:

$$\widetilde{p}_t = \vartheta \widetilde{p}_{t-1} + (1-\vartheta)\widetilde{p}_t^* \tag{27}$$

Equations (26) and (27) constitute the pricing block of the model.

In the following we simulate the quantitative effects of a tax redistribution that favors the borrowers in a sticky-price scenario. 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.[7] We choose a utility function of the form $\log c_{j,t} - n_{j,t}^{1+\varphi}/1+\varphi$. The relevant remaining parameters assume the values: $\beta_s = 0.99$, $\beta_b = 0.98$, $\varphi = 1$ (implying a Frisch elasticity of labor supply of 1), $\phi_\pi = 1.5$. The persistence of the tax shock ρ_τ is set to 0.5 (see more below on the role of persistence for the size of the output multiplier).

Figure 3 displays the effects on aggregate output and consumption of a temporary redistribution from the savers to the borrowers. A few observations are in order. First, notice that, in the case of sticky prices, such redistribution ceases to be neutral: it is expansionary on output if it favors the borrowers, and, correspondingly, it is contractionary if it favors the savers. This result is in accordance with our previous line of reasoning, based on a particular representation of the equilibrium.

Since government spending is held constant, the driver of the expansion in output is the underlying expansion in aggregate consumption. Figure 4 shows that the rise in aggregate in consumption results from an expansion in *borrowers*' consumption which more than compensates the contraction in *savers*' consumption. The key to this outcome is the sensitivity of borrowers' consumption to movements in the *effective* real interest rate, the riskless real interest rate plus the finance premium ψ_t.

As the Figure shows, the riskless real interest rate *rises* in response to the tax redistribution, but the finance premium sharply *falls*. The real riskless rate rises because

[7] The remaining parameters assume standard values: $\beta = 0.99, \varphi = 3, \phi_\pi = 1.5$

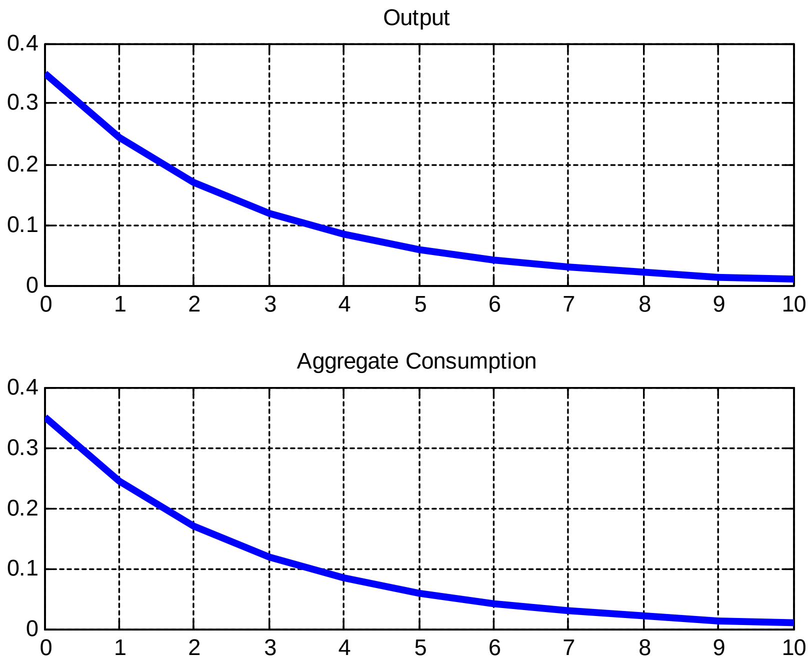

Figure 3: Aggregate effects of a tax redisribution from the savers to the borrowers: sticky prices.

the outward shift in the labor demand schedule pushes the firms' real marginal cost up and therefore rises inflation. The central bank, in turn, via the interest rate rule (20), raises the real rate via a more than proportional increase in the nominal rate. The finance premium falls because the reduction in borrowers' taxes induces a relaxation of the credit constraint, and therefore reduces the shadow value of borrowing.

The rise in the riskless real rate induces the savers to reduce their consumption, in line with a standard intertemporal substitution effect. At the same time, the fall in the finance premium ψ_t produces a fall in the effective real interest rate, and therefore boosts borrowers consumption. The net effect is a an increase in aggregate consumption.

