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Financial Globalization, Inequality, and the Rising Public Debt†

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During the last three decades government debt has increased in most developed countries. During the same period we have also observed a significant liberalization of international financial markets. We propose a multicountry model with incomplete markets and show that governments may choose higher levels of debt when financial markets become internationally integrated. We also show that public debt increases with the volatility of uninsurable income (idiosyncratic risk). To the extent that the increase in income inequality observed in some industrialized countries has been associated with higher idiosyncratic risk, the paper suggests another potential mechanism for the rise in public debt. (*JEL* D31, E62, F65, H63)

During the last three decades, we have observed an increase in the stock public debt in most developed countries. As shown in panel A of Figure 1, public debt in OECD (Organisation for Economic Co-operation and Development) countries increased from around 30 percent of gross domestic product (GDP) in the early 1980s to about 50 percent in 2005. Similar increases are observed in the United States and Europe.

Historically, the dynamics of public debt have been closely connected to war financing and business cycle fluctuations, where budget deficits and surpluses are instrumental in minimizing the distortionary effects of taxation. 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 is difficult to rationalize this trend with the tax-smoothing argument since this period has been characterized by relatively peaceful times and low macroeconomic volatility.

The last three decades have also been characterized by two additional trends. The first trend is the international liberalization of financial markets as shown in panel B

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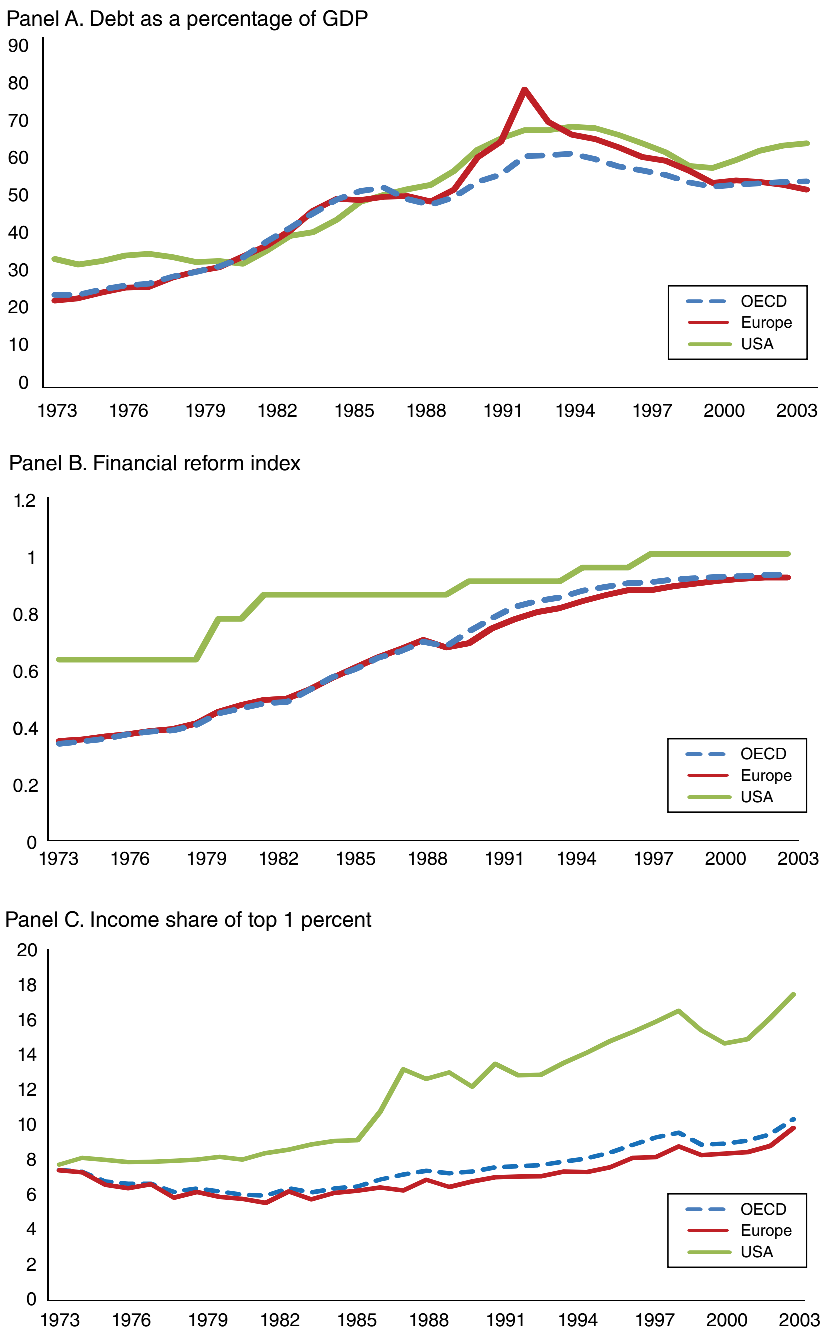

Figure 1. Public Debt, Financial Liberalization, and Inequality in Advanced Economies

Note: Online Appendix A provides the definition of variables and the data sources.

of Figure 1. This panel, which plots the index of financial liberalization constructed by Abiad, Detragiache, and Tressel (2008) for the OECD countries as a group, the United States, and Europe, shows that world financial markets have become much less regulated starting in the early 1980s. This pattern can also be seen with other indicators of international capital mobility as shown in Obstfeld and Taylor (2005). The second trend that took place during the last three decades is the increase in inequality as shown in panel C of Figure 1, which plots the share of income earned by the top 1 percent of the population as reported by Atkinson, Piketty, and Saez (2011).

In this paper we propose a theory in which government borrowing responds positively to financial liberalization. Furthermore, to the extent that income inequality is associated with higher uninsurable income risks, public debt also responds positively to income inequality.

We study a multicountry model where agents face uninsurable idiosyncratic risks and public debt is held to smooth consumption. To keep tractability, we assume there are two types of agents: those who face idiosyncratic risks (entrepreneurs) and those who are less exposed to these risks (workers). Both agents have some preferences for public debt. Agents who face higher idiosyncratic risk (entrepreneurs) benefit from public debt because it provides an instrument to smooth consumption. The demand for safe assets is reflected in the equilibrium interest rate being lower than the intertemporal discount rate. Because of the lower interest rate, agents who face lower risk (the workers) would also benefit from public debt if they cannot borrow directly in private markets. Effectively, government debt acts as a substitute for private debt. The benefits for workers, however, fade away as the stock of debt increases because this requires higher interest rates. Thus, once the debt has reached a certain level, workers no longer support further increases in public debt; the internalization of the increasing cost of debt serves as a limit to its growth.

How does financial integration affect the government's incentive to issue 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 also from their foreign counterparts. Therefore, when governments do not coordinate their policies, each country faces a lower elasticity of the interest rate to the supply of *their own* public debt. Since the interest rate is less responsive to a country's debt, governments have more incentive to increase borrowing provided that workers have sufficient political influence.

Figure 2 suggests that the responsiveness of the interest rate to public debt has declined over time. This figure plots the fitted values of a simple cross-country regression where the dependent variable is the ratio of the change in the real interest rate over the growth rate of real government debt; the dependent variable is time (calendar year). A more extensive analysis of the impact of international liberalization on the elasticity of the interest rate is provided in the online Appendix.[1] The declining interest rate elasticity complements the observation of higher cross-country interest rates' convergence, as shown, for example, in Obstfeld and Taylor (2005).

How does income risk affect preferences for public debt? When entrepreneurs face higher risk, they increase the demand for safe assets (government bonds). Then

[1] Our theory posits that financial liberalization affects the elasticity of demand for public debt. However, the evidence provided in Figure 2 and in the online Appendix is only *suggestive* of the changes in this elasticity. As is well known, observed changes in the interest rate can be the result of movements in both demand and supply, and it is extremely difficult to separate them. The estimation would capture the slope of the demand function only if the position of the demand (but not necessarily the slope) has remained stable during the sample period relatively to the supply. Although we do not have evidence in this regard, we still find it useful to report the estimation results.

