Financial globalization and the raising of public debt*

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Abstract

During the last three decades the stock of government debt has increased in most developed countries. During the same period international capital markets have been liberalized. In this paper we develop a two-country political economy model with incomplete markets and endogenous government borrowing and show that countries choose higher levels of public debt when financial markets are internationally integrated. We also conduct an empirical analysis using OECD country data and find that the predictions of the theoretical model are consistent with the empirical results.

1 Introduction

During the last three decades we have observed an increase in the stock of public debt in most of the developed countries. As shown in the top panel of Figure 1, the stock of public debt in OECD countries has increased from around 30 percent of GDP in the early 1980s to about 50 percent in 2005. Similar increases are observed in United States and Europe.

Historically, the dynamics of public debt has been closely connected to war financing and business cycle fluctuations, where budget deficits and surpluses were instrumental to minimizing the distortionary effects of taxation.

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The tax-smoothing theory developed by Barro (1979) provides a rationale for such dynamics. However, when we look at the upward trend in public debt that started in the early 1980s, it becomes difficult to rationalize it with tax-smoothing arguments since this period is characterized by relatively peaceful times and low volatility of output.

The last three decades are also characterized by a significant process of financial liberalization. The second panel of Figure 1 plots the index of financial liberalization constructed by Abiad, Detragiache and Tressel (2008) for the group of OECD countries, United States and Europe. As can be seen, the world financial markets have become much less regulated starting in the early 1980s. A fact also confirmed by other indicators of international capital mobility as shown in Obstfeld and Taylor (2005).

In this paper we propose a theory in which financial globalization leads to higher government borrowing. We study a two-country model where agents face uninsurable idiosyncratic risks and public debt is held by private agents to smooth consumption. To keep tractability, we assume that there are two types of agents: those who face idiosyncratic risks (entrepreneurs) and those who are insulated from these risks (workers). Government policies are determined through the aggregation of agents' preferences based on probabilistic voting. The goal is to show how the choice of government debt changes when we move from a regime with financial autarky to a regime with international mobility of capital.

Both agents have preferences for some public debt. Agents who face idiosyncratic risks (entrepreneurs) benefit from public debt because it provides an additional instrument to smooth consumption. This is the same reason why in Aiyagari and McGrattan (1998) and Shin (2006) public debt improves welfare. Agents who do not face idiosyncratic risks (workers) can also benefit from government borrowing because the equilibrium interest rate is lower than the intertemporal discount rate. The benefits from public debt, however, fade away as the stock of debt increases. Once the debt has reached a certain level, further increases provide only small gains to entrepreneurs since they already hold large amounts of assets. On the other hand, workers internalize that raising the stock of debt increases its cost given by the interest rate. Thus, once the debt has reached a certain level, workers do not support further increases. It is the internalization of the raising cost of debt that limits its growth.

How does financial integration affect the preferences for public debt? The central mechanism is the elasticity of the interest rate to the supply of debt. In a globalized world, both the demand and supply of government debt come not only from domestic agents (investors and governments) but

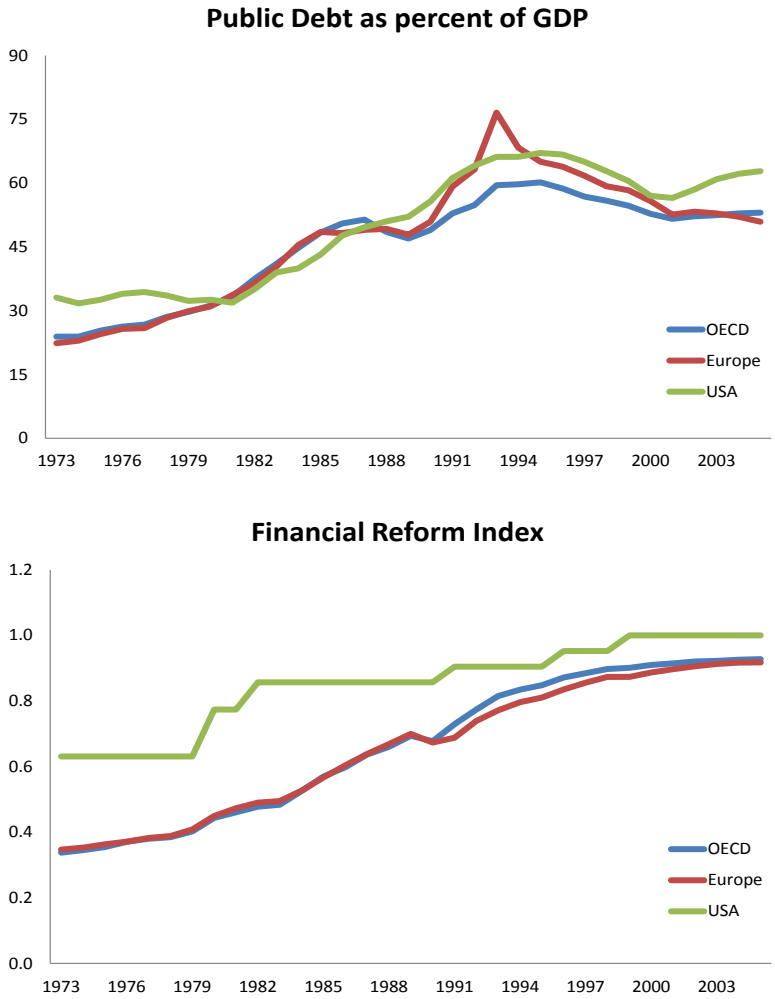

Figure 1: Public debt and financial liberalization in advanced economies. Appendix A provides the data sources and the description of variables.

also from their foreign counterparts. Therefore, when governments do not coordinate their actions and act only on their citizens' interest, each individual country faces a lower elasticity of the interest rate to the supply of 'their own' government debt. Since the interest rate is less responsive to one's country debt, governments have more incentives to expand borrowing provided that workers have sufficient political influence.

Recent literature has explored the importance of market incompleteness for international financial flows. Caballero, Farhi and Gourinchas (2008),

Mendoza, Quadrini and Rios-Rull (2009), Angeletos and Panousi (2011), have all emphasized the importance of cross-country heterogeneity in financial markets for global imbalances. Our study differs from these contributions in three dimensions. First, our finding that capital market liberalization leads to higher government borrowing does not rely on country heterogeneity. In fact, we present the results with perfectly symmetric countries. Thus, our theory is relevant also for countries that have similar financial structure, e.g., OECD countries. Second, our focus is on public debt while the above contributions have focused on private debt. There is an important difference between public and private debt which is crucial for our results: While in private borrowing atomistic agents do not internalize the impact that the issuance of debt has on the interest rate, governments do. As already mentioned, part of our results are driven by the fact that governments do not take the interest rate as given, as individual agents do. The third difference is that the goal of our study is to explain the global volumes of (public) debt while the contributions mentioned above focus on net volumes. In these models financial liberalization leads to higher liabilities in one country but lower liabilities in others, with the difference defining the imbalance. The global volume of credit, however, does not change significantly. In contrast, in our model capital liberalization generates an increase in the global stock of debt. Therefore, we can explain why government debt has increased globally during the last thirty years.

The paper is also related to the theoretical literature on optimal debt management pioneered by Barro (1979), Lucas and Stokey (1983), and subsequent work that builds on these contributions such as Aiyagari, Marcet, Sargent, and Seppala (2002), Angeletos (2002), Chari, Christiano, and Kehoe (1994), and Marcet and Scott (2008). We depart from the tax-smoothing mechanism that is central to this literature because we abstract from aggregate fluctuations and distortionary taxation. Instead, we focus on the role of heterogeneity within a country which is assumed away in these papers.

Our model is closer to the models studied in Aiyagari and McGrattan (1998) and Shin (2006). In these papers the role of government debt is to partially complete the asset market when agents are subject to uninsurable idiosyncratic risks. The government accumulates debt in order to crowd out private capital, which is inefficiently high due to precautionary savings. In our model we abstract from capital accumulation. Therefore, the government choice to issue debt is independent of production efficiency considerations but it is based on redistributive concerns. Because of this, our paper is also related to the literature on optimal redistributive policy in heterogeneous agent economies such as Golosov, Kocherlakota, and Tsyvinski

(2003), Albanesi and Sleet (2008), and Farhi and Werning (2008).

The paper is also related to the literature on the political economy of debt initiated by the original work of Alesina and Tabellini (1990), Persson and Svensson (1989), and further developed by Song, Storesletten and Zilibotti (2007), Battaglini and Coate (2008), Caballero and Yared (2008), and Ilzetzki (2008). The key common feature in these papers is the strategic use of public debt in economies where the interest rate is exogenous and governments with different preferences over public spending alternate in power. We abstract from political turnover and consider instead how the supply of government bonds endogenously affects interest rates and redistribution. The 'interest rate manipulation' channel is also present in Azzimonti, de Francisco, and Krusell (2009) but it relies on the existence of distortionary taxation, which we assume away here.

An important difference between our study and most of the literature on optimal government policies is that we consider an open economy environment. Our goal is to study how the international liberalization of capital markets affect government policies in the form of public debt. Kehoe (1989), Mendoza and Tesar (2005) and Quadrini (2005) also study equilibrium government policies with capital mobility but in models without public debt or with public debt that is not chosen optimally.

The organization of the paper is as follows. In Section 2 we present the details of the general model and Sections 3 and 4 define the equilibrium with exogenous and endogenous government policies. Section 5 explores a simplified version of the model with only two periods, providing simple analytical intuition for the key results of the paper. Section 6 conducts a quantitative analysis with the infinite horizon model and repeated voting. This allows us to study the transition dynamics from the autarkic steady state to the steady state with capital mobility. Section 7 conducts a cross-country empirical analysis whose results support the theoretical findings and Section 8 concludes. All technical proofs are relegated to the Appendix.

2 Model

Consider an economy composed of two symmetric countries indexed by $j \in \{1, 2\}$. Markets are incomplete in the sense that agents face uninsurable idiosyncratic risks but some agents are more exposed to risk than others.

To model heterogeneous exposure to risk in a tractable manner, we assume that there are two types of agents: a measure 1 of workers and a measure 1 of entrepreneurs. Workers do not face any idiosyncratic uncer-

tainty while entrepreneurs are subject to investment risks. In modeling entrepreneurs we adopt the approach proposed by Angeletos (2007), which allows for linear aggregation. We can then conduct the general equilibrium analysis by focusing only on a representative worker and a representative entrepreneur, without paying attention to the evolution of wealth distribution among entrepreneurs. In this sense our setup is reminiscent of the model studied in Judd (1985). In our model, however, risk is central to the analysis and governments policies are in the form of public debt.

Although we focus on heterogeneity between workers and entrepreneurs and make the extreme assumption that workers do not face any risk, the model should be interpreted more generally as an environment in which some agents face more risk than others. Because of the different exposure to risk, preferences over government debt differ. Thus, the public debt chosen by the government will depend on the relative political power of these two groups, as we will see in the characterization of the politico-economic equilibrium.

Both types of agents maximize the expected lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \ln(c_t), \tag{1}$$

where c_t denotes consumption and $\beta \in (0,1)$ is the intertemporal discount factor. Workers are endowed with one unit of labor that they supply inelastically. In each country $j \in \{1,2\}$ there is one unit of land, an international immobile asset traded at price $p_{j,t}$.