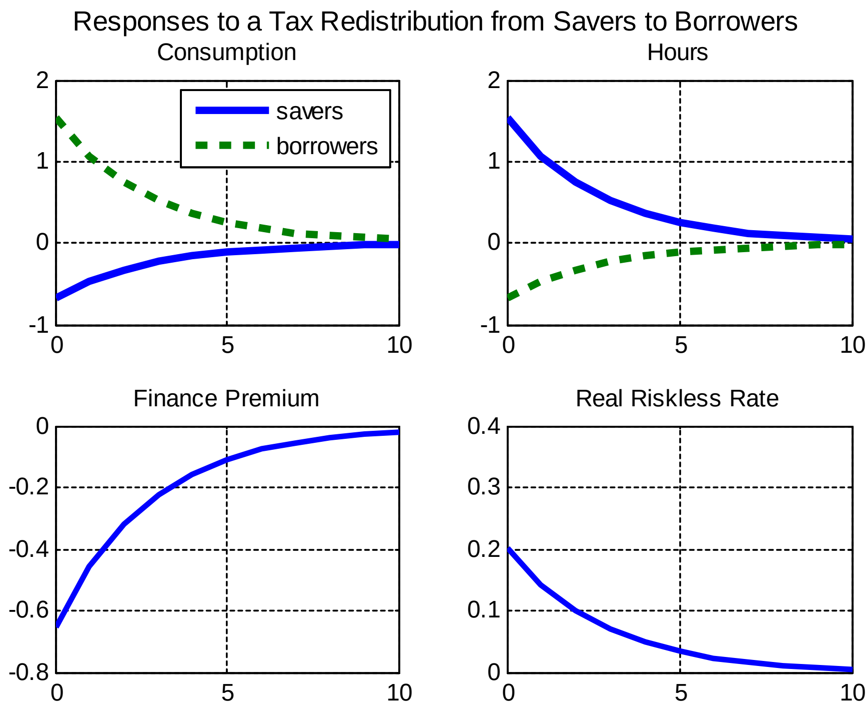

Figure 4: Responses to a tax redistribution from the savers to the borrowers: sticky prices.

4.3 Temporary vs. permanent tax cuts

Standard permanent income theory of consumption maintains that the marginal propensity to consume out of *transitory* shocks to income (e.g., tax changes) should be close to zero, while the marginal propensity to consume out of *permanent* shocks should be close to one. In our environment, however, this logic is reversed.

Let $dy_{\tau}^{j}(k)$ be the impulse response of output at horizon k to a temporary unanticipated tax redistribution that favors agent j (i.e., $j = b$ indicates that taxes are reduced to the borrowers and simultaneously raised to the savers by an equal amount, whereas $j = s$ indicates the reverse situation). Figure 5 displays the effect on the output impact multiplier $dY_{\tau}^{b}(1)$ of varying the degree of persistence ρ_{τ} of the tax redistribution shock. The degree of persistence ranges from zero to (almost) one, thereby approaching the limit case of a permanent shock. Notice that in our setting the output multiplier exactly coincides with the aggregate consumption multiplier.

Thus we see that the output multiplier is negatively affected by the degree of persistence of the tax shock, and strongly so. Interestingly, close to the limit case of a permanent shock, the impact effect on output tends to be zero. Intuitively, when the degree of persistence of the shock is low, the agents' different ability to substitute intertemporally, which is the key driver of the non-neutrality result, makes a substantial difference. When the shock becomes more persistent or, in the limit, permanent, the degree of intertermporal substitution, and therefore the heterogeneity of consumption responses, becomes gradually irrelevant.