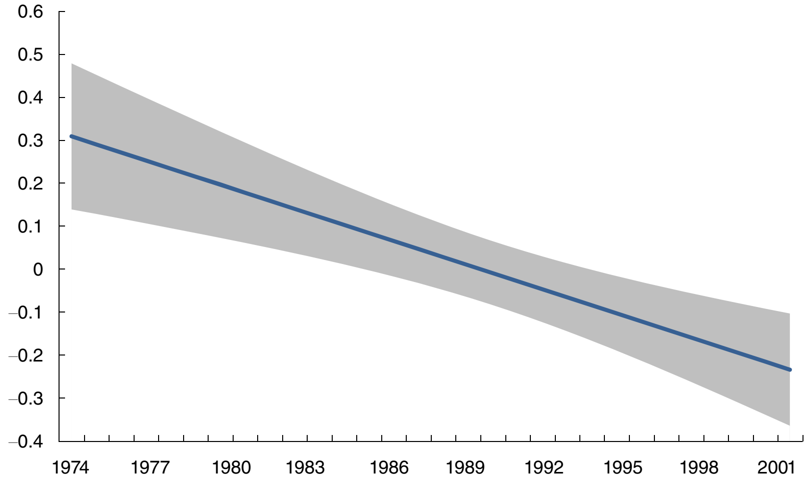

Figure 2. Interest Rate Elasticity over Time

Notes: The solid line is the fitted value of a linear regression in which the dependent variable is the ratio of the percentage change in the real interest rate over the percentage change in real government debt; the dependent variable is time (calendar year). The shaded area is the 95 percent confidence band. Online Appendix A provides the definition of variables and the data sources.

the issuance of more debt is beneficial for both entrepreneurs and workers. For entrepreneurs, it is beneficial because additional public bonds provide safe assets available for consumption smoothing. This more than counterbalances the negative effect of earning a lower interest rate on bonds. For workers, it is beneficial because, through government debt, they can borrow at a lower interest rate.

An increase in uninsurable income risk leads to higher government borrowing independently of the international capital markets regime. However, if financial markets are integrated, our model could generate an increase in government debt of all countries even if the increase in income risk arises in a subset of countries. This is an important property of our model because the increase in public debt has been observed in most developed countries, while the increase in income inequality took place only in some of these countries. This is another dimension in which financial globalization affects government borrowing.

The organization of the paper is as follows. After the literature review, Section I describes the model and defines the competitive equilibrium when governments' policies are exogenous. This section provides some preliminary results that are needed for the core analysis of the paper—that is, the characterization of the choice of public debt. Section II characterizes optimal government policies. To derive analytical results and facilitate the intuition, the analysis of this section is specialized to a simplified version of the model with only two periods. It is in this section that we derive the primary theoretical results of the paper—that is, how public debt is affected by capital market liberalization and increased income risk. Section III characterizes additional properties of the model and outlines certain features of the model that are important to generate the key results of the paper. Section IV extends the analysis to an infinite horizon setup. Since an analytical solution to the model with infinite-lived agents is not available, we solve the model numerically. The numerical analysis shows that financial liberalization can lead to an increase in public debt and that this is exacerbated by the rise in income risk. Although these properties were already shown in the two-period model, the consideration of more periods allows us to study the transition dynamics induced by structural changes and to relate more precisely the predictions of the model to the dynamics observed in the data. Section V provides some concluding remarks. All technical proofs are relegated to the online Appendix.

Literature Review.—An influential theoretical literature studies the optimal choice of public debt over the business cycle with contributions by Barro (1979); Lucas and Stokey (1983); Aiyagari et al. (2002); Angeletos (2002); Chari, Christiano, and Kehoe (1994); and Marcet and Scott (2009). We depart from the tax-smoothing mechanism because we abstract from aggregate fluctuations and distortionary taxation. Instead, we focus on the role of heterogeneity within a country that is assumed away in these papers.

The structure of our model is closer to models studied in Aiyagari and McGrattan (1998) and Shin (2006). In these papers the role of government debt is to partially complete the assets market when agents are subject to uninsurable idiosyncratic risk. The government accumulates debt in order to crowd out private capital, which is inefficiently high due to precautionary savings. In our model, however, we abstract from capital accumulation, and the government choice of debt is based on redistributive considerations. In this sense, our paper is related to the literature on optimal redistributive policy in economies with heterogeneous agents, such as papers by Krusell and Ríos-Rull (1999); Corbae, D'Erasmo, and Kuruscu (2009); and Bachmann and Bai (2013). In our model, however, we do not impose that the government budget has to balance each period and intertemporal redistribution (across time) is more important than intratemporal redistribution (between groups at a particular point in time).

The paper is also related to the literature on the political economy of debt initiated by Alesina and Tabellini (1990) and Persson and Svensson (1989), and further developed by Battaglini and Coate (2008); Caballero and Yared (2010); Ilzetzki (2011); Aguiar and Amador (2011); and Song, Storesletten, and Zilibotti (2012). A common feature of these studies is the strategic use of public debt in economies where the interest rate is exogenous and governments with different preferences 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 is also present in Krusell, Martin, and Ríos-Rull (2006) and in Azzimonti, de Francisco, and Krusell (2008), but it relies on the use of distortionary taxation, which we do not consider here.

Another difference with many of the papers that study optimal public debt is that we consider an open economy environment with large countries. An exception is Chang (1990), who also studies how the international liberalization of capital markets affects government borrowing in an economy with overlapping generations. Although the structure of the model is different, the mechanism through which capital liberalization leads to higher government borrowing is similar. The analysis of Chang (1990), however, abstracts from risk. 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 paper is also related to the literature that explores the importance of market incompleteness for international financial flows. Caballero, Farhi, and Gourinchas (2008); Mendoza, Quadrini, and Ríos-Rull (2009); and 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 two dimensions. First, 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 that 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. Part of our results is driven by the fact that governments do not take the interest rate as given, as individual agents do. The second difference is that the goal of our study is to explain the gross stocks 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 (and income risk) generates an increase in the global stock of debt even if countries are symmetric and liberalization does not generate international imbalances.

I. Theoretical Environment and Competitive Equilibrium

Consider an economy composed of N symmetric countries indexed by $j \in \{1, \ldots, N\}$ that lasts for T periods. The infinite-horizon case is obtained as a special case with $T \to \infty$. Agents face uninsurable idiosyncratic risk, but some agents are more exposed to risk than others.

To model heterogeneous exposure to risk in a tractable manner, we assume there are two types of agents: a measure Φ of workers and a measure 1 of entrepreneurs. Workers do not face idiosyncratic uncertainty, while entrepreneurs encounter investment risk. In modeling the entrepreneurs, we adopt the approach proposed by Angeletos (2007), which allows for linear aggregation. We can then analyze the general equilibrium by focusing on a representative worker and a representative entrepreneur, without the need to track the wealth distribution of entrepreneurs.

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 level of debt chosen by the government will depend on the relative size (or political power) of these two groups.

Both types of agents maximize expected lifetime utility,

$$E_0 \sum_{t=1}^{T} \beta^t \ln(c_t), \tag{1}$$

where c_t is consumption and $\beta \in (0, 1)$ is the intertemporal discount factor.

In each country j there is a unit supply of land, an international immobile asset traded at price $p_{j,t}$. Entrepreneurs are individual owners of firms, each operating the production function $F(z, k, l)$, where k is the input of land chosen in the previous period, l the input of labor supplied by workers that is chosen in the current period, and z is an idiosyncratic productivity shock that is observed after the input of land but before the choice of labor. The productivity shock is independently and identically distributed among agents and over time and takes values in the set $\{z_1, \ldots, z_m\}$, with probabilities $\{\mu_1, \ldots, \mu_m\}$. This is the only source of risk in the model. The function $F(z, k, l)$ is strictly increasing in z, k, l and homogeneous of degree 1 in k and l (constant returns).