Entrepreneurs are individual owners of private firms, each producing output with technology

$$f(z,k,l) = (zk)^{\theta} l^{1-\theta},$$

where k is the input of land, l the input of labor supplied by workers, and $\theta \in (0,1)$. The variable z is an idiosyncratic productivity shock that is observed after the input of land. It is independently and identically distributed among agents and over time, and takes values in the set $\{z_1, ..., z_n\}$ with probabilities $\{\mu_1, ..., \mu_n\}$. This is the only source of risk in the model.

Entrepreneur i in country j hires workers in a competitive labor market at wage $w_{j,t}$ and the profits are given by

$$\pi(z_{i,j,t}, k_{i,j,t}, l_{i,j,t}, w_{j,t}) = f(z_{i,j,t}, k_{i,j,t}, l_{i,j,t}) - w_{j,t} l_{i,j,t}.$$

The budget constraint of the entrepreneur is

$$c_{i,j,t} + p_{j,t} k_{i,j,t+1} + \frac{b_{i,j,t+1}}{R_{j,t}} = \pi(z_{i,j,t}, k_{i,j,t}, l_{i,j,t}, w_{j,t}) + p_{j,t} k_{i,j,t} + b_{i,j,t}, \tag{2}$$

where $b_{i,j,t}$ is the holding of riskless bonds with current unit price $1/R_{j,t}$.

Workers are endowed with one unit of time supplied inelastically in the domestic market for the wage $w_{j,t}$. Labor is internationally immobile. Workers also receive lump-sum transfers $T_{j,t}$ from the government. For simplicity we assume that workers do not hold assets or borrow. Therefore, workers' consumption is equal to

$$c^w_{j,t} = w_{j,t} + T_{j,t}. \tag{3}$$

The assumption that workers do not hold assets or borrow is without loss of generality. As we will see, the equilibrium interest rate is smaller than the intertemporal discount rate, that is, $R_{j,t} < 1/\beta$. Since workers do not face any risk, they will not hold bonds in the long-run. The inability to borrow can be rationalized by limited enforcement, leading to an upper bound in the amount of borrowing. Again, since $R_{j,t} < 1/\beta$ and workers do not face uncertainty, in the long run they will borrow up to the limit which for simplicity we set to zero.

The government raises revenues by issuing one-period bonds. The proceeds are redistributed as lump-sum transfers to workers and used to pay outstanding debt. The government budget constraint is

$$T_{j,t} + B_{j,t} = \frac{B_{j,t+1}}{R_{j,t}}, \tag{4}$$

where $B_{j,t}$ are the bonds issued at time $t-1$ and due in period t, and $B_{j,t+1}$ are the new bonds issued at t. The assumption that the government makes lump-sum transfers only to workers is made for analytical tractability. If transfers were paid also to entrepreneurs, we would not be able to derive the aggregation result stated below. We conjecture, however, that the qualitative results of the paper are not affected in important ways by this assumption.

3 Competitive equilibrium for given policies

We start characterizing the competitive equilibrium taking as given government policies. This is the necessary first step to characterize the policies that governments will choose optimally, as we will do in the next section. We consider two trading arrangements. In the first arrangement each country is under financial autarky, where riskless bonds cannot be traded in international markets. In the second arrangement countries are financially integrated, so governments can sell bonds to (or borrow from) domestic and foreign entrepreneurs.

The decision problem of workers is trivial because transfers are taken as given and the supply of labor is inelastic. Workers simply consume their income. The decision problem of entrepreneurs is more complex. Given the initial holdings of land and bonds, they choose labor input, consumption and asset holdings (land and bonds) that maximize their lifetime utility. These choices are functions of their individual states which we denote by $s_{i,j,t} = (k_{i,j,t}, b_{i,j,t}, z_{i,j,t})$. Following is the definition of a competitive equilibrium for given government policies.

Definition 3.1 (Autarkic Equilibrium) *Given a sequence of government debt $\{B_{j,t+1}\}_{t=0}^{\infty}$, a competitive equilibrium without mobility of capital (autarky) is defined as a sequence of prices $\{w_{j,t}, p_{j,t}, R_{j,t}\}_{t=0}^{\infty}$, entrepreneurs' decisions $\{c_{i,j,t}(s_{i,j,t}), l_{i,j,t}(s_{i,j,t}), k_{i,j,t+1}(s_{i,j,t}), b_{i,j,t+1}(s_{i,j,t})\}_{t=0}^{\infty}$, consumption of workers $\{c_{j,t}^{w}\}_{t=0}^{\infty}$, and transfers $\{T_{j,t}\}_{t=0}^{\infty}$ for $j \in \{1,2\}$ such that:*

i. Entrepreneurs' decisions maximize (1) subject to the budget constraint (2). Workers' consumption satisfies the budget constraint (3).

ii. Prices clear domestic markets for labor, $\int_i l_{i,j,t}(s_{i,j,t})di = 1$, for land, $\int_i k_{i,j,t+1}(s_{i,j,t})di = 1$, and for bonds, $\int_i b_{i,j,t+1}(s_{i,j,t})di = B_{j,t+1}$.

iii. Domestic bonds and transfers satisfy the government's budget (4).

The definition of a competitive equilibrium with integrated capital markets is similar. The only difference is that the bond market clears internationally instead of country by country, that is, $\sum_{j=1}^{2} \int_i b_{i,j,t+1}(s_{i,j,t})\mathrm{d}i = \sum_{j=1}^{2} B_{j,t+1}$ and interest rates are equalized across countries, that is, $R_{1,t} = R_{2,t} = R_t$.

3.1 Characterization of a competitive equilibrium

The hiring decision of entrepreneurs is static since it affects only current profits. Given the productivity shock $z_{i,j,t}$ and the ownership of land $k_{i,j,t}$, the optimal demand of labor is

$$l_{i,j,t}(z_{i,j,t}, k_{i,j,t}, w_{j,t}) = \left(\frac{1-\theta}{w_{j,t}}\right)^{\frac{1}{\theta}} z_{i,j,t} k_{i,j,t}. \tag{5}$$

Using the demand of labor, the entrepreneurial profits can be written as

$$\pi(z_{i,j,t}, k_{i,j,t}, w_{j,t}) = A(z_{i,j,t}, w_{j,t}) k_{i,j,t}, \tag{6}$$

where $A(z_{i,j,t}, w_{j,t}) = \theta \left(\frac{1-\theta}{w_{j,t}}\right)^{\frac{1-\theta}{\theta}} z_{i,j,t}$. Therefore, profits are linear in $k_{i,j,t}$.

We can now characterized the optimal entrepreneurial decisions for consumption and investment.

Lemma 3.1 *Given the equilibrium prices, entrepreneur's policies are*

$$\begin{aligned} c_{i,j,t} &= (1-\beta)a_{i,j,t}, \\ k_{i,j,t+1} &= \frac{\beta\phi_{j,t}}{p_{j,t}}a_{i,j,t}, \\ b_{i,j,t+1} &= R_{j,t}\beta(1-\phi_{j,t})a_{i,j,t}, \end{aligned}$$

where $\phi_{j,t}$ *satisfies* $\mathbb{E}_t\left[\frac{R_{j,t}}{\left(\frac{A(z_{i,j,t+1},w_{j,t+1})+p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t}+R_{j,t}(1-\phi_{j,t})}\right] = 1.$

Proof 3.1 *Appendix B.*

As in Angeletos (2007), the decision rules for consumption, land and bonds are linear in wealth $a_{i,j,t} = A(z_{i,j,t}, w_{j,t})k_{i,j,t} + p_{j,t}k_{i,j,t} + b_{i,j,t}$.

In the analysis that follows we shall distinguish the stock of public debt issued by country j from the aggregate bonds held by the residents (entrepreneurs) of that country. The debt issued by country j government is denoted by $B_{j,t}$ and the aggregate bonds held by country j residents are denoted by $\overline{B}_{j,t} = \int_i b_{i,j,t}$. In a closed economy $\overline{B}_{j,t} = B_{j,t}$. In an open economy, however, the two quantities may differ since government bonds can be acquired by both domestic and foreign investors.

Aggregating agents' decision rules using Lemma 3.1 and imposing market clearing, we can establish our first result, which is again reminiscent of Angeletos (2007).

Proposition 3.1 *Given the sequence of government debt* $\{B_{1,t+1}, B_{2,t+1}\}_{t=0}^{\infty}$, *equilibrium prices and aggregate allocations are independent of the distribu-*

tion of wealth among entrepreneurs (aggregation) and are equal to

$$w_{j,t} = (1-\theta)\bar{z}^{\theta}, \tag{7}$$

$$c^{w}_{j,t} = w_{j,t} + \frac{B_{j,t+1}}{R_{j,t}} - B_{j,t}, \tag{8}$$

$$\phi_{j,t} = \mathbb{E}\left[\frac{A(z_{i,j,t+1}) + p_{j,t+1}}{A(z_{i,j,t+1}) + p_{j,t+1} + \overline{B}_{j,t+1}}\right], \tag{9}$$

$$p_{j,t} = \frac{\beta\phi_{j,t}[A(\bar{z}) + \overline{B}_{j,t}]}{(1-\beta\phi_{j,t})}, \tag{10}$$

$$R_{j,t} = \frac{(1-\beta\phi_{j,t})\overline{B}_{j,t+1}}{\beta(1-\phi_{j,t})[A(\bar{z}) + \overline{B}_{j,t}]}, \tag{11}$$

$$\bar{c}_{j,t} = \frac{1-\beta}{\beta}\left(p_{j,t} + \frac{\overline{B}_{j,t+1}}{R_{j,t}}\right), \tag{12}$$

where $A(z_{i,j,t}) = \theta\frac{z_{i,j,t}}{\bar{z}^{1-\theta}}$, $\bar{z} = \int_i z_{i,j}$, $\bar{c}_{j,t} = \int_i c_{i,j,t}$.

Proof 3.1 *Appendix C.*

From the above expressions we can verify that, if the sequence of government policies were identical in both countries, that is, $B_{1,t} = B_{2,t}$ for all t and in both capital regimes, the autarkic equilibrium would coincide with the equilibrium with integrated capital markets. This is a consequence of the cross-country symmetry in technology and preferences. However, as we will see next, when policies are chosen endogenously by governments, the sequences of public debt differ in the two capital market regimes. As a result of different government policies, the equilibrium allocations will also differ.

4 Determination of government policies

We now turn to the derivation of the optimal government policies, which is the main goal and contribution of this paper. In particular, we study how governments choose the supply of bonds and how this choice is affected by the international capital market regime. We start analyzing the case without mobility of capital (financial autarky).

4.1 Politico-economic equilibrium with financial autarky

We focus on Markov-Perfect equilibria where government policies are functions of the stock of public debt. Since in an equilibrium with financial autarky government debt is always equal to the private ownership of bonds from entrepreneurs, that is, $\overline{B}_{j,t} = B_{j,t}$, the only aggregate state variable is $B_{j,t}$. To simplify notations we denote next period variables with a prime and drop the country index j.

Define $\mathcal{B}(B)$ the equilibrium policy rule governing the supply of bonds. Each government chooses the current period supply, B', under the assumption that future policies will be determined by the function $\mathcal{B}(B')$. In order to specify how the political process aggregates preferences for B' to form the government's objective, we have to derive agents' indirect utilities.