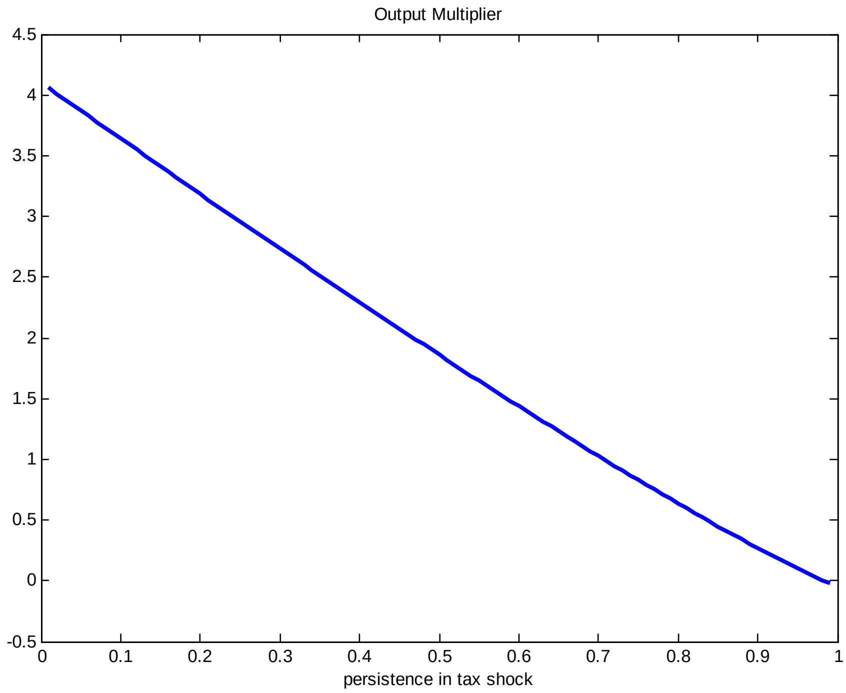

Figure 5: Aggregate output (consumption) impact multiplier of a tax redistribution that favors the borrowers.

5 Endogenous borrowing constraint

So far the impatient household could borrow up to an exogenously given constant limit. It is highly realistic to assume, however, that the ability to borrow varies endogenously with the state of the economy. In the following, we assume that, due to a problem of limited enforcement, the borrowers cannot credibly commit to repay more than a certain fraction of their expected labor income.

Formally, this implies that the borrowers face the following constraint:

$$d_{b,t} \leq (1-\chi)\frac{\mathbb{E}_t\left\{w_{t+1}n_{b,t+1}\right\}}{r_t} \tag{28}$$

where $(1-\chi)$ is the fraction of the expected future labor income that can be pledged when purchasing new debt at time t. Written in this form, equation (28) states that the impatient agents cannot borrow more than a constant fraction of the present value of their labor income.

A borrowing constraint such as (28), where the ability to borrow varies endogenously with the expected variations in labor income, yields two main implications for our analysis. First, the model under flexible prices ceases to be inherently static as it is the case under an exogenous borrowing limit (see our discussion under Section 2). Second, in making their labor supply choice, the constrained agents internalize that the same choice will affect their borrowing conditions

In this setting, the first order conditions of the household's problem include (3), and the following "adjusted" consumption/leisure condition:

$$\frac{v'(n_{j,t})}{\Lambda_{j,t}} = w_t \tag{29}$$

where

$$\Lambda_{j,t} \equiv \left[\lambda_{j,t} + \mathcal{I}_j \beta_b^{-1}(1-\chi)\lambda_{b,t-1}\psi_{t-1}\right],$$

Equation (29) requires that the real wage be equated to the "effective" marginal rate of substitution between consumption and leisure. The latter depends on the marginal utility of leisure (the numerator), and (in the case of the borrower) on an *effective* measure of the shadow value of income $\Lambda_{j,t}$ (at the denominator).

For an agent of type $j = b$, the marginal utility of wealth $\Lambda_{b,t}$ has two components: first, the marginal utility of relaxing the budget constraint $\lambda_{j,t}$; second, the (lagged) marginal utility of borrowing. Intuitively, the higher the last period's shadow value of borrowing ψ_{t-1}, i.e., the more constrained an agent of type b was in period $t-1$, the larger the marginal utility of labor income for that agent in the current period.

Notice that under an endogenous borrowing constraint, movements in the effective shadow value of income $\Lambda_{b,t}$ will induce persistent movements in the labor supply: at any given real wage, a higher current marginal utility of income $\lambda_{b,t}$ will induce the constrained agent to work more not only today but also tomorrow.

Equilibrium An equilibrium with endogenous borrowing constraint is a set of processes for $\{c_{j,t}, n_{j,t}, d_t, w_t, \psi_t\}$ satisfying, (5), (1), (13) (28), and (29), for $j = b, s$ and for any given evolution of $\{\tau_{j,t}\}$.

Figures (6) and (7) show impulse responses from the model with an endogenous borrowing limit, respectively with and without nominal rigidities. The exercise is the usual one: a tax redistribution that favors the borrowers.[8]

A few observations are in order. Notice, first, that the tax redistribution ceases to be neutral even under flexible prices. Even more interestingly, the effect is contractionary,

[8] In this simulation we set parameter χ in the borrowing constraint equal to 0.25.

although only mildly. The key to this result is the different behavior of labor supply for the two agents (labor demand is unaffected in the flexible price equilibrium, as markups are constant). Savers' labor supply rises in response to the negative income shock, but borrowers' labor supply falls more persistently: the fall in taxes, in fact, induces a fall in the shadow value of income $\lambda_{b,t}$, which induces a fall in current and future labor supply. The net effect is a contraction in aggregate employment and, therefore, output.