Entrepreneurs hire workers paying the wage rate w. The hiring decision is static because it affects only current profits. Given productivity z and land k, the marginal product of labor is equalized to the wage rate: that is, $F_l(z, k, l) = w$. Because the production function is homogeneous of degree 1, the demand for labor is linear in the input of land and can be expressed as $l = l(z, w)\,k$. The entrepreneurial profits are also linear in the input of land and can be expressed as

$$F(z, k, l) - wl = A(z, w)k. \tag{2}$$

Entrepreneur i in country j enters period t with risk-free bonds $b^i_{j,t}$, land $k^i_{j,t}$, and productivity $z^i_{j,t}$, and receives lump-sum transfers $\tau_{j,t}$ from the government. The budget constraint is

$$c^i_{j,t} + p_{j,t}k^i_{j,t+1} + \frac{b^i_{j,t+1}}{R_{j,t}} = A(z^i_{j,t}, w_{j,t})k^i_{j,t} + p_{j,t}k^i_{j,t} + b^i_{j,t} + \tau_{j,t}. \tag{3}$$

Entrepreneurs also face the terminal condition $b^i_{j,T+1} \geq 0$, requiring that any outstanding debt be fully repaid in the terminal period T. In the limiting case with $T \to \infty$, this is replaced by a transversality condition.

Workers are endowed with $1/\Phi$ units of labor[2] supplied inelastically for the wage $w_{j,t}$. Labor is internationally immobile. Workers also receive the same lump-sum transfers $\tau_{j,t}$ paid to entrepreneurs, but they do not hold assets or borrow. Thus, workers' consumption is equal to

$$c^w_{j,t} = w_{j,t}\left(\frac{1}{\Phi}\right) + \tau_{j,t}. \tag{4}$$

The assumption that workers do not hold assets is without loss of generality. As we will see, the equilibrium interest rate is typically smaller than the intertemporal discount rate ($R_{j,t} < 1/\beta$). Since workers do not face any risk, the low interest rate implies that they will choose not to hold bonds in the long run. The inability to borrow can be rationalized by limited enforceability of private debt contracts,

[2] The assumption that the individual labor supply is $1/\Phi$ is a normalization that keeps the ratio of total land over the aggregate supply of labor equal to 1.

leading to a borrowing limit. Here we set the borrowing limit to zero, but later we will consider less tight borrowing constraints.

Governments raise revenues by issuing one-period bonds. The proceeds are used to pay lump-sum transfers and to repay outstanding debt. Thus, the government budget constraint is

$$(1 + \Phi)\tau_{j,t} + B_{j,t} = \frac{B_{j,t+1}}{R_{j,t}}, \tag{5}$$

where $B_{j,t}$ are the bonds issued at time $t - 1$ and due in period t, and $B_{j,t+1}$ denotes the new bonds. The term $1 + \Phi$ is the population size (a mass 1 of entrepreneurs and a mass Φ of workers). Governments face the terminal condition $B_{j,T+1} = 0$, which becomes a transversality condition if $T \to \infty$.

A. *Competitive Equilibrium for Given Policies*

In this section we characterize the competitive equilibrium *given* government policies. This is a necessary first step to characterize *optimal* government debt. The endogenous derivation of government policies will be described in Sections II and IV.

The decision problem of workers is trivial because transfers are taken as given and the supply of labor is inelastic. They simply consume their income. The decision problem of entrepreneurs is more complex. Given the initial holdings of land and bonds, the choices of labor, consumption, and new portfolio holdings (land and bonds) are functions of individual histories $\mathbf{z}^i_{j,t} = \{z^i_{j,1}, \ldots, z^i_{j,t}\}$. Following is the formal definition of a competitive equilibrium starting from a regime in which bonds cannot be traded in international markets (financial autarky).

DEFINITION 1 (Autarky Equilibrium): *Given a sequence of government debt $\{B_{j,t}\}_{t=1}^T$ and $B_{j,T+1} = 0$, a competitive equilibrium without mobility of capital is defined as a sequence of prices $\{w_{j,t}, p_{j,t}, R_{j,t}\}_{t=1}^T$, entrepreneurs' decisions $\{c^i_{j,t}(\mathbf{z}^i_{j,t}), l^i_{j,t}(\mathbf{z}^i_{j,t}), k^i_{j,t+1}(\mathbf{z}^i_{j,t}), b^i_{j,t+1}(\mathbf{z}^i_{j,t})\}_{t=1}^T$, consumption of workers $\{c^w_{j,t}\}_{t=1}^T$, and transfers $\{\tau_{j,t}\}_{t=1}^T$ for $j \in \{1, \ldots, N\}$ such that:*

(*i*) *Entrepreneurs' decisions maximize* (1) *subject to the budget constraint* (3) *and the terminal condition $b^i_{j,T+1} \geq 0$. Workers' consumption satisfies the budget constraint* (4).

(*ii*) *Prices clear domestic markets for labor, $\int_i l^i_{j,t}(\mathbf{z}^i_{j,t})\,di = 1$, land, $\int_i k^i_{j,t+1}(\mathbf{z}^i_{j,t})\,di = 1$, and bonds, $\int_i b^i_{j,t+1}(\mathbf{z}^i_{j,t})\,di = B_{j,t+1}$.*

(*iii*) *Domestic bonds and transfers satisfy the government's budget* (5).

If financial markets are financially integrated, governments can sell their bonds to (borrow from) domestic and foreign entrepreneurs. The definition of a competitive equilibrium is similar. The only modification is that the bond market clears internationally instead of country by country: i.e., $\sum_{j=1}^{N} \int_i b_{j,t+1}^i(\mathbf{z}_{j,t}^i)\, di = \sum_{j=1}^{N} B_{j,t+1}$, and interest rates are equalized worldwide, $R_{1,t} = \ldots = R_{N,t}$.

For the analysis that follows, it will be convenient to define

$$\tilde{b}_{j,t}^i = b_{j,t}^i - \frac{B_{j,t}}{1 + \Phi}.$$

The variable $b_{j,t}^i$ is the demand for bonds from entrepreneur i and $B_{j,t}/(1 + \Phi)$ is the per capita stock of domestic public debt (remember that $1 + \Phi$ is the country population). Thus, $\tilde{b}_{j,t}^i$ is the demand for bonds from entrepreneur i in *excess* of the per capita stock of domestic public debt. We will refer to $\tilde{b}_{j,t}^i$ as the "excess demand for bonds." The aggregate excess demand is $\tilde{b}_{j,t} = \int_i \tilde{b}_{j,t}^i$.

Using $\tilde{b}_{j,t}^i$ and the government budget (5), we rewrite the entrepreneurs' budget constraint as

$$c_{j,t}^i + p_{j,t}\, k_{j,t+1}^i + \frac{\tilde{b}_{j,t+1}^i}{R_{j,t}} = A(z_{j,t}^i, w_{j,t})k_{j,t}^i + p_{j,t}\, k_{j,t}^i + \tilde{b}_{j,t}^i. \tag{6}$$

We can now show that entrepreneurs' decision rules are linear in wealth $a_{j,t}^i = A(z_{j,t}^i, w_{j,t})k_{j,t}^i + p_{j,t}\, k_{j,t}^i + \tilde{b}_{j,t}^i$, which generalizes the result of Angeletos (2007) to an economy with fiscal transfers.

LEMMA 1: *Given the sequence of prices* $\{w_{j,t}, p_{j,t}, R_{j,t}\}_{t=1}^{T}$, *entrepreneurs' policies are*

$$c_{j,t}^i = (1 - \eta_t)a_{j,t}^i,$$

$$p_{j,t}\, k_{j,t+1}^i = \phi_{j,t}\, \eta_t\, a_{j,t}^i,$$

$$\frac{\tilde{b}_{j,t+1}^i}{R_{j,t}} = (1 - \phi_{j,t})\eta_t\, a_{j,t}^i,$$

where $\eta_t = \dfrac{\beta}{1 + \dfrac{\beta^{T-t}}{\sum_{s=1}^{T-t} \beta^{s-1}}}$ *and* $\phi_{j,t}$ *satisfies* $\mathrm{E}_t\left[\dfrac{R_{j,t}}{\left(\frac{A(z_{j,t+1}^i, w_{j,t+1}) + p_{j,t+1}}{p_{j,t}}\right)\phi_{j,t} + R_{j,t}(1 - \phi_{j,t})}\right] = 1.$

PROOF:

See online Appendix B.

By aggregating agents' decisions as characterized in Lemma 1 and imposing market clearing, we establish the following result, which is also a generalization of Angeletos (2007).