Before turning to the derivation of the indirect utilities, we observe that the price of land and the interest rate are equal to

$$p(B;B') = \frac{\phi(B')B'}{[1-\phi(B')]R(B;B')} \tag{13}$$

$$R(B;B') = \frac{[1-\beta\phi(B')]B'}{\beta[1-\phi(B')][A(\bar{z})+B]}, \tag{14}$$

where $\phi(B) = \mathbb{E}\left[\frac{A(z)+p(B;\mathcal{B}(B))}{A(z)+p(B;\mathcal{B}(B))+B}\right]$. These prices are functions of the current and next period stock of debt and they are obtained from equations (10) and (11) after imposing $\overline{B} = B$.

Now suppose that the government choice of debt in the current period is B' and, starting in the next period, the debt will be determined by the policy rule $B'' = \mathcal{B}(B')$. We then have the following proposition.

Proposition 4.1 *Given current policy B' and the policy rule $\mathcal{B}(B')$ determining future policies,*

i. The indirect utility of workers is

$$W(B;B') = \ln\left((1-\theta)\bar{z}^{1-\theta} + \frac{B'}{R(B;B')} - B\right) + \beta W(B';\mathcal{B}(B')). \tag{15}$$

ii. The indirect utility of an entrepreneur with productivity z is

$$\left(\frac{1}{1-\beta}\right)\ln(k) + V(B,z;B') \tag{16}$$

where $V(B, z; B')$ is defined recursively as

$$\begin{aligned} V(B, z; B') &= \ln(1-\beta) + \left(\frac{1}{1-\beta}\right) \ln\Big[A(z) + B + p(B; B')\Big] \\ &+ \left(\frac{\beta}{1-\beta}\right) \ln\left(\frac{\beta\phi(B')}{p(B; B')}\right) + \beta \mathbb{E}V\Big(B', z'; \mathcal{B}(B')\Big). \end{aligned}$$

Proof 4.1 *Appendix D.*

We can see from equation (16) that entrepreneurs are heterogeneous in lifetime utility. The heterogeneity is fully summarized by the current stock of land k and productivity z. The variable k enters the indirect utility additively, and therefore, it does not affect preferences over B'. The variable z, instead, does generate heterogeneous preferences over policies. However, since the distribution of z is exogenous and time invariant, the aggregation of preferences remains simple. Therefore, when the government aggregates entrepreneurs' preferences, the only *endogenous* variable that matters for the choice of the optimal policy today is the current stock of outstanding debt B.[1]

An important implication of this property is that, since the aggregate stock of debt B is a sufficient statistic to characterize the optimal policy in a Markov equilibrium, it makes sense to assume that future policies are only determined by future aggregate values of debt. This justifies the assumption made in the above proposition that future policies are determined by some function $\mathcal{B}(B')$.

We now describe briefly the political process. Government policies are implemented by representatives who are selected through democratic elections. Consider a political race between two opportunistic candidates that only care about gaining power and have commitment to some platforms. Under standard assumptions made in the probabilistic voting literature, political competition leads to convergence in policy proposals. As shown in Persson and Tabellini (2001), government policies maximize a weighted sum of agents' welfare. In our framework the government's objective function is a weighted sum of workers' and entrepreneurs' welfare. Given Φ the relative weight assigned to workers, the optimization problem solved by the government is

$$\max_{B'} \left\{ \Phi W(B; B') + (1-\Phi) \sum_{\ell=1}^{n} V(B, z_\ell; B') \mu_\ell \right\},$$

[1]This property would not hold if the government pays lump-sum transfers also to entrepreneurs.

where $W(B;B')$ and $V(B,z_i;B')$ are defined in Proposition 4.1.

Because elections are held every period and candidates are identical, it must be the case that $B' = \mathcal{B}(B)$ in the politico-economic equilibrium. The government behaves de-facto as a benevolent planner (with a particular set of weights) who does not have a commitment technology to future policies. Since there is no distortionary taxation, the level of debt does not affect aggregate production. Thus, changes in the relative weight Φ do not generate production losses but only redistributional consequences.[2]

4.2 Politico-economic equilibrium with financial integration

With capital mobility the relevant state space is augmented since the domestic supply and demand of government bonds are no necessarily equalized, that is, $\overline{B}_j$ may be different from B_j. Given the initial states and the prices, workers' consumption is only affected by the domestic supply of bonds B'_j while entrepreneurs' consumption depends on their holding of bonds $\overline{B}'_j$ (recall eqs. (8) and (12)). In addition, the interest rate is now determined by the worldwide market clearing condition $\sum_{j=1}^{2} \overline{B}'_j = \sum_{j=1}^{2} B'_j$, implying that agents in one country need to form expectations about the foreign demand and supply of bonds. This creates a strategic interaction between the government policies of the two countries.

We restrict attention to Nash equilibria where public borrowing decisions are made simultaneously and independently (i.e. there is no coordination among countries). The government of country j only cares about the welfare of its own citizens and, in choosing the optimal B'_j, it takes the policy of the other country, B'_{-j}, as given. Formally the government in country 1 solves

$$\max_{B'_1} \left\{ \Phi W(\overline{B}_1, B_1, B_2; B'_1, B'_2) + (1-\Phi) \sum_{\ell=1}^{n} V(z_\ell, \overline{B}_1, B_1, B_2; B'_1, B'_2)\mu_\ell \right\},$$

where the indirect utilities are derived in a similar fashion as in the autarky regime. The sufficient set of state variables are $\overline{B}_1$, B_1, B_2. Once we know these three variables, we can derive $\overline{B}_2$ from the worldwide market clearing condition, *i.e.*, $B_1 + B_2 = \overline{B}_1 + \overline{B}_2$.

[2] If the government was financing transfers with distortionary taxes and the supply of labor was endogenous, taxes would affect the demand and supply of labor and hence the level of production. In an earlier version of the model we allowed for endogenous supply of labor and distortionary taxes. Since the effect of taxes on debt resulting from changing the weights were not quantitatively important, we decided to abstract from distortionary taxes (and endogenous labor supply) to keep the model simpler.

Because of the symmetry, if we start with $\overline{B}_1 = \overline{B}_2 = B_1 = B_2 = B$ and the governments of the two countries use the same weights, $\Phi_1 = \Phi_2$, we will have that $\overline{B}'_1 = \overline{B}'_2 = \frac{B'_1+B'_2}{2} \equiv B'$, provided that the equilibrium is unique. The worldwide interest rate can then be derived from eq. (11) as

$$R(B; B') = \frac{(1 - \beta\phi(B'))B'}{\beta(1-\phi)[A(\bar{z}) + B]}. \tag{17}$$

At this point we can compare this equation with the corresponding equation for the interest rate in the autarky regime, which reads

$$R(B_j; B'_j) = \frac{(1 - \beta\phi(B'_j))B'_j}{\beta(1-\phi)[A(\bar{z}) + B_j]}. \tag{18}$$

The difference is that in autarky the interest rate is only determined by domestic debt, that is, B_j and B'_j. With mobility, instead, the interest rate is a function of worldwide debt, that is, $B = \frac{B_1+B_2}{2}$ and $B' = \frac{B'_1+B'_2}{2}$. Therefore, when government j considers a change in B'_j, the induced change in $B' = \frac{B'_1+B'_2}{2}$ is smaller than in the autarky regime. This is because in the Nash game the debt issued by the other government is taken as given. Thus, the change in the interest rate is smaller. What this means is that the worldwide interest rate is perceived by each government as being less elastic to its own supply of bonds. This increases the (individual) incentive to issue more debt because the marginal increase in the repayment costs R is lower when B'_2 is taken as given.

To the best of our knowledge, this channel has not been emphasized in the literature. Most of the studies focus either on closed economy models or on open economies but with private debt. However, private issuers do not internalize the impact of their choices on the equilibrium interest rate since each agent is too small to affect aggregate prices. This property arises independently of the financial regime in which private issuers operate. Therefore, with only private issuers, the autarkic equilibrium would not be different from the equilibrium with capital mobility. In our framework, on the contrary, when governments issue debt, they fully internalize the effect of higher borrowing on the interest rate. Since the effect on the interest rate depends on the international capital market regime, the equilibrium debt differs in the economy with and without mobility of capital. The model thus predicts that capital market liberalization affects the equilibrium outcome even if countries are homogeneous.

This property differentiates our study from the recent literature on global imbalances where liberalization affects the equilibrium because countries are

heterogeneous in some important dimension. See Fogli and Perri (2006), Caballero, Farhi and Gourinchas (2008), Mendoza, Quadrini and Rios-Rull (2009), Angeletos and Panousi (2011).

Because of the complexity of the model, we are unable to derive a closed-form solution and characterize the equilibrium analytically. Therefore, we will provide a numerical characterization. Before proceeding to the quantitative exercise, however, it will be helpful to focus on a simplified version of the model with only two periods where we can derive analytical intuitions.

5 Two-period model

Suppose that the economy lasts for only two periods. In the first period entrepreneurs start with the same stock of land, $k_{i,j,1} = 1$, and they do not face idiosyncratic shocks, that is, $z_{i,j,1} = \bar{z}$. We further assume that they do not hold bonds initially, that is, $b_{i,j,1} = 0$. The entrepreneurs' wealth, including current production is $a = A(\bar{z}) + p$, where $A(\bar{z}) = \theta \bar{z}^{\theta}$. They allocate their wealth between current consumption and next period savings in the form of bonds, b_2, and land, k_2. The second period output, however, is stochastic. It depends on the idiosyncratic shock z_2. Thus, entrepreneurial wealth in the second period is $A(z_2) + b_2$, where $A(z_2) = \theta \left(\frac{z_2}{\bar{z}^{1-\theta}}\right)$. Since this is the last period, land has no value after production.

5.1 Politico-economic equilibrium with autarky

To simplify notation ignore time subscripts and denote by k and b the individual land and bonds purchased at time 1. Also, we denote by R and B the gross interest rate and the bonds issued by the government in period 1, and z the idiosyncratic shock realized in period 2.

Period 1 consumption equals $c_1 = a - b/R - pk$. Since all entrepreneurs start with the same wealth a, they choose the same land and bond. Thus, $k = 1$ and $b = B$. Taking into account that $a = A(\bar{z}) + p$ (since all entrepreneurs start with one unit of land and zero bonds) consumption in period 1 is $c_1 = A(\bar{z}) - B/R$. Next period consumption depends on the realization of the idiosyncratic shock and can be written as $c_2 = A(z) + B$. Therefore, entrepreneurs' lifetime utility is

$$V(B) = \ln\left(A(\bar{z}) - \frac{B}{R}\right) + \beta \mathbb{E} \ln\Big(A(z) + B\Big). \tag{19}$$

Workers receive constant wages $w = (1-\theta)\bar{z}^{\theta}$ in both periods. In addition they receive transfers from the government. The transfer received in

period 1 is equal to government borrowing B/R, and the transfer received in period 2 is equal to the repayment of the debt, $-B$. Therefore, workers' consumption is $c_1^w = w + B/R$ in the current period and $c_2^w = w - B$ in the next period. The lifetime utility is

$$W(B) = \ln\left(w + \frac{B}{R}\right) + \beta \ln\left(w - B\right). \tag{20}$$

Apart from the effects that the issuance of debt has in the determination of prices R and p, equations (19) and (20) make clear that public debt redistributes consumption inter-temporally between workers and entrepreneurs. The following lemma establishes some properties of the lifetime utilities.