Figure (7) shows that, once again, the outcome is reversed under sticky prices. Hence our result that tax redistributions that favor the borrowers are expansionary is robust to the specification of the borrowing limit (exogenous vs. endogenous). One further insight from the case with endogenous debt limit is that the two scenarios are strongly asymmetric. In other words, while the output fall is minimal in the case of flexible prices, the output expansion is sizeable in the case of sticky prices.

6 Redistribution via Government Debt

So far we have focused on balanced-budget tax redistributions only: as a result, any reduction in borrowers' taxes had to be financed by an increase in savers' taxes of equal amount. In this section we turn our attention to *debt-financed* redistributions.

In order to introduce a role for government debt we modify our economy as follows. We assume that government bonds are purchased by the patient agents, who also save in the form of riskless nominal deposits. Deposits are intermediated by a financial sector, that in turn lends to the impatient agents, the ultimate borrowers. Intermediation frictions generate a wedge between the cost of borrowing faced by impatient agents and the remuneration of deposits obtained by the savers.

The savers' budget constraint reads:

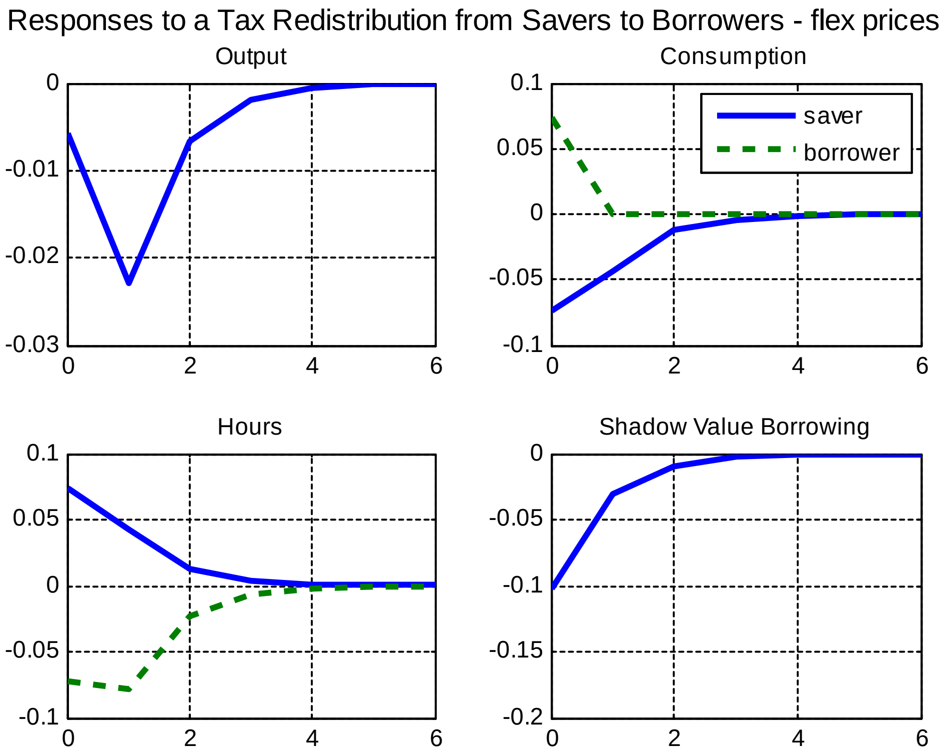

Figure 6: Endogenous debt limit: flexible prices.