PROPOSITION 1: *Given the sequence of public debt* $\{B_{1,t}, \ldots, B_{N,t}\}_{t=1}^{T}$, $B_{1,T+1} = , \ldots, = B_{N,T+1} = 0$, *the equilibrium wage is constant*, $w_{j,t} = \overline{w}$, *and the remaining prices and aggregate allocations are*

$$\phi_{j,t} = \mathrm{E}_t\left[\frac{A(z^i_{j,t+1}) + p_{j,t+1}}{A(z^i_{j,t+1}) + p_{j,t+1} + \tilde{b}_{j,t+1}}\right], \tag{7}$$

$$p_{j,t} = \frac{\eta_t\,\phi_{j,t}(\overline{A} + \tilde{b}_{j,t})}{(1 - \eta_t\,\phi_{j,t})}, \tag{8}$$

$$R_{j,t} = \frac{(1 - \eta_t\,\phi_{j,t})\tilde{b}_{j,t+1}}{\eta_t(1 - \phi_{j,t})(\overline{A} + \tilde{b}_{j,t})}, \tag{9}$$

$$c^e_{j,t} = \overline{A} + \tilde{b}_{j,t} - \frac{\tilde{b}_{j,t+1}}{R_{j,t}}, \tag{10}$$

$$c^w_{j,t} = \overline{w} + \left(\frac{\Phi}{1 + \Phi}\right)\left(\frac{B_{j,t+1}}{R_{j,t}} - B_{j,t}\right), \tag{11}$$

where $\overline{A} = \sum_\ell A(z_\ell)\mu_\ell$ *and the variables* $c^e_{j,t} = \int_i c^i_{j,t}$ *and* $c^w_{j,t}$ *are, respectively, the aggregate consumption of entrepreneurs and workers.*

PROOF:
See online Appendix C.

The proposition holds with and without capital mobility. Without mobility (autarky), the bonds held by residents must be equal to the bonds issued by the domestic government: that is, $\int_i b^i_{j,t} = B_{j,t}$. In terms of aggregate excess demand for bonds, $\tilde{b}_{j,t} = \int_i \tilde{b}^i_{j,t} = \nu B_{j,t}$. To simplify notation we have defined $\nu = \Phi/(1 + \Phi)$ as the population share of workers. When financial markets are integrated, bonds held by residents of a country could differ from the bonds issued by their government. A corollary to Proposition 1 characterizes bond holdings with capital mobility.

COROLLARY 1: *With capital mobility, if* $\tilde{b}_{j,1} = \tilde{b}_1$, *then* $\tilde{b}_{j,t} = \nu\left(\frac{\sum_{j=1}^{N} B_{j,t}}{N}\right)$ *for all* $t > 1$.

PROOF:
See online Appendix D.

The corollary says that, if the initial aggregate excess demands of bonds are equal across countries, then future excess demands are also equal across countries. This follows from the assumption that countries are homogeneous in endowments and technology and, with integrated financial markets, interest rates are equalized.

Since the excess demand $\tilde{b}_{j,t}$ is the difference between the bonds purchased by entrepreneurs and the outstanding government liabilities, this property implies that in countries where governments issue more liabilities, entrepreneurs save more because they anticipate higher payments of future taxes in the form of negative transfers. Notice that this result does not apply if the risk faced by entrepreneurs differs across countries.

II. Optimal Policy in the Two-Period Model

We start by analyzing optimal government policy in a special version of the model with only two periods, $T = 2$. This allows us to characterize several properties of the model analytically.

To further simplify the analysis, we assume that in period 1 governments have zero debt: that is, $B_{j,1} = 0$. Furthermore, all entrepreneurs start period 1 with one unit of land, $k_{j,1}^i = 1$; zero bonds, $b_{j,1}^i = 0$; and the same productivity, $z_{j,1}^i = \overline{z}$. Under these assumptions, initial entrepreneurs' wealth, including current profits, is $a_{j,1}^i = \overline{A} + p_{j,1}$. Wealth in period 1 is allocated between consumption and savings in the form of bonds, $b_{j,2}^i$, and land, $k_{j,2}^i$. Thus, wealth in period 2 is $a_{j,2}^i = A(z_{j,2}^i) + b_{j,2}^i - B_{j,2}/(1 + \Phi) = A(z_{j,2}^i) + \tilde{b}_{j,2}^i$, which is stochastic because profits depend on the realization of the idiosyncratic shock $z_{j,2}^i$. Land has no value in period 2 after production. Finally, we assume that the production function takes the form $F(z, k, l) = z^\theta\, k^\theta\, l^{1-\theta}$. With this functional form, $A(z) = \theta z/\overline{z}^{1-\theta}$.

A. *Financial Autarky*

We first characterize the equilibrium with financial autarky. Since entrepreneurs are homogeneous in period 1, we drop the individual superscript i. We also ignore country and time subscripts and let k and b denote the individual land and bonds purchased at time 1. Furthermore, we use p, R, and B, without subscripts, to denote the price of land, the gross interest rate, and the bonds issued in period 1. The idiosyncratic shock realized in period 2 is denoted by z. Total government transfers paid in period 1 equal government borrowing B/R, while total government transfers paid in period 2 equal the repayment of debt, $-B$. Since the population size is $1 + \Phi$, per capita transfers are equal to $\tau_1 = (B/R)/(1 + \Phi)$ in period 1 and $\tau_2 = -B/(1 + \Phi)$ in period 2.

Entrepreneurs start period 1 with wealth $a = \overline{A} + p$ and consume $c_1^e = a - \tilde{b}/R - pk$. Since they start with the same wealth, they all choose the same next-period land and bonds. Thus, $k = 1$ and $b = B$, which implies $\tilde{b} = \nu B$ and $c_1^e = \overline{A} - \nu B/R$. Next-period consumption depends on the realization of the idiosyncratic shock and is equal to $c_2^e = A(z) + \nu B$. The equilibrium interest rate is equal to

$$R(B) = \frac{B\nu[1 + \beta(1 - \phi(B))]}{\beta\overline{A}(1 - \phi(B))},$$

where $\phi(B) = \mathrm{E}\left(\frac{A(z)}{A(z) + \nu B}\right)$. Therefore, entrepreneurs' indirect lifetime utility can be written as

$$(12) \qquad V(B) = \ln\left(\overline{A} - \nu\frac{B}{R(B)}\right) + \beta \mathrm{E}\ln(A(z) + \nu B).$$

Workers earn wage $\overline{w}$ every period, on labor $1/\Phi$, and receive transfers τ_1 and τ_2. Consumption is equal to $(\overline{w} + \nu B/R)/\Phi$ in period 1 and $(\overline{w} - \nu B)/\Phi$ in period 2. Thus, the indirect lifetime utility can be written as

$$(13) \qquad W(B) = \chi + \ln\left(\overline{w} + \nu\frac{B}{R(B)}\right) + \beta\ln(\overline{w} - \nu B),$$

where $\chi = -(1 + \beta)\ln\Phi$ is a constant and we have used $\nu = \Phi/(1 + \Phi)$.

Entrepreneurs are identical in period 1 but heterogeneous in period 2, after realization of the idiosyncratic shock z. This creates a precautionary saving motive and, since workers cannot borrow, the government is the only provider of safe assets available for consumption smoothing. Apart from the effects that the issuance of debt has on the interest rate $R(B)$, equations (12) and (13) make clear that public debt redistributes consumption intertemporally between workers and entrepreneurs.

LEMMA 2: *The indirect utility of workers* (13) *is strictly concave in B with a unique maximum in the interval* $\left(0, \frac{\overline{w}}{\nu}\right)$. *The indirect utility of entrepreneurs* (12) *is strictly increasing in B*, $\forall B \geq 0$.

PROOF:

See online Appendix E.

The indirect utilities of workers and entrepreneurs are plotted in Figure 3 for particular parameter values. Starting from $B = 0$, workers would like to increase public debt because the interest rate is lower than the intertemporal discount rate. In fact, we can verify that $R(B) < 1/\beta$ when $B = 0$. However, as the government borrows more, it reaches a point at which the welfare of workers starts to decline. This happens for two reasons. First, keeping the interest rate fixed, the marginal utility of consumption in the next period becomes bigger 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.