Lemma 5.1 *In the autarky equilibrium*

i. The indirect utility of workers (20) is strictly concave in B with a unique maximum in the interval $[0, (1-\theta)\bar{z}^{\theta}]$.

ii. The indirect utility of entrepreneurs (19) is strictly increasing in B.

Proof 5.1 *Appendix E.*

Workers would like to borrow initially since the interest rate is lower than the intertemporal discount rate. In fact, as B converges to zero, we can prove that the interest rate converges to $R < 1/\beta$. However, as the government borrows more, it reaches a point in which worker's welfare starts to decrease. This happens for two reasons. First, keeping the interest rate fixed, the marginal utility of consumption in the next period becomes smaller than the marginal utility of consumption in the current period. Second, as the government borrows more, the interest rate increases, raising the cost of borrowing. Entrepreneurs, on the other hand, always prefer higher debt because it increases the interest rate, and therefore, the return on their financial wealth (entrepreneurs are net holders of public debt).

Given the properties of the indirect utilities characterized in Lemma 5.1, entrepreneurs and workers disagree on the optimal level of debt above a certain threshold. This is the point above which workers' utility becomes downward sloping.

Based on probabilistic voting, the optimal level of debt is chosen to maximize the weighted sum of workers and entrepreneurs' utilities, that is,

$$\max_{B} \Big\{ \Phi W(B) + (1-\Phi) V(B) \Big\}, \tag{21}$$

where the functions $W(B)$ and $V(B)$ are defined in (19) and (20).

Although we cannot establish the global concavity of the objective function, we know that there is an optimal level of debt which is interior to the interval $[0, (1-\theta)\bar{z}^{\theta}]$. This must be the case because the objective function is continuous and converges to minus infinity as B converges to $(1-\theta)\bar{z}^{\theta}$. Since the objective function is differentiable, its derivative must be zero at the optimal B. Differentiating (21) we obtain the first order condition

$$\Phi\left[\frac{\partial B/R}{\partial B}\left(\frac{1}{c_1^w}\right)-\beta\left(\frac{1}{c_2^w}\right)\right]+(1-\Phi)\left[-\frac{\partial B/R}{\partial B}\left(\frac{1}{c_1}\right)+\beta\mathbb{E}\left(\frac{1}{c_2(z)}\right)\right]=0. \tag{22}$$

A marginal unit of debt issued by the government in period one transfers consumption from entrepreneurs (who save by buying bonds) to workers (who receive transfers financed by government borrowing). This affects the marginal utility of each agent in the first period, weighted by the relative political weights. In the second period the government pays back the debt by taxing workers (negative transfers). This reduces worker's consumption c_2^w and increases the consumption of entrepreneurs, c_2. The effects in terms of marginal utilities are weighted by the political weights.

Because the government is a monopolist in the supply of bonds, it takes into account that its debt affects the interest rate. Each dollar issued generates a transfer to worker equal to

$$\frac{\partial B/R}{\partial B}=\frac{1}{R}\Big(1-\epsilon(B)\Big),$$

where $\epsilon(B)=\frac{B}{R}\frac{\partial R}{\partial B}$ is the elasticity of the interest rate R to the supply of bonds. Clearly, higher values of the elasticity imply smaller transfers to the worker. With private borrowing made by atomistic agents, instead, $\epsilon(B)$ would be zero since atomistic agents take the interest rate as given. In this case the perceived benefit of (private) borrowing would be $1/R$.

Figure 2 plots the welfare of workers and entrepreneurs in country 1. The continuous lines, denoted by V^A and W^A, are for the autarky regime. The dashed lines, to which we will come back in the next section, are for the regime with capital mobility. The actual level of debt chosen by the government depends on the relative weight Φ. Although the indirect utility of workers $W(B)$ is strictly concave, the indirect utility of entrepreneurs $V(B)$ is not concave. As a result, the government's objective is not necessarily concave. Only for small values of Φ we can establish concavity.

Proposition 5.1 *If $\Phi > 1-\frac{\theta}{1+\beta}$, the government's objective is strictly concave and there is a unique maximum interior to the interval $[0,(1-\theta)\bar{z}^{\theta}]$.*

Proof 5.1 *Appendix F.*

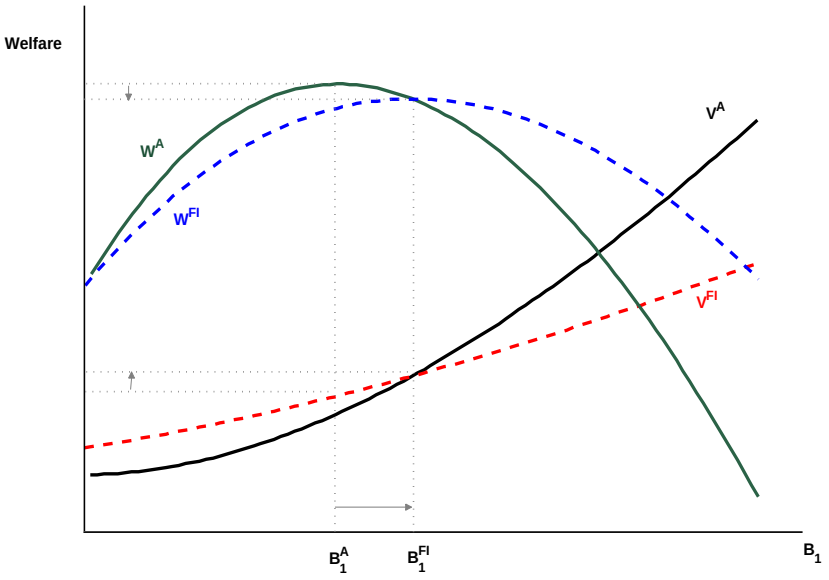

Figure 2: Indirect utilities of workers and entrepreneurs with and without capital mobility. The parameter values are $\beta = 0.95$, $z_\ell = \{1, 3\}$, $\mu_\ell = 0.5$, and $\theta = 0.36$.

Two remarks are in order here. First, the condition $\Phi > 1 - \frac{\theta}{1+\beta}$ is sufficient and not necessary for establishing the concavity of the government's objective. The second remark is that, even if the government objective is not strictly concave, the maximum is still interior to the interval $[0, (1-\theta)\bar{z}^\theta]$ since the objective function is continuous and converges to minus infinity as B converges to $(1-\theta)\bar{z}^\theta$. However, we can not establish uniqueness and the first order condition is only necessary, not sufficient.

For the simple model considered here, we can always check concavity numerically as we do in Figure 3. This figure plots the government objective for different values of Φ and shows that the optimal level of B decreases with the weight assigned to workers.

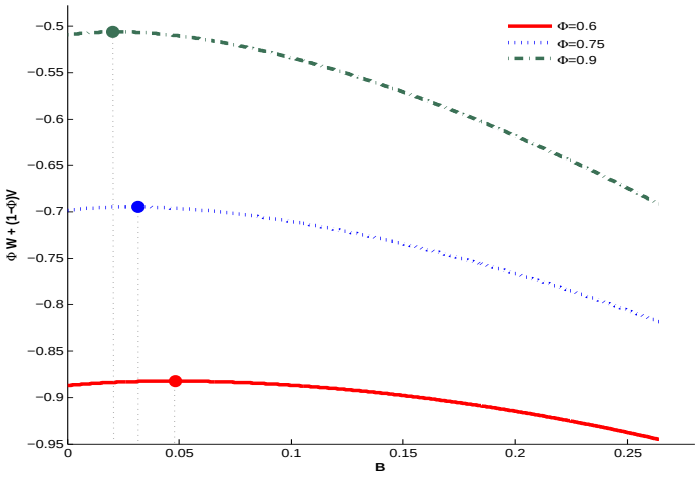

Figure 3: Government's objective function in autarky. The parameter values are $\beta = 0.95$, $z_\ell = \{1, 3\}$, $\mu_\ell = 0.5$, and $\theta = 0.36$.

5.2 Politico-economic equilibrium with capital mobility

We now consider the case in which the financial markets of the two countries are integrated. We focus on Nash equilibria where governments choose the supply of bonds independently and simultaneously. When the economy is open, entrepreneurs in country 1 can purchase domestic and foreign bonds. Therefore, the demand of bonds from domestic entrepreneurs could be different from the supply of the domestic government.

The central finding is that governments issue more debt when the economy is financially integrated. The main mechanism leading to this result is the fact that the elasticity of the interest rate to one country debt is smaller compared to the interest elasticity in financial autarky. When the government of country 1 chooses the optimal debt B_1 taking as given the debt of country 2, it faces the world demand and the equilibrium condition is $\overline{B}_1 + \overline{B}_2 = B_1 + B_2$. Moreover, since countries are symmetric, $\overline{B}_1 = \frac{B_1+B_2}{2}$. Therefore, we can write the indirect utility of domestic entrepreneurs in financially integrated economies as

$$V(B_1, B_2) = \ln\left(A(\bar{z}) - \frac{B_1 + B_2}{2R}\right) + \beta \mathbb{E} \ln\left(A(z) + \frac{B_1 + B_2}{2}\right). \tag{23}$$

The properties of $V(B_1, B_2)$ are very similar to the properties of the value function in autarky. Entrepreneurs still prefer higher levels of debt

since higher debt increases the equilibrium interest rate, and therefore, the return on the risk-free bonds held to insure the idiosyncratic risk. Now, however, the elasticity of the interest rate to the issuance of domestic debt is lower.

The indirect utility of workers in country 1 can be written as

$$W(B_1, B_2) = \ln\left(w + \frac{B_1}{R}\right) + \beta \ln\left(w - B_1\right), \tag{24}$$

which is very similar to (20). The only difference is that the interest rate R is now determined in the world market and is equal to

$$R = \Big(\frac{B_1 + B_2}{2}\Big)\frac{[1 + \beta(1-\phi)]}{\beta(1-\phi)A(\bar{z})}, \tag{25}$$

where $\phi = \mathbb{E}\left(\frac{A(z)}{A(z)+(B_1+B_2)/2}\right)$.

The optimal level of debt B_1^* satisfies the first order condition

$$\Phi\left[\frac{\partial B_1/R}{\partial B_1}\left(\frac{1}{c_1^w}\right) - \beta\left(\frac{1}{c_2^w}\right)\right] + \tag{26}$$
$$(1-\Phi)\left[-\frac{\partial \frac{B_1+B_2}{2R}}{\partial B_1}\left(\frac{1}{c_1}\right) + \beta\frac{\partial \frac{B_1+B_2}{2}}{\partial B_1}\mathbb{E}\left(\frac{1}{c_2(z)}\right)\right] = 0,$$

which is necessary but not sufficient as in the autarky regime.

While the government is still trading-off the benefits and costs of transferring consumption from entrepreneurs to workers in the first period, this expression differs from eq. (22) in several dimensions. First, workers' transfers depend only on the domestic supply of government bonds B_1, while entrepreneurs' utility depends on both domestic and foreign bonds. Hence, an extra unit of B_1 increases c_1^w by $\frac{\partial B_1/R}{\partial B_1}$, but decreases c_1 by only $\frac{\partial \frac{B_1+B_2}{2R}}{\partial B_1} = \frac{1}{2}\frac{\partial B_1/R}{\partial B_1}$. The reason is that part of the extra bonds are absorbed by entrepreneurs in country 2, who do not enter the objective function of country 1's government. In the second period, the government repays B_1 by taxing workers (with negative transfers), which reduces c_2^w in the same amount as before. The increase in c_2, however, is smaller than in the autarky case because the stock of domestic bonds held by domestic entrepreneurs is smaller.