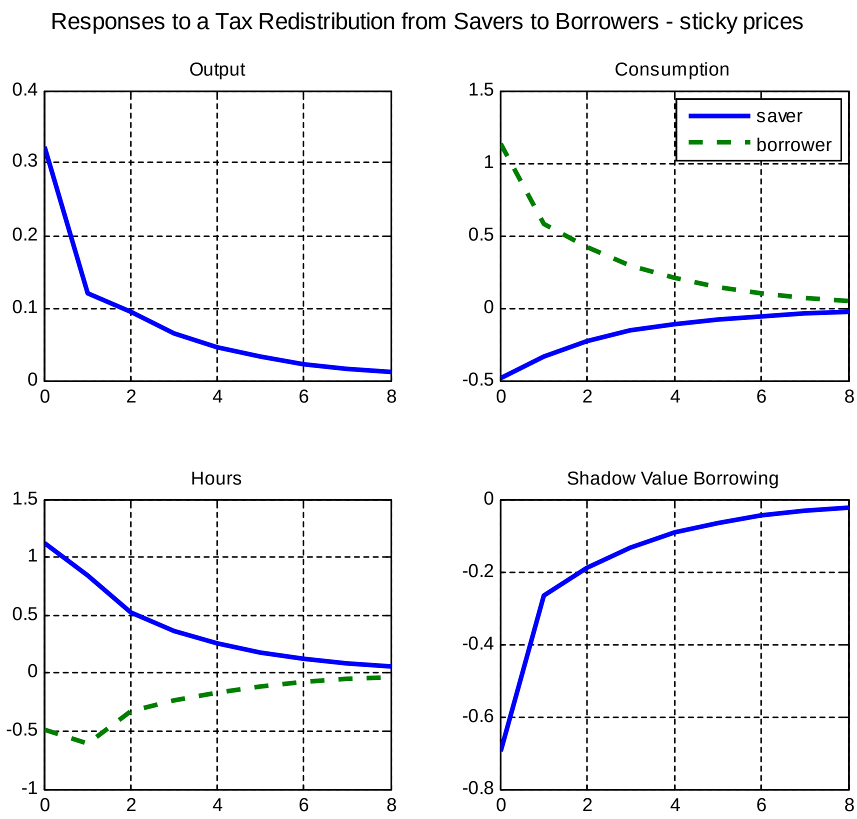

Figure 7: Endogenous debt limit: sticky prices.

$$c_{s,t} + s_t + \mathcal{B}_t = \frac{i_{t-1}(s_{t-1} + \mathcal{B}_{t-1})}{\pi_t} + \frac{w_t}{p_t} n_{s,t} - \tau_{s,t} + \mathcal{P}_t, \tag{30}$$

where s_t denotes holdings of riskless nominal deposits, $\mathcal{B}_t$ denotes the holdings of government debt (both expressed in real consumption units), and i_t now denotes the nominal one-period interest rate. Notice that nominal deposits and government bonds are perfectly substitutable in the savers' portoflio, and that all firms' profits accrue to the savers.

The borrowers' budget constraint reads:

$$c_{b,t} + \frac{(1 + i^d_{t-1}) d_{b,t-1}}{\pi_t} = d_{b,t} + w_t n_{b,t} - \tau_{b,t}, \tag{31}$$

where i^d_t is the nominal interest rate on one-period private loans. Borrowers continue to face the following constraint on borrowing

$$d_{b,t} \leq \overline{d}_b \tag{32}$$

As in Curdia and Woodford (2010), we assume that the process of originating private loans by financial intermediaries requires the consumption of real resources.[9] The amount of resources needed to generate $d_{b,t}$ units of private loans is given by the increasing and convex function $\Omega \left(d_{b,t} \right) = (\kappa/\eta) d^{\eta}_{b,t}$, with $\eta > 1$ and $\kappa \geq 0$.

The balance sheet of the financial intermediaries therefore reads:

$$s_t = d_{b,t} + \Delta \left(d_{b,t} \right).$$

Perfect competition among financial intermediaries implies:

$$(1 + i^d_t) = (1 + i_t)(1 + \delta_t),$$

where $\delta_t \equiv \Delta' \left(d_{b,t} \right)$. Along with ψ_t (the multiplier on the borrowing constraint 32), movements in δ_t constitute an additional source of variation in the finance premium.

[9] We abstract here from other possible sources of credit spreads, such as risk of default.

The government finances an exogenous stream of government spending $\{g_t\}$ by issuing debt and by raising lump-sum taxes.The government budget constraint can be written:

$$g_t + \frac{(1+i_{t-1})\mathcal{B}_{t-1}}{\pi_t} = \mathcal{B}_t + \sum_{j=s,b} \tau_{j,t} \tag{33}$$

The conduct of fiscal policy can be described by the following tax feedback rules:

$$\tau_{j,t} = (1-\rho_\tau)\tau_j + \rho_\tau \tau_{j,t-1} + \phi_j^B \mathcal{B}_{t-1} + \varepsilon_{j,t} \qquad j = b, s \tag{34}$$

where $\phi_j^B > 0$, and $\varepsilon_{j,t}$ is an iid random disturbance. Finally,monetary policy continues to obey the feedback rule (20).