The government's choice of debt takes into account the preferences of workers and entrepreneurs by maximizing the sum of their utilities,[3]

$$(14) \qquad \max_B \{\Phi W(B) + V(B)\}.$$

[3] The interpretation is that policies are chosen by representatives who are selected through democratic elections. Under standard assumptions in probabilistic voting, if there are two candidates who care only about gaining power and have a commitment to platforms, political competition leads to convergence in policy proposals and government policies maximize the weighted sum of agents' welfare. See, for example, Persson and Tabellini (2000). The government behaves, de facto, as a benevolent planner but without commitment to future policies.

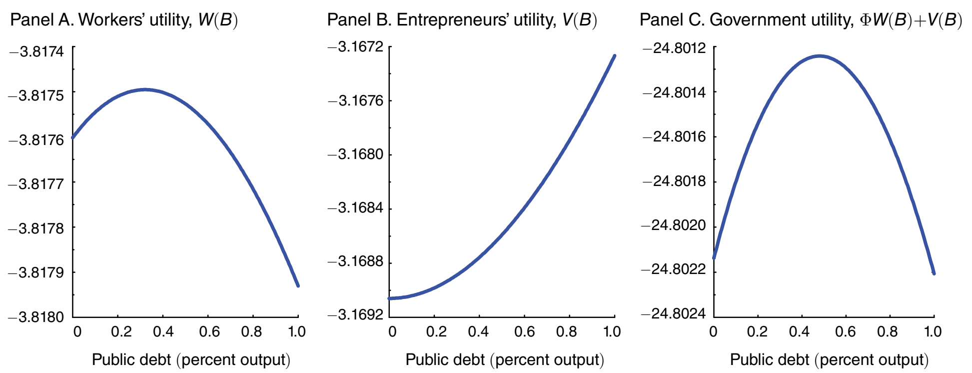

FIGURE 3. INDIRECT UTILITIES IN AUTARKY

Note: Baseline parameters: $\beta = 0.95, \theta = 0.2, z \in \{0.75, 1.25\}$ with equal probabilities, and $v = \Phi/(1+\Phi) = 0.85$.

Since the indirect utility of entrepreneurs $V(B)$ is not concave, the government's objective is not necessarily concave. We can establish concavity only for large values of Φ: that is, when the government's choice is highly influenced by the preferences of workers (or equivalently, when the government assigns a large weight to workers and a small weight to entrepreneurs).

PROPOSITION 2: *If* $\Phi > \frac{(1+\beta)\overline{w}}{\bar{A}} + \beta$, *the government's objective* (14) *is strictly concave and there is a unique maximum in the interval* $\left[0, \frac{\overline{w}}{\nu}\right]$.

PROOF:

See online Appendix F.

Two remarks are in order here. First, the condition on Φ is sufficient, not necessary. Second, even if the government's objective is not strictly concave, the maximum is still interior in the interval $\left[0, \frac{\overline{w}}{\nu}\right]$. This is because the objective function is continuous and converges to minus infinity as B converges to $\frac{\overline{w}}{\nu}$. Since the objective function is also differentiable, its derivative must be zero at the optimum. Differentiating (14) we obtain

$$(15)\quad \Phi \cdot \left[\frac{\partial\left(\frac{B}{R(B)}\right)}{\partial B}\left(\frac{1}{c_1^w}\right) - \beta\left(\frac{1}{c_2^w}\right)\right] = \left[\frac{\partial\left(\frac{B}{R(B)}\right)}{\partial B}\left(\frac{1}{c_1^e}\right) - \beta \mathrm{E}\left(\frac{1}{c_2^e(z)}\right)\right],$$

where c_1^w and c_2^w are the aggregate consumptions of workers (per capita consumption multiplied by the mass of workers Φ); and c_1^e and $c_2^e(z)$ are the individual consumptions of entrepreneurs. In period 2, entrepreneurs' consumption depends on the realization of the idiosyncratic shock z.

An additional unit of debt issued in period 1 transfers consumption from entrepreneurs (who buy bonds net of transfers) to workers (who receive government transfers). In period 2, the government pays back debt with negative transfers, which reduces workers' consumption, c_2^w, and increases the consumption of entrepreneurs, $c_2^e(z)$. As the size of workers Φ increases, the left-hand side of (15) receives more weight. Thus, the effect of public borrowing on workers' welfare becomes more important for the government.

Because the government is a monopolist in the supply of bonds, it takes into account that its debt affects the interest rate. Remember that the total transfers made by the government in period 1 are $B/R(B)$. Thus, when the government increases B marginally by one unit, the increase in current transfers is not $1/R(B)$ because the interest rate $R(B)$ also changes with B. More specifically, the marginal change in the transfers made in period 1 is

$$\frac{\partial\left(\frac{B}{R(B)}\right)}{\partial B} = \frac{1}{R(B)}(1 - \epsilon^A(B)),$$

where $\epsilon^A(B) = \frac{\partial R(B)}{\partial B}\frac{B}{R(B)}$ is the elasticity of the interest rate to the supply of bonds in autarky. Clearly, higher values of the elasticity imply smaller transfers allowed by higher borrowing.

The internalization of the interest rate elasticity in the decision of governments is the key difference between public and private borrowing. With private borrowing, atomistic agents take the interest rate as given and $\epsilon^A(B)$ is zero in their individual optimality condition. In this case, the perceived increase in consumption in period 1 from private borrowing would be $1/R(B)$.

B. *The Effects of Financial Integration*

When N countries are financially integrated, entrepreneurs can purchase both domestic and foreign bonds, while transfers are only a function of domestic debt. Thus, the debt held by domestic entrepreneurs, b, is not necessarily equal to the debt issued by the domestic country, B. However, according to Corollary 1, the excess holdings of bonds will be equalized across countries. Therefore, $\tilde{b} = \nu \sum_{j=1}^{N} B_j/N$. Effectively, in countries where governments make larger transfers in period 1, entrepreneurs save more because they anticipate higher taxes in period 2. Using this result, the indirect utility of entrepreneurs in country j can be written as

$$V_j(\mathbf{B}) = \ln\left(\bar{A} - \frac{\tilde{b}}{R(\mathbf{B})}\right) + \beta \mathrm{E} \ln\left(A(z) + \tilde{b}\right), \tag{16}$$

where $\mathbf{B} = (B_1, \ldots, B_N)$ is the vector of public debts in all countries. Since $\tilde{b} = \nu \sum_{j=1}^{N} B_j/N$ (Corollary 1), entrepreneurs' welfare depends on the average worldwide public debt.

The properties of $V_j(\mathbf{B})$ are similar to the autarky case. Keeping the debts in all other countries constant, entrepreneurs still prefer higher B_j since this increases the equilibrium interest rate and therefore the return on the risk-free bonds held to hedge the idiosyncratic risk.

The indirect utility of workers is similar to (13) for the autarky case and can be written as

$$(17) \qquad W_j(\mathbf{B}) = \chi + \ln\left(\overline{w} + \nu \frac{B_j}{R(\mathbf{B})}\right) + \beta \ln(\overline{w} - \nu B_j).$$

The interest rate is now determined in the world market. Using (9), this is equal to

$$(18) \qquad R(\mathbf{B}) = \nu\left(\frac{\sum_{j=1}^{N} B_j}{N}\right)\left[\frac{1 + \beta(1 - \phi(\mathbf{B}))}{\beta(1 - \phi(\mathbf{B}))\overline{A}}\right],$$

where $\phi(\mathbf{B}) = \mathrm{E}\left(\frac{A(z)}{A(z) + \nu\left(\sum_{j=1}^{N} B_j\right)/N}\right)$. This expression makes clear that it is the worldwide debt that determines the interest rate. Thus, the debt of an individual country affects the interest rate in proportion to its relative size in the world market.