There is another, less evident difference between eqs. (22) and (26): the effect of a unilateral change in B_1 on the world-wide interest rate is now

smaller. It is possible to show that in a symmetric equilibrium $\frac{\partial R}{\partial B_1} = \frac{1}{2}\frac{\partial R}{\partial B}$. Imposing $B_1 = B_2$ in equation (26) and re-arranging we can show that

$$\Phi\left[\frac{1}{c_1^w}\frac{1}{R}\left(1-\frac{\epsilon(B)}{2}\right)-\frac{\beta}{c_2^w}\right]+(1-\Phi)\frac{1}{2}\left[-\frac{1}{c_1}\frac{1}{R}\Big(1-\epsilon(B)\Big)+\mathbb{E}\frac{\beta}{c_2(z)}\right]=0,$$

where $\epsilon(B)$ is the elasticity of the interest rate under autarky.

Relative to the autarkic case, the cost of the transfer for the workers is now smaller since the perceived elasticity of the interest rate is $\epsilon(B)/2$. The costs and benefits for entrepreneurs are also different, since they are split between domestic and foreign residents. As a result, the marginal effects on $V(B)$ are halved when the economy is financially integrated.

Proposition 5.2 establishes the effects of capital market liberalization formally under some special conditions.

Proposition 5.2 *Suppose that $\Phi \simeq 1$. Relative to the autarky equilibrium, a financially integrated economy exhibits larger government debt. This reduces the welfare of workers and increases the welfare of entrepreneurs.*

Proof 5.2 *To be added.*

When the weight assigned to entrepreneurs is small, the government objective is approximately equal to the utility of workers. Workers would like the government to borrow more since the interest rate is less sensitive to B_1 (domestic debt). This implies that the repayment cost of the debt increases less compared to the autarky regime.

The dashed lines in Figure 2 are the welfare of workers and entrepreneurs (W^{FI} and V^{FI}) when the two countries are financially integrated, as functions of the domestic bond supply B_1, while keeping B_2 fixed at the autarky level. We can see that the optimal level of debt for workers (the maximum of the utility function) shifts to the right. Entrepreneurs' utility remains increasing in B_1 but becomes flatter. However, as long as workers have a sufficiently high weight, the government objective is dominated by workers and capital liberalization leads to higher public debt.

6 Quantitative analysis

In this section we solve the infinite horizon model numerically. The goal of the exercise is to provide a quantitative assessment of the importance of capital market liberalization for the accumulation of public debt. Starting

from a steady state equilibrium without mobility of capital, we assume that countries become financially integrated. Under the assumption that capital liberalization is not anticipated, we compute the transition dynamics to the new steady state. The numerical procedure used to solve the model is based on the discretization of the state space (the stock of public debt in the two countries).

6.1 Calibration

A period in the model is one year and the discount factor is set to $\beta = 0.95$. The parameter θ in the production function is set to 0.2 implying a capital income share of 20 percent. This is lower than the typical number used in the literature because in our model there is no depreciation. Therefore, θ represents the share of 'net' capital income in 'net' output.

Productivity is specified as $z_t = \bar{z} + \upsilon_t$ where υ_t is uniformly distributed in the domain $[-5.5, 5.5]$ and $\bar{z}$ is the mean value normalized to 1. This parametrization implies a significant amount of idiosyncratic risk. In particular, the maximum loss associated with the minimum value of z_t is about 30 percent the market value of land used in production. However, if we interpret the risk as coming from both capital gains/losses, in addition to revenues, then the parameterized risk is not implausible.

The only remaining parameter to be calibrated is the political weight Φ assigned to workers. Starting from $\Phi = 1$, the steady state debt is inversely related to the workers' weight. We can then choose Φ to achieve the desired target for the stock of public debt. We choose the early 1980s as the initial calibration target since a common view is that the process of international liberalization started in the 1980s. The pre-1980s period can then be considered as closer to a regime of financial autarky. According to Figure 1, the stock of public debt in the OECD countries at the beginning of the 1980s was about 30 percent of GDP. Therefore, we choose Φ so that the steady state level of public debt in the autarky regime is 30 percent of output. This is obtained by setting the workers' weight to $\Phi = 0.855$.[3]

[3]This value of Φ is smaller than the range of values under which the government objective in the two-period model is concave, that is, $\Phi > 1 - \frac{\theta}{1+\beta}$ (see Proposition 5.1). However, this condition was specific to the two-period model and it is only sufficient, not necessary. We checked the concavity numerically and verified that this is satisfied for the calibrated value of Φ.

6.2 Results

Figure 4 plots the response function of country 1, B_1', to the debt chosen by country 2, B_2'. Because we are considering symmetric countries, the optimal response of country 2 is equivalent to the response of country 1 but with inverted axes. Three response functions are plotted. The first (short dashed line) is the response of country 1 in the autarky regime when the current stocks of debt of both countries, B_1 and B_2, are at the steady state. This function is perfectly horizontal, meaning that the optimal choice of debt for country 1 does not depend on the debt chosen by country 2. Obviously, if we are in a regime without capital mobility, the government does not care what happens in other countries. Since the current debt is assumed to be at the autarky steady state, the intersection of the response function with the 45 degree line is the steady state debt. This is close to 30 percent of output, consistent with the calibration target.

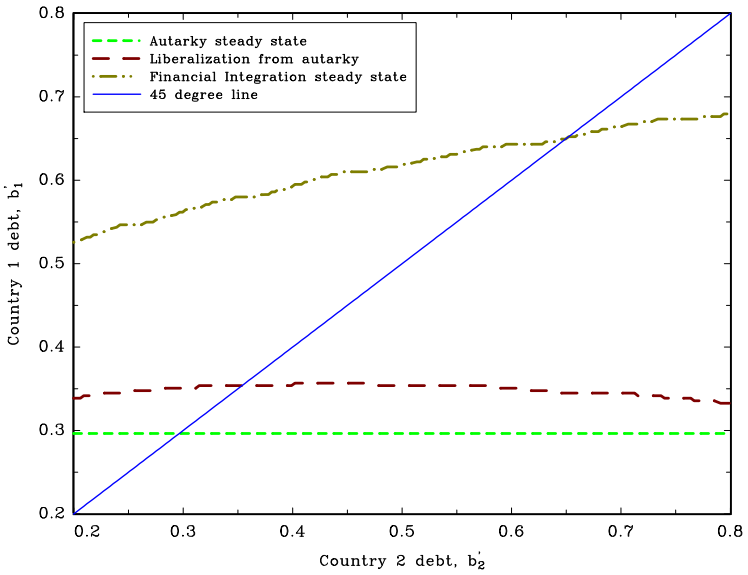

Figure 4: Country 1 optimal response functions to country 2 debt.

The next response function (long dashed line) is constructed as follows. Suppose that we start from the autarky steady state. Therefore, B_1 and B_2 are at the steady state level with autarky. Starting from this state, the two countries become financially integrated. The liberalization is a complete surprise: it is not anticipated neither by governments nor by private agents. Of course, this is an unrealistic assumption made only for expositional pur-

poses. We then compute the optimal response function of country 1 in the first period in which the liberalization arises. This is the long dashed line plotted in Figure 4.

Compared to the response function in the closed economy (short dashed line), we see that country 1 chooses a higher B_1' for any level of debt B_2' chosen by country 2. Already in the first period after the liberalization, the stock of debt increases to about 35 percent of output. This is the point in which the response function crosses the 45 degree line since countries are symmetric, and therefore, the response function of country 2 (not plotted) intersects the response function of country 1 also at this point.

We can now conjecture what happens in subsequent periods after the liberalization. In the second period, both countries start with a higher initial debt. Thus, the response functions of the two countries will move up and this will generate a further increase in public debt. Eventually, the stocks of debt converge to a new steady state level. The third response function (dotted-shaded line) has been constructed at this new steady state, that is, under the assumption that the current states, B_1 and B_2, are at the steady state level in the regime with capital mobility. Thus the intersection of this response function with the 45 degree line is by definition the steady state debt with capital mobility (given the symmetry).

The full transitional dynamics following capital markets liberalization is plotted by the dashed line in the first panel of Figure 5. Starting from the steady state with financial autarky where the stock of public debt is about 30 percent of output, government liabilities increase gradually and converge to a new long-term level which is about 65 percent of output.

The response of the interest rate is plotted by the dashed line in the second panel of Figure 5. The interest rate jumps immediately in response to the liberalization. This is necessary to make government bonds attractive to entrepreneurs who are the ones who need to absorb the additional bonds. In fact, the increase in the holding of bonds requires entrepreneurs to reduce current consumption in compensation for higher future consumption, which in turns requires higher interest rates. Since the government continues to increase the debt after the first period, the interest rate remains high. However, since the increase in government debt slows down over time, the interest rate declines gradually after the initial jump. In the long-run, R is higher than in the autarky steady state but the difference is small.

To compare the simulation of the model with the actual data, Figure 5 also plots the empirical series of public debt and interest rates for the group of OECD countries, Europe and the United States. The data sources and the construction of the plotted variables are described in Appendix A. As

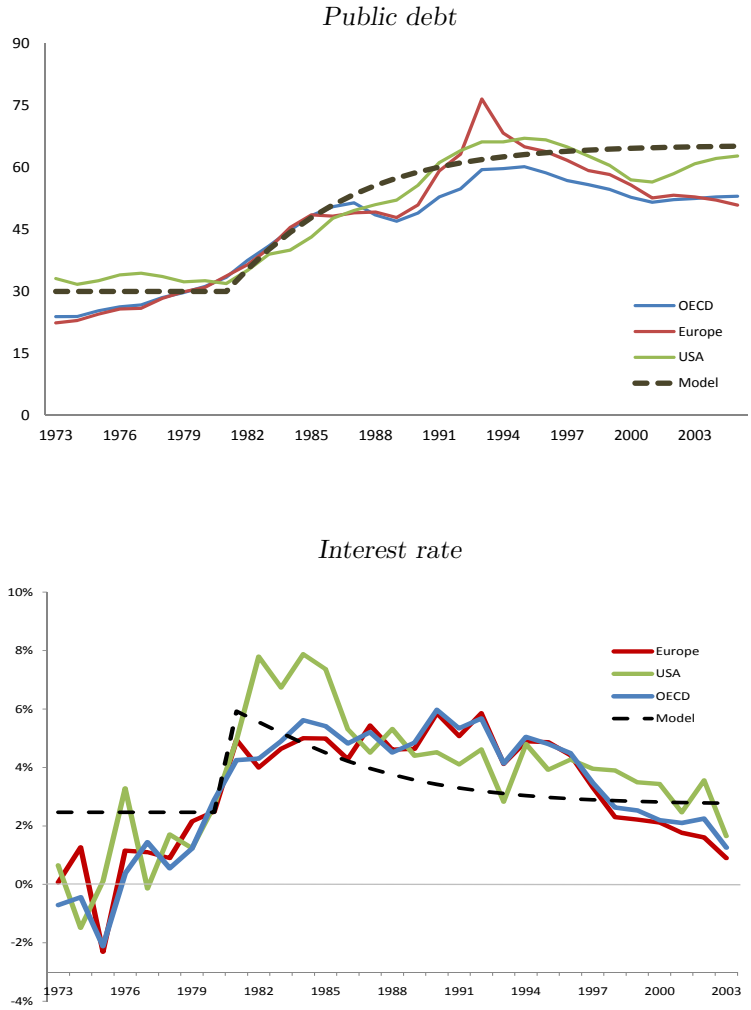

Figure 5: Dynamics of public debt and real interest rates: Model and Data.

can be seen, the general path of public debt generated by the model (dashed line) is remarkably close to the dynamics observed in the data (continuous lines). The general dynamics of the interest rates is also similar, particularly for Europe and OECD countries where we see a hike in the real rates in the first half of 1980s, which then decline later in the sample period. The model does not capture the low real rates in the 1970s. These low rates are likely to be associated with unexpected inflation induced by raising oil prices during the 1970s which the model abstracts from.