Our specification of the tax rules is deliberately simple. Taxes evolve persistently and rise in the current period when the inherited real level of government debt is higher. This specification rules out, for instance, any discretionary motive for output stabilization, as well as any explicit correlation between tax innovations.[10]

Parameters ϕ_j^B are the key policy parameters. Two aspects are relevant. First, and in order to rule out a unit-root evolution of government debt, we must insure that *at least one* ϕ_j^B has a positive value. Second, we need to make an assumption on the value of ϕ_s^B relative to ϕ_b^B. In other words, when taxes are reduced for the borrowers, and government debt therefore increased, how is the burden of the future adjustment of government debt distributed between the agents?

We start by studying the impact of a tax cut to the borrowers under flexible prices.[11] We set $\phi_s^B = \overline{\phi}_s^B = 0.1$, whereas we let ϕ_b^B vary between zero and alternative positive values. The case $\phi_b^B = 0$ is our baseline: it corresponds to a scenario in which the

[10]See Leeper et al. (2010) for the specification and estimation of more elaborate tax rules.

[11]We calibrate $\kappa = 0.01$, $\eta = 1.01$. These values, combined with $\beta = 0.97$ and $\gamma = 0.99$, yield a steady state finance premium $\psi = 1\%$, and an interest rate spread $(1+i^b)/(1+i) = 2\%$.

borrowers do not face any (current or future) tax burden aimed at the stabilization of government debt.

Figures (8) and (9) report impulse responses to an unexpected tax cut to the borrowers under alternative values of the feedback paramerer ϕ_b^B. A few observations are in order. First, the size of the effect on aggregate output and consumption is small. Second, whether the tax cut is neutral, expansionary or contractionary (although mildly) depends on how the burden of debt stabilization is distributed between the agents. When the borrowers are exempt from any tax adjustment ($\phi_b^B = 0$), the tax cut is expansionary on output and consumption. The larger the required adjustment in borrowers' taxes, the smaller the effect on output, with that effect becoming contractionary for a relatively high value of $\phi_b^B = 0.5 > \phi_s^B = 0.1$. When the burden of adjustment is equally shared ($\phi_b^B = \phi_s^B = 0.1$), however, the effect of the tax cut is basically neutral.

Next we compare the above results with a scenario under sticky prices, Figures (10) and (11). Notice, first, that the aggregate effect on output and consumption is considerably larger relative to the case of flexible prices. Under sticky prices, in fact, intertemporal substitution matters. The fall in taxes generates not only a positive income effect, but also a relaxation of the borrowing constraint, and therefore a fall in the finance premium ψ_t. This additional channel generates a heightened sensitivity of current consumption to variations in what we have already defined as the "effective" real interest rate.[12]

The effect of varying parameter ϕ_b^B is also interesting. Higher values of ϕ_b^B make the profile of consumption steeper. The reason is that (with the exception of the case $\phi_b^B = 0$) the borrowers anticipate that the current fall in taxes will be followed by future increases in taxes. This makes the current fall in taxes "more temporary", inducing a larger current reaction in consumption, but also a more rapid reversion to the steady state.

[12] Notice that this kind of acceleration effect would not be present in a model in which the non-permanent-income agents are interpreted as "hand-to-mouth" consumers, as in Galí et al. (2007).