In a Nash equilibrium, each government chooses its own debt, taking as given debt issued by all other countries:[4]

$$(19) \qquad \max_{B_j} \{\Phi W_j(\mathbf{B}) + V_j(\mathbf{B})\}.$$

Optimal debt is denoted by $B_j = \varphi_j(\mathbf{B}_{-j})$, where $\mathbf{B}_{-j}$ is the vector of government debt of all other countries, except country j. The function $\varphi_j(\cdot)$ is the best response function of country j to other countries' policies. A Nash policy equilibrium is a vector $\mathbf{B}^* = (B_1^*, \dots, B_N^*)$ that satisfies

$$B_j^* = \varphi_j(\mathbf{B}_{-j}^*), \qquad \text{for all } j = 1, \dots, N.$$

For each country j, the optimal debt B_j^* satisfies the first-order condition

$$(20) \quad \Phi \cdot \left[\frac{\partial\left(\frac{B_j}{R(\mathbf{B})}\right)}{\partial B_j}\left(\frac{1}{c_1^w}\right) - \beta\left(\frac{1}{c_2^w}\right)\right] = \left[\frac{\partial\left(\frac{1}{N}\sum_{j=1}^{N}\frac{B_j}{R(\mathbf{B})}\right)}{\partial B_j}\left(\frac{1}{c_1^e}\right) - \beta\frac{1}{N}\mathrm{E}\left(\frac{1}{c_2^e(z)}\right)\right],$$

which is derived by differentiating the government objective (19). As in the autarky regime, this condition is necessary but not sufficient unless Φ is sufficiently large.

[4]Each government takes as given the level of debt issued by all other countries but internalizes the fact that by changing its own debt it affects the interest rate and therefore the transfers made by other governments. As a result, they take into account that the budget constraints of all governments need to be satisfied in and out of the equilibrium.

While the government still faces a trade-off between the benefits and costs of transferring consumption from entrepreneurs to workers in the first period, this expression differs from equation (15) in several respects. First, transfers depend only on the domestic supply of government bonds B_j, while entrepreneurs' utility depends on both domestic and foreign bonds. Hence, an extra unit of B_j increases the consumption of workers, c_1^w, by $\frac{\partial(B_j/R(\mathbf{B}))}{\partial B_j}$ but decreases the consumption of entrepreneurs, c_1^e, by only $\frac{\partial\left(\frac{1}{N}\sum_{j=1}^{N} B_j/R(\mathbf{B})\right)}{\partial B_j} < \frac{\partial(\nu B_j/R(\mathbf{B}))}{\partial B_j}$. This is because part of the extra bonds issued by the domestic government is absorbed by entrepreneurs in the rest of the world. In the second period, the government repays B_j (with negative transfers), which reduces c_2^w by the same amount as in the autarky case. The increase in $c_2^e(z)$, however, is smaller because domestic entrepreneurs hold only part of the increase in domestic bonds.

Another difference between equations (15) and (20) is that the effect of a unilateral change in B on the interest rate is smaller when financial markets are integrated (see equation (18)). In a symmetric equilibrium, $B_j = \sum_{j=1}^{N} B_j/N = B$ and condition (20) becomes

$$\Phi \cdot \left[\frac{1}{R(B)}\left(1 - \frac{\epsilon^A(B)}{N}\right)\left(\frac{1}{c_1^w}\right) - \frac{\beta}{c_2^w}\right] \tag{21}$$

$$= \frac{1}{N}\left[\frac{1}{R(B)}(1 - \epsilon^A(B))\left(\frac{1}{c_1^e}\right) - \mathrm{E}\left(\frac{\beta}{c_2^e(z)}\right)\right],$$

where $\epsilon^A(B)$ is the elasticity of the interest rate in autarky.

Compared to the autarky case, the cost of increasing debt unilaterally is smaller because the perceived elasticity is $\epsilon^A(B)/N$. The costs and benefits for entrepreneurs are also different since the new bonds are shared by domestic and foreign residents. More specifically, the marginal effects on $V(\mathbf{B})$ are reduced when the economy is financially integrated. Thus, whether financial integration leads to more or less public debt depends on the relative size of workers and entrepreneurs.

PROPOSITION 3: *If* $\Phi/(1 + \Phi) \simeq 1$, (i) *per capita debt is strictly increasing in the number of countries* N, (ii) *as* $N \to \infty$ *there exists a unique symmetric equilibrium where debt is bounded and* $\beta R(B) < 1$, *and* (iii) *financial integration generates welfare losses for workers and gains for entrepreneurs.*

PROOF:

See online Appendix G.

When the size of workers is large, the government's objective is approximately equal to the utility of domestic workers. Since the interest rate is less elastic in an integrated world, workers would like the government to borrow more. However, if the government assigns a large weight to entrepreneurs, public debt may decline with

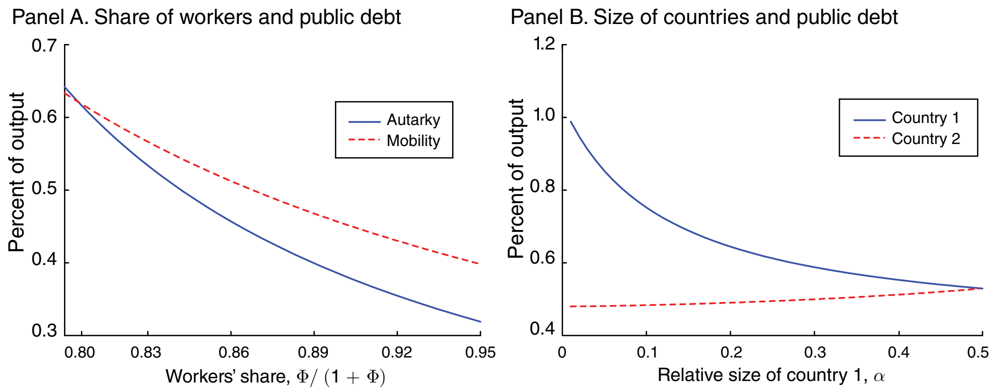

FIGURE 4. DEPENDENCE OF GOVERNMENT DEBT ON WORKERS' SHARE AND COUNTRIES' SIZE WITH CAPITAL MOBILITY

Note: Baseline parameters: $\beta = 0.95$, $\theta = 0.2$, $z \in \{0.75, 1.25\}$ with equal probabilities, $\nu = \Phi/(1 + \Phi) = 0.85$, and $\alpha = 0.5$.

liberalization (since the benefits of issuing public debt for domestic entrepreneurs are shared with foreign entrepreneurs). Thus, the government may have a lower incentive to borrow. This is shown in panel A of Figure 4 for given parameter values.

The channel through which capital mobility affects public borrowing derives from the non-atomistic nature of governments—which is also emphasized in Chang (1990)—and it is essential to differentiate the equilibrium with public borrowing (where the government internalizes the impact on the equilibrium interest rate) from an equilibrium with private borrowing (where private issuers are small and do not internalize the impact of their own borrowing on the equilibrium interest rate). With only private borrowers, the autarky equilibrium would not be different from the equilibrium with capital mobility. With public borrowing, on the contrary, the equilibrium debt differs in economies with and without mobility of capital. As a result, our model predicts that financial integration 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.[5]

The effects of financial integration on public debt depend on the relative size of the integrating countries. To show this, suppose there are only two countries, $N = 2$. The population and land endowment of country 1 is a proportion α of the worldwide endowment. If $\alpha = 0.5$, we revert to the symmetric case.

PROPOSITION 4: *Suppose that $\Phi/(1 + \Phi) \simeq 1$. If $\alpha < 0.5$, in the regime with capital mobility country 1 issues higher per capita debt than country 2, that is, $B_1 > B_2$.*

PROOF:

See online Appendix H.

[5] Examples are Fogli and Perri (2006); Caballero, Farhi, and Gourinchas (2008); Mendoza, Quadrini, and Ríos-Rull (2009); Bacchetta and Benhima (2012); and Angeletos and Panousi (2011).

Since small countries face a larger world market relative to their own economies, they perceive the interest rate as less sensitive to their own debt and borrow more. This is shown in panel B of Figure 4. However, if the relative size of workers is not large, the government's objective is dominated by the benefit of providing safe assets to entrepreneurs, and since these benefits are shared with foreign entrepreneurs, the government may borrow less.

C. *The Effects of Rising Income Risk*

The fact that entrepreneurs face idiosyncratic risk implies that their income becomes unequal in period 2. Here we want to study how changes in income risk affect the choice of public debt.

PROPOSITION 5: *Consider the autarky regime and* $\Phi/(1+\Phi) \simeq 1$. *If an increase in the mean preserving spread of the distribution of* z *raises the term* $\frac{1-\epsilon(B)}{\overline{w}R(B)+B}$, *then* B *increases.*

PROOF:

See online Appendix I.