6.3 Welfare implications

Government borrowing has only redistributional implications in this model. Since the labor supply is fixed and there is not capital accumulation, public debt does not have any implications for production efficiency. However, through the redistribution, government policies have welfare consequences for the two types of agents. In this section we study the redistributional consequences.

The top panel of Figure 6 plots the dynamics of consumption for workers and entrepreneurs in response to capital market liberalization. As the government increases borrowing after liberalization, the consumption of workers increases while the consumption of entrepreneurs decreases. In the long run, workers' consumption stabilizes at a lower level than the consumption in the autarky steady state. This is because the higher debt implies higher payment of interests, and therefore, lower transfers to workers (which become negative in the long run). For entrepreneurs we have the opposite dynamics since aggregate production and consumption are constant.

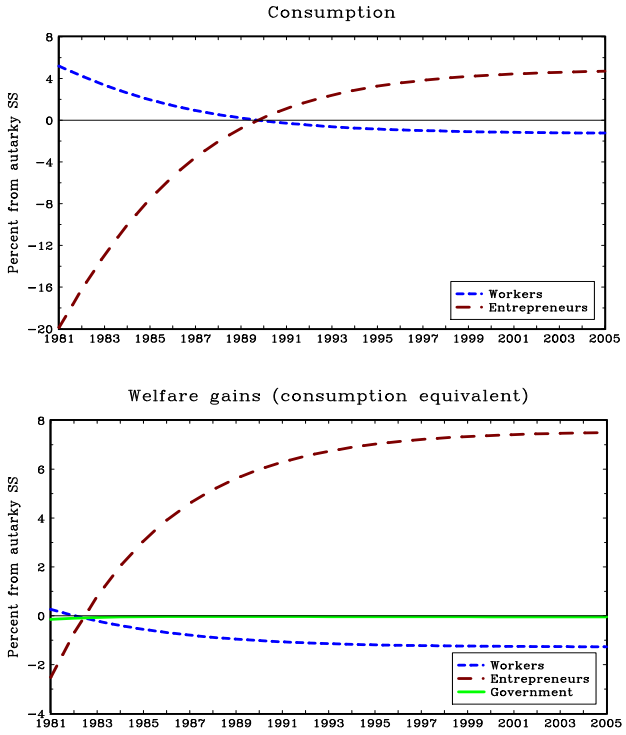

Figure 6: Dynamics of consumption and welfare.

The bottom panel of Figure 6 plots the welfare gains from liberalization, computed using the standard 'consumption equivalent' measure. This is the percentage increase in steady state consumption that would leave the agent indifferent between staying in a regime without capital mobility or liberalizing capital markets. To evaluate the welfare consequences of liberalization we only need to consider the first point of the plotted lines. The other points simply show the continuation welfare at any point in time in the future.

As can be seen from the figure, workers gain while entrepreneurs incur welfare losses. The reason is that, with the exception of the first few periods, the interest rate is lower than the intertemporal discount rate. Therefore, the anticipation of consumption through government borrowing is optimal for workers. For entrepreneurs, however, this implies a temporary reduction in consumption. Even if the issuance of government bonds allows them to have better consumption insurance, this is not enough to compensate the temporary reduction in consumption.

Next we look at government's welfare gains, which are also computed applying the 'consumption equivalent' measure to the government's objective. The government's objective is the weighted sum of workers and entrepreneur's welfare with weight $\Phi = 0.855$. As can be seen from the figure, government's welfare declines in response to liberalization. This is a consequence of the non-cooperative game played between the two countries which leads to an inferior outcome from the point of view of government's welfare.

Although the welfare loss from capital market liberalization is very small, this finding raises the question of why countries liberalize their capital markets if this has negative welfare consequences (again, from the point of view governments). Two remarks are in order. First, the model abstracts from many possible benefits we can think of associated with capital market liberalization.[4] Once these benefits are properly accounted for, they might compensate for the small welfare losses shown in Figure 6. Second, what induces a welfare loss is not liberalization per se but the fact that governments do not coordinate their policies in an environment with capital mobility. This may justify the introduction of statutory debt limits before the liberalization as in the case of the Maastricht treaty for European countries, assuming that these limits are de-facto enforceable.

[4]In addition to the efficiency gains from higher competition, Kehoe (1989) shows that capital mobility may be a deterrent to excessive capital taxes when governments cannot commit to future policies and they face a well-known time-inconsistency problem associated with capital taxation. Quadrini (2005) shows that through this mechanism, capital mobility could generate sizable welfare gains in absence of coordination.

7 Empirical analysis

The theoretical analysis conducted in the previous section has shown that higher mobility of capital leads to higher government borrowing. In this section we conduct a simple empirical investigation of this prediction using cross-country data for the OECD countries. The main objective is to check whether there are statistically significant links between indices of capital market liberalization and government borrowing. To do so we estimate the following regression equation

$$\mathrm{dDEBT}_{j,t} = \alpha_D \mathrm{DEBT}_{j,t-1} + \alpha_G \mathrm{dGDP}_{j,t} + \alpha_Y \mathrm{YEAR}_t + \alpha_M \mathrm{dMOB}_{t-1} + u_{j,t}, \tag{27}$$

where the variables have the following content:

- $\mathrm{DEBT}_{j,t}$: Ratio of public debt over GDP of country j in year t.
- $\mathrm{dDEBT}_{j,t}$: Change in debt-to-output ratio in country j in year t.
- $\mathrm{dGDP}_{j,t}$: log-change in GDP in country j in year t.
- YEAR_t: Calendar year common to all countries.
- dMOB_{t-1}: Change in the index of capital liberalization in year $t-1$.
- $u_{j,t}$: residual variable containing country fixed effect.

Few remarks are in order. First, we relate the *change* in public debt to the *change* in the liberalization index, instead of the level of the financial index, since this better captures the dynamics predicted by the model. In fact, in the long run, there is no relation between the degree of capital mobility (level of the index) and the change in debt ratio since the stock of debt converges to the steady state.

The second remark is that we consider the lagged value of the index, possibly capturing some delays between the date of liberalization and the actual change in debt induced by the liberalization. However, we will also show the results when the interaction is contemporaneous.

The third remark pertains to the construction of the index of financial liberalization. This index is not country-specific as can be noticed from the absence of the country subscript j. Instead, we constructed the index as the average of country-specific indices for all countries included in the sample, weighted by their size (measured by total GDP).

The reason we adopt this particular measure of capital liberalization can be explained as follows. The typical indicator of financial liberalization

refers to the private sector, not the public sector. Thus, the fact that one country has very strict international capital controls does not mean that the government is restrained from borrowing abroad. So what is relevant for the government ability to borrow abroad is the openness of other countries. Therefore, to determine the easiness with which the government can sell the bonds to foreign (private) investors, we have to look at the capital controls imposed by other countries. An easy way of doing this is by computing an average indicator for the whole countries included in the sample.[5]

A related issue is whether in computing the weighted average of the liberalization index we should exclude the country of reference. For example, to evaluate the importance of capital mobility for the US public debt, we should perhaps average the indices of the OECD countries but with the exclusion of the US. Similarly, for the other countries. We have chosen not to do so for the following reason. Although the liberalization of other countries is what defines the foreign market for government bonds, the domestic liberalization can still affect domestic issuance through an indirect channel. As can be seen from the impulse responses plotted in Figure 4, domestic issuance depends on foreign issuance, which in turn depends also on domestic liberalization.

Regarding the data for the liberalization variable, we use two measures: The first is based on the liberalization index constructed by Abiad, Detragiache and Tressel (2008). The second is based on the index of capital account openness constructed by Chinn and Ito (2008). Both indices are based on de-jure measures.

Table 1 reports the estimation results. The data sources are described at the bottom of the table. In all four specifications we find that the change in financial index is positively correlated with the change in public debt and is highly significant. Although we do not claim that this proves causation, there is a strong conditional correlation between these two variables, which is consistent with our theory.

As far as the other variables are concerned, we find that the lagged stock of debt is negatively correlated with the change. This is what we expect if the debt tends to converge to a long term level. The change in GDP is meant to capture business cycle effects and it has the expected negative sign: when the economy does well, government revenues increase and automatic

[5]Another way of showing the irrelevance of the country own indicator is with the following example. Suppose that country A liberalizes its capital markets, allowing free international mobility of capital. However, all other countries maintain strict controls. Obviously, the government of country A does not have access to the foreign market even if it had liberalized its own market.

Table 1: Country fixed-effect regression. Dependent variable is the change in Public Debt over GDP.

	(1) *Financial Index 1 (Lagged)*	(2) *Financial Index 2 (Lagged)*	(3) *Financial Index 1 (No lagged)*	(4) *Financial Index 2 (No lagged)*
Lagged debt ratio	-0.0388^{***}	-0.0383^{***}	-0.0349^{***}	-0.0348^{***}
	(0.0109)	(0.0110)	(0.0108)	(0.0108)
Growth in GDP	-0.0054^{***}	-0.0053^{***}	-0.0049^{***}	-0.0049^{***}
	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Calendar year	−0.0003	−0.0004	−0.0002	−0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
Change in financial index	0.3643^{***}	0.0698^{***}	0.2533^{**}	0.0838^{***}
	(0.1067)	(0.0257)	(0.4872)	(0.0262)
Number of years	31	31	32	32
Number of countries	26	26	26	26
Number of observations	765	765	787	787
R-square	0.0975	0.0811	0.0705	0.0765

Notes: *Financial Index 1* is constructed using the liberalization index of Abiad, Detragiache and Tressel (2008). *Financial Index 2* is constructed using the capital account openness index of Chinn and Ito (2008). The ratio of debt to GDP is from Reinhart and Rogoff (2010) and GDP growth is from the World Development Indicators (World Bank). The sample period 1973-2005 and includes the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. Standard errors in parenthesis.

*** Significant at 1% confidence interval. ** Significant at 5% confidence interval.

stabilizer expenses decline so that government debt increases less. Finally, time does not seem to play a significant role.

8 Conclusion

The stock of public debt has increased in most advanced economies during the last thirty years, a period also characterized by extensive liberalization of international capital markets. In this paper we study a two-country politico-economic model where the incentives of governments to borrow increase when financial markets become internationally integrated. We propose this mechanism as one of the possible explanations for the growing stocks of

government debt observed in most of the advanced economies since the early 1980s. The model also captures the overall dynamics of the interest rates observed during this period. We have also conducted a cross country analysis using OECD country data and the empirical results are consistent with the theoretical prediction of the model.