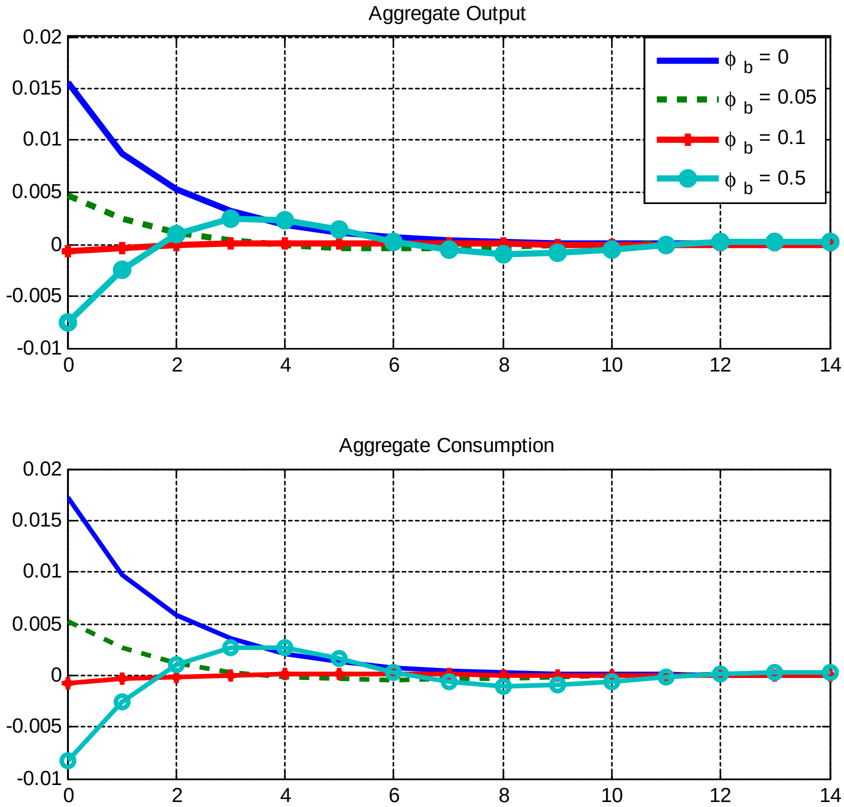

Figure 8: A tax cut to the borrowers under alternative values of ϕ_b^B: *flexible* prices.

7 Conclusions

(to be written)

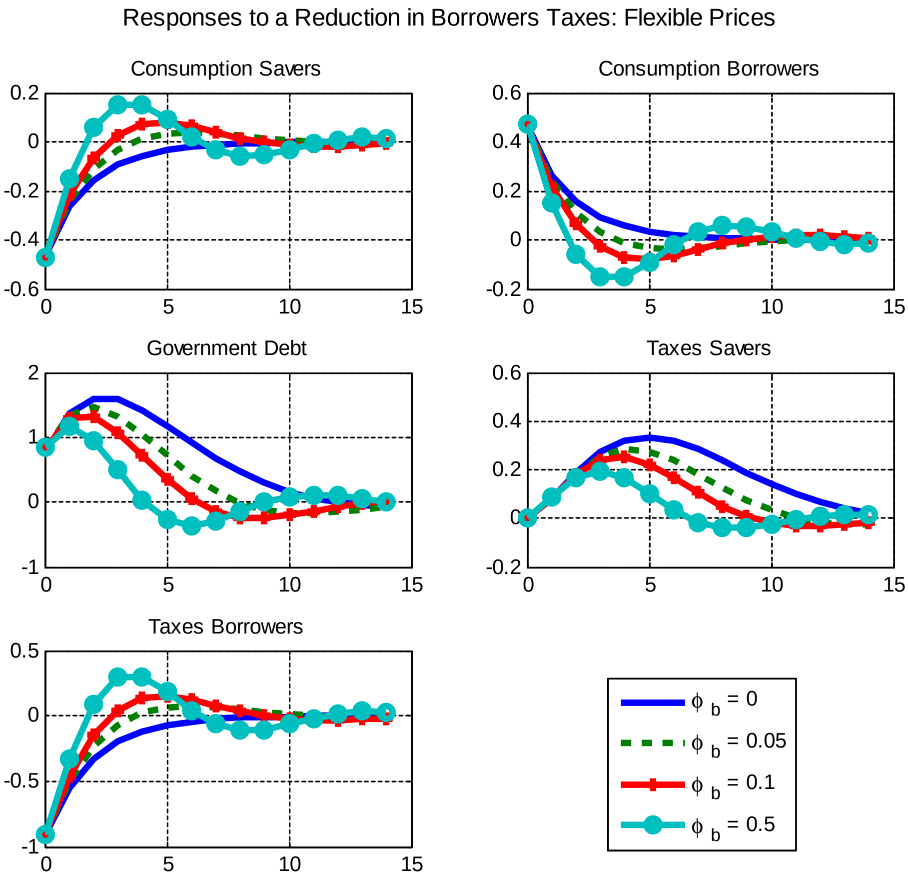

Figure 9: A tax cut to the borrowers under alternative values of ϕ_b^B: *flexible* prices.