An increase in the volatility of the idiosyncratic shock implies that entrepreneurs face higher risk. This strengthens the demand for safe assets (government bonds) and reduces the interest rate. Because of the lower interest rate, workers would like more public debt. The government, however, takes into account not only the level of the interest rate but also the increase in the equilibrium interest rate in response to a higher debt (elasticity). At the same time, the government also finds it optimal to increase public debt to improve entrepreneurs' welfare. In general, we cannot establish unambiguously whether government debt increases in response to an increase in risk. However, as long as the term $(1-\epsilon(B))/(\overline{w}R(B)+B)$ increases, public debt does rise as we show in the proof of the proposition. Therefore, to the extent that the increase in income inequality was at least in part associated with an increase in income risk, the paper provides another potential mechanism for the increase in public debt.

The dependence of public debt on risk is shown in panel A of Figure 5, which plots the equilibrium debt as a function of the volatility of the idiosyncratic shock. In this numerical example the shock can take only two values, and therefore the volatility is captured by $z_2 - z_1$. Panel B plots the debt when the volatility of the idiosyncratic shock increases only in country 1. Even if income inequality changes only in one country, debt increases in both countries. This happens because the higher risk faced by entrepreneurs in country 1 increases their demand for bonds and reduces the world interest rate. If the government's weight assigned to workers is sizable—as assumed in the numerical example—the lower interest rate makes public debt more attractive for the governments of both countries.[6]

[6] The fact that debt increases more in country 1 when the degree of inequality rises only in this country is not general. For alternative parameterizations, country 2's debt may raise more than in country 1.

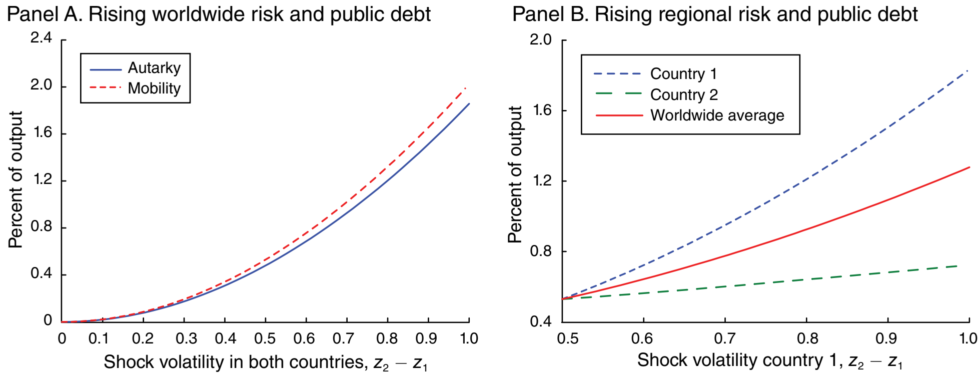

FIGURE 5. DEPENDENCE OF GOVERNMENT DEBT ON RISING RISK WITH CAPITAL MOBILITY

Notes: Panel A considers rising risk in all countries and panel B rising risk in country 1 only. Baseline parameters: $\beta = 0.95$, $\theta = 0.2$, $z \in \{0.75, 1.25\}$ with equal probabilities, $\nu = \Phi/(1+\Phi) = 0.85$, and $\alpha = 0.5$.

The finding that the increase in risk in a few countries may trigger an increase in public debt in other countries is important to reconcile the theory with the data. In fact, while the increase in public debt has taken place in most industrialized countries, the increase in income inequality has been observed only in a few countries (see Atkinson, Piketty, and Saez 2011). The fact that in the 1980s capital markets were liberalized may explain why the increase in inequality in a few countries may have affected other countries, provided that the rising inequality was associated with higher risk in sizable economies such as the United States. But was the rising income inequality observed in the United States associated with an increase in individual income risk?

To answer this question we should look at individual income data over time and separate the predictable components (such as education premium and age dependence) from the stochastic components (both permanent and transitory). Although this is a very difficult task, there are several empirical studies showing that the increase in the volatility of the stochastic components of income (both permanent and transitory) has played an important role in the increasing income inequality in the United States. For example, using PSID data, Blundell, Pistaferri, and Preston (2008) find that the variance of the permanent income shock increased significantly in the first half of 1980s. This is especially important because in our model the productivity shock z acts as a permanent income shock: Thanks to the linearity of the production and saving functions, individual entrepreneurial income follows a random walk even if the productivity shock is i.i.d. Also relevant are the empirical studies of DeBacker et al. (2011, 2012), which are based on US income tax returns over the period 1987–2009. They find that part of the increase in income inequality can be attributed to the volatility of the stochastic components of income, especially for business and investment incomes. Considering that business and investment incomes are more volatile and tend to be concentrated at the top of the distribution, this finding justifies our modeling choice of focusing on the rising income risk of entrepreneurs. Entrepreneurs should be interpreted broadly as "investment decision makers," including those in many managerial occupations.

III. Further Analysis of the Two-Period Model

In this section we further analyze the properties of the two-period model and emphasize the importance of some key assumptions.

A. *On the Relevance of Public Debt*

The well-known Ricardian equivalence result states that, absent any frictions, public debt is irrelevant. However, public debt could become relevant if there are frictions in the market structure or restrictions in the set of policy instruments. For example, the tax-smoothing theory of Barro (1979) is based on the assumption that agents are borrowing constrained and taxation is distortionary (no lump-sum taxes). Chang (1990) and Song, Storesletten, and Zilibotti (2012) consider missing markets for intergenerational trading. Aiyagari and McGrattan (1998) and Shin (2006) assume that markets are incomplete because agents cannot trade state-contingent claims. In our model, the relevance of public debt is based on three assumptions: (i) some agents (entrepreneurs) face more risk than others (workers); (ii) there is no market for state-contingent claims and workers cannot borrow (market incompleteness); and (iii) fiscal policies are limited to public debt and lump-sum transfers (limited fiscal instruments). We now discuss each of these three assumptions.

Risk Heterogeneity.—The assumption that workers do not face any risk is not important per se. It is only made to capture, parsimoniously, the idea that some agents face more risk than others. We could relax this assumption and assume that workers also face earning risks. As long as the risk faced by workers is lower than the risk faced by entrepreneurs, we obtain similar results.

To show this point, we now assume that the efficiency units of labor supplied by each worker are stochastic and take the form $\eta = (1/\Phi)\epsilon$, where $\epsilon \in \{\epsilon_1, \epsilon_2\}$ with probabilities $\{0.5, 0.5\}$, and $(\epsilon_1 + \epsilon_2)/2 = 1$. Figure 6 shows the dependence of public debt on $\epsilon_2 - \epsilon_1$, which captures the idiosyncratic risk faced by workers. The risk faced by entrepreneurs is kept at the baseline value $z_2 - z_1 = 0.5$. As the volatility of earnings increases, the optimal level of public debt goes down. When $\epsilon_2 - \epsilon_1 = 0.5$, workers and entrepreneurs face the same risk and optimal debt is zero. Therefore, as long as the risk faced by workers is not too large, government debt remains positive.

What would happen if the risk faced by workers was bigger than the risk faced by entrepreneurs? In this case we would have that entrepreneurs borrow from workers and, if entrepreneurs face a borrowing limit, government debt would still emerge. This case would only reverse the role of workers and entrepreneurs in financial markets but would not change the basic theory of the paper. For the theory to work, we need only that some agents face more risk than others.