Although we have focused on government borrowing, it is natural to ask whether public debt is simply a substitute for private debt. Since the issuance of government debt could be Pareto improving relative to an economy where government's budgets have to be balanced in every period, it is natural to ask whether the welfare gains can also be achieved with private debt once we allow workers to borrow from entrepreneurs. It turns out that, under certain conditions, the economy with public debt can be replicated by an economy with private debt—a point also made by Kocherlakota (2007).

There are two potential limitations to the application of the equivalence result. First, in our economy the competitive equilibrium with private debt is different from the equilibrium with public debt. As emphasized throughout the paper, governments internalize the effect of issuing bonds on interest rates while individual agents take prices as given when they choose their bond holdings. This implies that, if workers were allowed to borrow, the equilibrium private debt would be very different from the debt chosen by the government. Therefore, from the point of view of a positive analysis—that is, explaining the actual level of borrowing that would arise in equilibrium—the consideration of public debt is not a substitute to private debt. Of course, we can consider an environment in which the government intervenes with policies insuring that private agents choose the same amount of debt as the one chosen by the government. However, in absence of these policies, the equilibrium with private borrowing will be very different from the equilibrium with public borrowing.[6]

The second limitation to the application of the equivalence result is that private agents may face tighter constraints than governments. In our framework private debt arises if workers are allowed to borrow. But in the presence of limited enforcement of private contracts, workers may not be able to borrow or their borrowing capacity is limited. If governments have higher credit capacity than workers, then the economy with public debt will not be

[6]In particular, if we allow workers to borrow privately, the equilibrium debt will grow until it reaches some borrowing limit. Without a limit the debt will converge to infinity. On the other hand, the debt chosen endogenously by the government is bounded even in absence of a very tight borrowing limit. This is an important feature of our model where the imposition of a borrowing limit for the government may not be necessary besides, of course, the imposition of some transversality condition.

equivalent to the economy with private debt since the latter will have zero or insufficient private debt.

Although we have considered only two symmetric countries, the model can be easily extended to study the effects of capital liberalization among heterogeneous countries and, more specifically, between developed and developing economies. This is the approach taken by the literature on global imbalances where most studies consider heterogeneous countries but do not allow for an active role of governments. The extension of our model with heterogeneous countries would allow us not only to study the implications for the 'gross' public debt but also for cross-country 'net' capital flows.

A Data appendix

Variables and Sources

1) *Debt/GDP Ratio* is total (domestic plus external) gross central government debt over GDP, from Reinhart and Rogoff (2010). The sample period is 1973-2005.

2) *Deflator,* p, is the GDP deflator from Kaminsky, Reinhart, and Végh (2004). The sample period is 1970-2003.

3) *Inflation,* π, is computed as $\pi_t = p_t/p_{t-1} - 1$.

4) *Expected Inflation,* π^e, is computed as the fitted values from the regression

$$\pi_t = \alpha_0 + \alpha_1\pi_{t-1} + \alpha_2\pi_{t-2} + \alpha_3\pi_{t-3} + \alpha_4\pi_{t-4} + \epsilon_t.$$

5) *Nominal Interest Rate,* i, is the long term (10 years) interest rates on government bonds from OECD Statistics. Generally the yield is calculated at the pre-tax level and before deductions for brokerage costs and commissions and is derived from the relationship between the present market value of the bond and that at maturity, taking into account also interest payments paid through to maturity.

6) *Real Interest Rate,* r, is computed as $r_t = (1 + i_t)/(1 + \pi^e_{t+1}) - 1$, where i is the nominal interest rate and π^e is expected inflation.

7) *Financial Liberalization Index* is from Abiad, Detragiache and Tressel (2008). The sample period is 1973-2005.

Countries

OECD: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. *EUROPE*: Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, and United Kingdom.

B Proof of Lemma 3.1

Guess that $k_{i,j,t+1}$ and $d_{i,j,t+1}$ are linear in wealth $a_{i,j,t}$: $k_{i,j,t+1} = \frac{\eta\phi_{j,t}}{p_{j,t}}a_{i,j,t}$ and $d_{i,j,t+1} = R_{j,t}\eta(1-\phi_{j,t})a_{i,j,t}$, where η is an unknown constant. Thus, consumption follows $c_{i,j,t} = (1-\eta)a_{i,j,t}$ and $a_{i,j,t+1}$ satisfies

$$a_{i,j,t+1} = \eta\left[\left(\frac{A(z_{i,j,t+1}, w_{j,t+1}) + p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t} + R_{j,t}(1-\phi_{j,t})\right]a_{i,j,t}.$$

The first order conditions with respect to land and bond holdings become

$$\frac{\eta}{1-\eta} = \beta\mathbb{E}\left\{\frac{R_{j,t}}{(1-\eta)\left[\left(\frac{A(z_{i,j,t+1},w_{j,t+1})+p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t}+R_{j,t}(1-\phi_{j,t})\right]}\right\},$$

$$\frac{\eta}{1-\eta} = \beta\mathbb{E}\left\{\frac{\frac{A(z_{i,j,t+1},w_{j,t+1})+p_{j,t+1}}{p_{j,t}}}{(1-\eta)\left[\left(\frac{A(z_{i,j,t+1},w_{j,t+1})+p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t}+R_{j,t}(1-\phi_{j,t})\right]}\right\}.$$

Multiply these conditions by $1-\phi_{j,t}$ and $\phi_{j,t}$ respectively and add them to get:

$$\frac{\eta}{1-\eta} = \beta\mathbb{E}\left(\frac{1}{1-\eta}\right)$$

Hence, $\eta = \beta$ verifies the guess and the first optimality condition becomes

$$\mathbb{E}\left[\frac{R_{j,t}}{\left(\frac{A(z_{i,j,t+1},w_{j,t+1})+p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t}+R_{j,t}(1-\phi_{j,t})}\right] = 1. \tag{28}$$

Q.E.D.

C Proof of Proposition 3.1

Equation (7) is derived from the market clearing condition for labor, which yields

$$\left(\frac{1-\theta}{w_{j,t}}\right)^{\frac{1}{\theta}}\bar{z} = 1.$$

Equation (8) follows from replacing the government's budget constraint, eq. (4) into the worker's budget constraint eq. (3). Equation (9) is obtained by substituting $p_{j,t}R_{j,t}(1-\phi_{j,t}) = \phi_{j,t}\overline{B}_{j,t+1}$ into eq. (28) (see section B). To obtain eq. (10) combine aggregate assets holdings $\bar{a}_{j,t} = A(\bar{z},w_{j,t}) + p_{j,t} + \overline{B}_{j,t}$ with the aggregate low of motion for land $k_{i,j,t+1}$ $p_{j,t}\bar{k} = \beta\phi_{j,t}\bar{a}_{j,t}$.

To derive eq. (11) combine the entrepreneurs' budget constraint with their law of motion for assets and obtain

$$\bar{c}_{j,t} + \frac{\overline{B}_{j,t+1}}{R_{j,t}} = A(\bar{z},w_{j,t}) + \overline{B}_{j,t}.$$

Then eliminate $\bar{c}_{j,t}$ and use equation (12) to solve for $R_{j,t}$, where $p_{j,t}$ is eliminated by using equation (10).

To derive equation (12), aggregate consumption across entrepreneurs $\bar{c}_{j,t} = (1-\beta)\bar{a}_{j,t}$ and use their (aggregate) budget constraint $\bar{a}_{j,t} = \bar{c}_{j,t} + p_{j,t} + \overline{B}_{j,t+1}/R_{j,t}$ to eliminate $\bar{a}_{j,t}$. *Q.E.D.*

D Proof of Proposition 4.1

Write the worker's value function recursively as

$$W(B;B') = \ln(c^w) + \beta W(B';\mathcal{B}(B'))$$

where $c^w = w + T$. Use the government's budget constraint eq. (4) to substitute away transfers $T = B'/R(B;B') - B$ and equation (7) to replace the wage rate into the workers' budget constraint. This yields $c^w = (1-\theta)\bar{z}^{1-\theta} + B'/R(B;B') - B$, which is replaced into $W(B;B')$ to obtain eq. (15).

From Lemma 3.1 (and omitting i, j indexes) we have,

$$\begin{aligned} c &= (1-\beta)a, \\ k' &= \left(\frac{\beta\phi(B)}{p(B,B')}\right)a, \\ b' &= R(B,B')\beta(1-\phi(B))a. \end{aligned}$$

The indirect utility of an entrepreneur can be written recursively as

$$\tilde{V}(k,b,z,B;B') = \ln(c) + \beta\mathbb{E}\tilde{V}(k',b',z',B';\mathcal{B}(B')).$$

Substitute consumption $(1-\beta)a$ and use the definition of current wealth, $a = A(z,\tau)k + pk + b$ to obtain

$$\begin{aligned} \tilde{V}(k,b,z,B;B') &= \ln(1-\beta) + \ln(k) \\ &+ \ln\left(A(z) + p(B,B') + \frac{b}{k}\right) + \beta\mathbb{E}\tilde{V}\Big(k',b',z',B';\mathcal{B}(B')\Big), \end{aligned}$$

which depends on b/k. Use equilibrium conditions to show that the ratio satisfies $b/k = \overline{B}/\bar{k} = B/\bar{k} = B$.

Subtract $\frac{1}{1-\beta}\ln(k)$ on both sides of the Bellman's equation. Then add and subtract $\frac{\beta}{1-\beta}\mathbb{E}\ln(k')$ in the right-hand-side to obtain

$$\begin{aligned} V(B,z;B') &= \ln(1-\beta) + \ln\left[A(z) + p(B;B') + B\right] \\ &+ \frac{\beta}{1-\beta}\ln\left(\frac{k'}{k}\right) + \beta\mathbb{E}V(B',z';\mathcal{B}(B')). \end{aligned} \tag{29}$$

Define the 'normalized' value function as

$$V(B,z;B') = \tilde{V}(k,d,z,B;B') - \frac{1}{1-\beta}\ln(k).$$

Impose the equilibrium condition $b/k = B$ in expression $a = [A(z,w) + p(B,B') + b/k]k$ to get

$$\frac{k'}{k} = \frac{\beta p(B,B')}{\phi(B')}[A(z) + p(B,B') + B],$$

which is independent individual state variables other than z. Substitute this into eq. (29) and re-arrange to derive eq. (16). *Q.E.D.*

E Proof of Lemma 5.1

Follow the steps in the proof of Proposition 3.1 (see section D) to derive

$$\frac{B}{R} = \frac{\beta A(\bar{z})[1-\phi(B)]}{1+\beta[1-\phi(B)]} > 0, \tag{30}$$

where $\phi(B)$ satisfies

$$\phi(B) = \mathbb{E}\frac{A(z)}{A(z)+B} < 1.$$

i. Let B^* satisfy the FOC $\frac{\partial W(B)}{\partial B} = 0$, with

$$\frac{\partial W(B)}{\partial B} = \frac{1}{c_1^w}\frac{\partial B/R}{\partial B} - \beta\frac{1}{c_2^w},$$

where $c_1^w = w + B/R$ and $c_2^w = w - R$. Since $\frac{\partial W(B)}{\partial B} > 0|_{B=0}$ and $\frac{\partial W(B)}{\partial B} \to -\infty$ as $B \to (1-\theta)\bar{z}^\theta$, then $B^* \in [0, (1-\theta)\bar{z}^\theta]$.