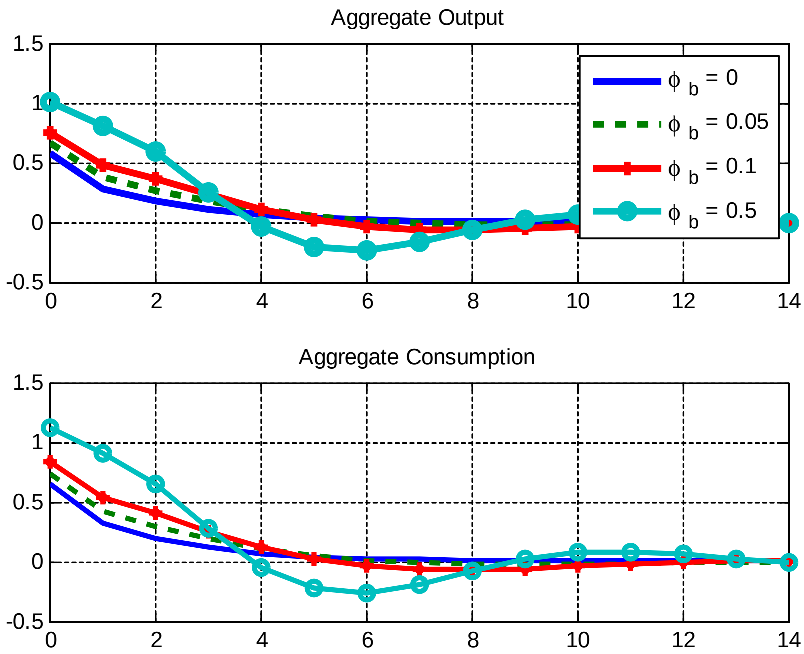

Figure 10: A tax cut to the borrowers under alternative values of ϕ_b^B: *sticky* prices.

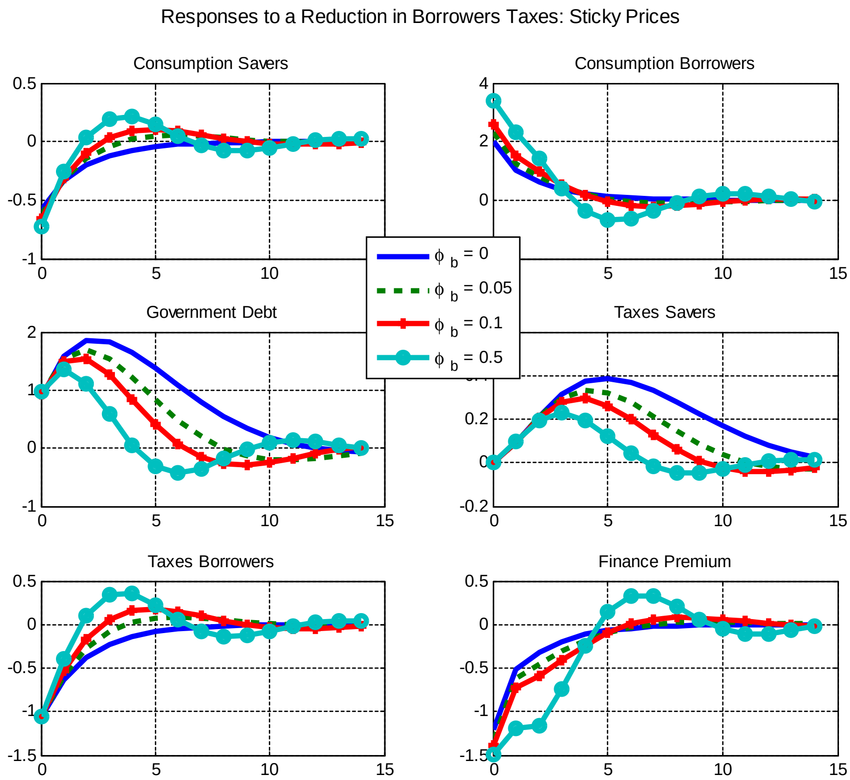

Figure 11: A tax cut to the borrowers under alternative values of ϕ_b^B: *sticky* prices.

8 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:

$$c_b - c_b^{-\frac{1}{\varphi}} \left[1 - \delta_b \left(\frac{1}{\beta_s} - 1\right)\right] - \tau_b = 0 \tag{35}$$

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:

$$c_s - c_s^{-\frac{1}{\varphi}} \left[1 - \delta_s \left(\frac{1}{\beta_s} - 1\right)\right] - \tau_s = 0 \tag{36}$$

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:

$$c_b < c_s \tag{37}$$

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

$$n_b > n_s \tag{38}$$

In the special case $\overline{d} = 0$, however, if $\tau_b = \tau_s$, consumption and labor supply will be equalized across agents:

$$c_b = c_s \tag{39}$$

$$n_b = n_s \tag{40}$$

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