Uniqueness follows from the fact that $W(B)$ is strictly concave in this interval. Differentiating eq. (20) yields

$$\frac{\partial^2 W(B)}{\partial B^2} = -\frac{1}{(c_1^w)^2}\left[\frac{\partial B/R}{\partial B}\right]^2 + \frac{1}{c_1^w}\frac{\partial^2 B/R}{\partial B^2} - \frac{\beta}{(c_2^w)^2}. \tag{31}$$

Since

$$\frac{\partial^2\phi(B)}{\partial B^2} = 2\mathbb{E}\left[\frac{A(z)}{(A(z)+B)^3}\right] > 0 \Rightarrow$$

$$\frac{\partial^2 B/R}{\partial B^2} = -\frac{\beta A(\bar{z})}{(1+\beta[1-\phi(B)])^3}\left[\frac{\partial^2\phi(B)}{\partial B^2}(1+\beta[1-\phi(B)]) + 2\beta\left(\frac{\partial\phi(B)}{\partial B}\right)^2\right] < 0,$$

establishing concavity.

ii. Replace eq. (30) into the representative entrepreneur's consumption and obtain $c_1 = \frac{A(\bar{z})}{1+\beta[1-\phi(B)]}$. Then, differentiate the resulting indirect utility

$$\frac{\partial V(B)}{\partial B} = \frac{\beta}{1+\beta(1-\phi(B))}\frac{\partial\phi(B)}{\partial B} + \beta\mathbb{E}\left(\frac{1}{A(z)+B}\right).$$

Substitute

$$\frac{\partial\phi(B)}{\partial B} = -\mathbb{E}\left[\frac{A(z)}{(A(z)+B)^2}\right]$$

in the expression above and collect terms to show

$$\frac{\partial V(B)}{\partial B} = \beta\mathbb{E}\left[\frac{B+\beta[1-\phi(B)]\,(A(z)+B)}{(A(z)+B)^2\,(1+\beta[1-\phi(B)])}\right] > 0.$$

Q.E.D.

F Proof of Proposition 5.1

Suppose that $\Phi > 1 - \frac{\theta}{1+\beta}$ and let the government's objective be defined by

$$G(B) \equiv \Phi W(B) + (1-\Phi)V(B)$$

where $W(B)$ and $V(B)$ are given by equations (19) and (20). To prove concavity, differentiate $G(B)$ twice, with $\frac{\partial^2 W(B)}{\partial B^2}$ defined in eq. (31) and, given $c_1 = A(\bar{z}) - B/R$ and $c_2 = A(z) + B$, with

$$\frac{\partial^2 V(B)}{\partial B^2} = -\frac{1}{(c_1)^2}\left[\frac{\partial B/R}{\partial B}\right]^2 - \frac{1}{c_1}\frac{\partial^2 B/R}{\partial B^2} - \beta\mathbb{E}\frac{1}{(c_2)^2}.$$

After some manipulations, show that

$$\begin{aligned}\frac{\partial^2 G(B)}{\partial B^2} &= -\left[\frac{\partial B/R}{\partial B}\right]^2\left[\frac{\Phi}{(c_1^w)^2} + \frac{1-\Phi}{(c_1)^2}\right] - \beta\left[\frac{\Phi}{(c_2^w)^2} + \frac{1-\Phi}{(c_2)^2}\right] \\ &+ \frac{\partial^2 B/R}{\partial B^2}\left[\frac{\Phi}{c_1^w} - \frac{1-\Phi}{c_1}\right].\end{aligned}$$

The first row is negative for all B. Hence, a sufficient condition for $\frac{\partial^2 G(B)}{\partial B^2} < 0$ is that the second row is non-positive. We established that $\frac{\partial^2 B/R}{\partial B^2} < 0$ in section E, part *i.*. In addition,

$$\begin{aligned}\frac{\Phi}{c_1^w} - \frac{1-\Phi}{c_1} &= \frac{z^{\bar{\theta}}}{c_1^w c_1}\frac{1}{(1+\beta[1-\phi(B)])}\left[\theta - (1-\Phi)(1+\beta[1-\phi(B)])\right] \\ &\geq \frac{z^{\bar{\theta}}}{c_1^w c_1}\frac{1}{(1+\beta[1-\phi(B)])}\left[\theta - (1-\Phi)(1+\beta)\right] > 0.\end{aligned}$$

The first inequality follows from the fact that $\phi(B) \leq 1$, and the second from the assumption that $\Phi > 1 - \frac{\theta}{1+\beta}$. This establishes concavity.

Let B^* satisfy $\frac{\partial G(B)}{\partial B} = 0$. From Lemma 5.1, $V(B)$ is increasing in B $\forall B \in [0, (1-\theta)z^{\bar{\theta}}]$ and $\frac{\partial W(B)}{\partial B}|_{B=0} > 0 \Rightarrow \frac{\partial G(B)}{\partial B}|_{B=0} > 0$. Additionally, $\frac{\partial V(B)}{\partial B}$ is finite at $(1-\theta)z^{\bar{\theta}}$ and $\frac{\partial W(B)}{\partial B} \to -\infty$ as $B \to (1-\theta)z^{\bar{\theta}}$, so $\frac{\partial G(B)}{\partial B} \to -\infty$. Hence $B^* \in [0, (1-\theta)z^{\bar{\theta}}]$. Because $G(B)$ is strictly concave, B^* must be unique. *Q.E.D.*

References

Aiyagari, S. Rao, Albert Marcet, Thomas J. Sargent, and Juha Seppala. 2002. "Optimal Taxation without State-Contingent Debt". *Journal of Political Economy*, 110: 1220-1254.

Aiyagari, S. Rao, and Ellen R. McGrattan. 1998. "The Optimum quantity of Debt". *Journal of Monetary Economics*, 42(3): 44769.

Albanesi, Stefania and Christopher Sleet. 2006. "Dynamic Optimal Taxation with Private Information". *Review of Economic Studies*, 73: 1-30.

Alesina, Alberto and Guido Tabellini. 1990. "A Positive Theory of Fiscal Deficits and Government Debt". *Review of Economic Studies*, 57(3): 403-414.

Angeletos, George-Marios. 2002. "Fiscal Policy with Non-Contingent Debt and the Optimal Maturity Structure". *Quarterly Journal of Economics*, 117: 1105-1131.

Angeletos, George-Marios. 2007. "Uninsured Idiosyncratic Investment Risk and Aggregate Saving". *Review of Economic Dynamics*, 10(1): 1-30.

Angeletos, George-Marios, and Vasia Panousi. 2010. "Financial Integration, Entrepreneurial Risk and Global Dynamics". *Journal of Economic Theory*, 146(3), 863-96.

Azzimonti, Marina, Eva de Francisco and Per Krusell. 2008. "Production Subsidies and Redistribution". *Journal of Economic Theory*, 142: 77-99.

Barro, R. 1979."On the Determination of the Public Debt," *Journal of Political Economy*, Vol. 87: 940-71.

Battaglini, Marco and Stephen Coate. 2008. "A Dynamic Theory of Public Spending, Taxation, and Debt". *American Economic Review*, 98(1): 201-236.

Caballero, Ricardo J., Emanuel Farhi, and Pierre-Olivier Gourinchas. 2008, "An Equilibrium Model of Global Imbalances and Low Interest Rates". *American Economic Review*, 98(1): 358-93.

Caballero, Ricardo and Pierre Yared. 2008. "Future Renting-Seeking and Current Public Savings". NBER Working Paper No. 14417

Chari, V. V., Lawrence J. Christiano, and Patrick J. Kehoe. 1994. "Optimal Fiscal Policy in a Business Cycle Model". *Journal of Political Economy*, 102: 617-652.

Chinn, Menzio and Hiro Ito. 2008. "A New Measure of Financial Openness". *Journal of Comparative Policy Analysis*, 10(3): 309-22.

Farhi, Emmanuel and Ivan Werning. 2008. "The political economy of nonlinear capital taxation", Mimeo.

Fogli, Alessandra and Fabrizio Perri. 2006. "The Great Moderation and the U.S. External Imbalance". *Monetary and Economic Studies*, Institute for Monetary and Economic Studies, Bank of Japan, 24(S1), 209-25.

Golosov, Mikhail, Narayana Kocherlakota, and Aleh Tsyvinski. 2003. "Optimal Indirect and Capital Taxation". *Review of Economic Studies*, 70: 569-587.

Ilzetzki, Ethan. 2008. "Rent-Seeking Distortions and Fiscal Procyclicality". Job Market Paper.

Judd, Kenneth L. 1985. "Redistributive Taxation in a Simple Perfect Foresight Model". *Journal of Public Economics*, 28(1): 59-83.

Kaminsky, Graciela, Carmen Reinhart, and Carlos Végh. 2004 "When it rains, it pours: Procyclical capital flows and macroeconomic policies". *NBER macroeconomics annual 2004*, ed. Mark Gertler and Ken Rogoff, 11-82. Cambridge,

Kehoe, Patrick J. (1989). "Cooperation among benevolent governments may be undesirable". *Review of Economic Studies*, 56(2): 28996.

Kocherlakota, Narayana 2007. "Money and Bonds: An Equivalence Theorem". Working Paper.

Lucas, Robert E. Jr., and Nancy L. Stokey. 1983. "Optimal Fiscal and Monetary Policy in an Economy without Capital". *Journal of Monetary Economics*, 55: 710-27.

Marcet, Albert and Andrew Scott. 2008. "Debt, Deficits, and the Structure of Bond Markets". Forthcoming in *Journal of Economic Theory*.

Mendoza, Enrique, Vincenzo Quadrini, and Jose-Victor Rios-Rull. 2009, "Financial Integration, Financial Development and Global Imbalances". *Journal of Political Economy*, 117(3), 371-416.

Mendoza, Enrique, and Linda Tesar. 2005. "Why Hasnt Tax competition Triggered a Race to the Bottom? Some Quantitative Lessons from the EU. *Journal of Monetary Economics*, 52(1): 163-204.

Obstfeld, Maurice, and Alan M. Taylor. 2005. *Global Capital Markets Integration, Crisis, and Growth.* Cambridge University Press, New York.

Persson, Torsten and Lars Svensson. 1989. "Why a Stubborn Conservative Would Run a Deficit: Policy with Time-Inconsistent Preferences". *The Quarterly Journal of Economics*, 104(2): 325-345.

Persson, Torsten and Guido Tabellini. 2000. Political Economics: Explaining Economic Policy. Cambridge, Mass: MIT Press

Quadrini, Vincenzo. 2005. "Policy Commitment and the Welfare Gains from Capital Market Liberalization". *European Economic Review*, 49(8): 1927-51.

Reinhart, Camen and Kenneth Rogoff. 2010. "From Financial Crash to Debt Crisis". *NBER Working Paper* 15795, March. Forthcoming in American Economic Review.

Shin, Yongseok. 2006. "Ramsey Meets Bewley: Optimal Government Financing with Incomplete Markets". Unpublished manuscript, Washington University in St. Louis.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti. 2007. "Rotten Parents and Disciplined Children: A Politico-Economic Theory of Public Expenditure and Debt". Working Paper.