Market for Contingent Claims and Borrowing Constraint.—The assumption of incomplete markets is key for the results of the paper. If entrepreneurs could trade securities that are contingent on individual realizations of income to allow for perfect insurance, zero debt would be optimal. If in addition to contingent claims we

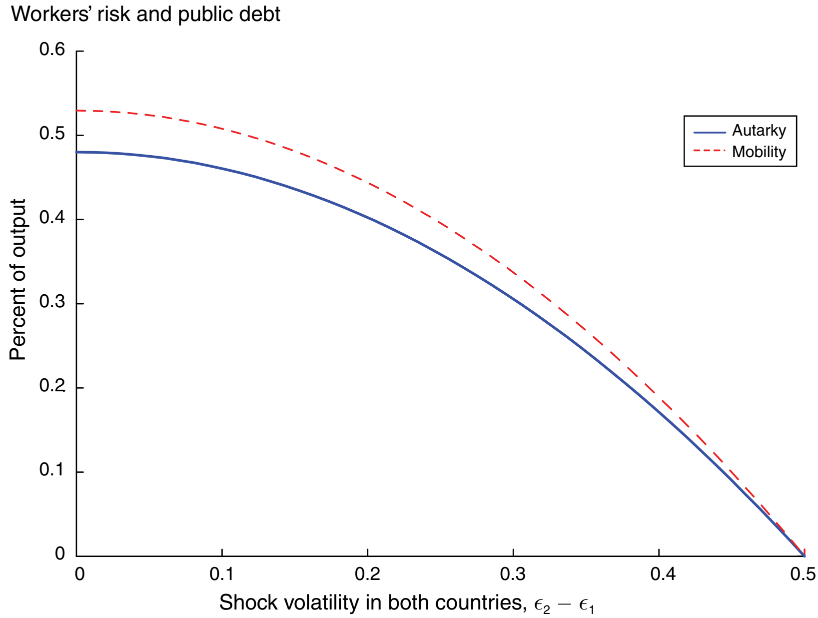

FIGURE 6. DEPENDENCE OF GOVERNMENT DEBT ON WORKERS' RISK

Note: Baseline parameters: $\beta = 0.95$, $\theta = 0.2$, $z \in \{0.75, 1.25\}$ with equal probabilities, $\nu = \Phi/(1 + \Phi) = 0.85$, and $\alpha = 0.5$.

allow workers to borrow and/or hold government bonds, public debt would not play any role and Ricardian equivalence would also hold in our model.

In the absence of a market for contingent claims, the borrowing constraint for workers is key for our results. However, the debt limit does not have to be zero. To see this, consider an environment where workers are allowed to borrow $D \leq \overline{D}$, where $\overline{D}$ is the borrowing limit. Aggregate workers' consumption in the first period is then $c_1^w = \overline{w} + (D + \nu B)/R$, while entrepreneurs' consumption is $c_1^e = \overline{A} - (D + \nu B)/R$. In the benchmark model we imposed $\overline{D} = 0$, in which case optimal debt is denoted by B^*. Let D^* denote aggregate debt when workers are fully unconstrained $\left(\overline{D} \rightarrow \infty\right)$ and there is no public debt. We can then characterize the optimal public debt as follows.

PROPOSITION 6: *The optimal debt issued by the government is* $B = B^* - \frac{\overline{D}}{\nu} \leq \frac{D^*}{\nu}$.

PROOF:

See online Appendix J.

What is relevant for the government is the total level of debt adjusted by transfers: that is, $D + \nu B$, since this is what determines individuals' consumption. When $\overline{D} = 0$, aggregate consumption levels equal $c_1^w = \overline{w} + \nu B^*/R$ and $c_1^e = \overline{A} - \nu B^*/R$. Clearly, the government would target the same allocation: that

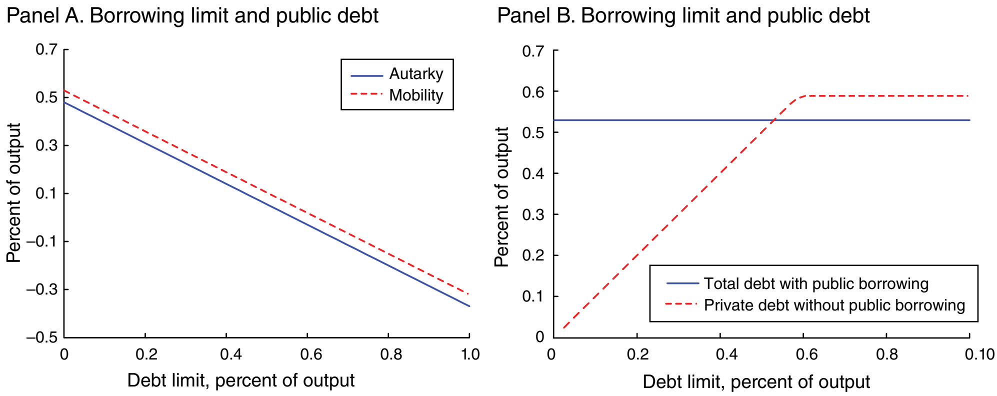

FIGURE 7. EFFECTS OF BORROWING LIMITS ON DEBT

Notes: Panel A considers the dependence of government debt on private borrowing limit. Panel B considers the dependence of total borrowing on private borrowing limit. Baseline parameters: $\beta = 0.95$, $\theta = 0.2$, $z \in \{0.75, 1.25\}$ with equal probabilities, $\nu = \Phi/(1+\Phi) = 0.85$, and $\alpha = 0.5$.

is, the same consumption for workers and entrepreneurs. This is achieved when $D + \nu B = \nu B^*$. Eventually workers would be pushed to their borrowing limit: that is, $D = \overline{D}$, and the optimal level of debt would be determined by the equation reported in the proposition.

Panel A of Figure 7 plots government debt as a function of the borrowing limit for workers. As the limit is relaxed, workers borrow more, which is compensated by lower borrowing from the government. If the borrowing limit is not too loose, as we have assumed in the baseline model, B remains positive. However, B may take negative values when $\overline{D}$ is large. When workers are fully unconstrained, on the other hand, no matter what the value of B is, they will always choose $D^* > \nu B^* - \nu B$ since they do not internalize the impact of their borrowing on the interest rate. In such a case, the government will not be able to reach its target. As long as the borrowing limit is finite, however, government intervention in financial markets remains relevant.[7]

Panel B of Figure 7 plots private debt in the absence of government intervention, $D/\nu = \min\{D^*/\nu, \overline{D}/\nu\}$ with $B = 0$ (dotted line); and total debt, $D/\nu + B$, when the government chooses public debt optimally (solid line). Private debt in the absence of government intervention increases with the borrowing limit $\overline{D}$ until the limit is sufficiently large and workers become unconstrained. Total debt with government intervention, instead, is constant independently of the borrowing limit on workers. Consistent with Proposition 6, the debt chosen by unconstrained workers is larger than B^*.[8]

[7] The international liberalization of capital markets may have been associated with a relaxation of the financial constraint on private borrowers. In our model this is captured by an increase in $\overline{D}$, which would have the opposite effect on government debt. In reality, however, securities issued by the private sector may not be perfect substitutes for securities issued by the government. Although in the model they are perfect substitutes, in reality, private debt may be considered riskier than government bonds. Thus, the expansion of private borrowing may not necessarily crowd out public borrowing.

[8] An immediate implication of this is that, in the infinite horizon model, private borrowing would increase every period (recall that $\beta R < 1$), up to the point where the natural debt limit is reached. As a result, workers'

Finally, we would like to stress that, from the point of view of a positive analysis, public debt is not a substitute for private debt. Of course, we could allow governments to intervene with other policies, such as taxes or restrictions on borrowing, ensuring that private agents choose the same amount of debt as the one desired by the government. Provided that the borrowing constraint on private borrowing is not too tight, these policies could replicate the equilibrium with public debt (see, for example, Kocherlakota 2007 and Yared 2013). In the example considered here, this could be achieved by setting $\overline{D} = \nu B^*$ (the point where the dotted and solid lines intersect in panel B of Figure 7). In the absence of these policies, however, the equilibrium with private borrowing would be different from the equilibrium with public debt.

Limited Policy Instruments.—If governments had access to type-specific taxes and transfers, debt would also be irrelevant. By taxing agents with high realizations of income and giving transfers to those with low realizations, the government would provide insurance and mimic the complete market equilibrium. This would make public debt irrelevant as stated in the next proposition.

PROPOSITION 7: *Suppose that* $\Phi = \frac{1-\theta}{\theta}$ *and the government can also use proportional income taxes, in addition to public debt. Then the optimal tax rate is* 100 *percent and public debt is zero.*

PROOF:

See online Appendix K.

The condition $\Phi = \frac{1-\theta}{\theta}$ ensures that the wage income of workers equals the profits earned by entrepreneurs. Therefore, there are no gains from redistributing income between the two groups and we can separate the purely redistributionary scope of taxes from their insurance role.

The optimality of a 100 percent tax rate follows from the fact that income taxes are nondistortionary in our model: By taxing income at 100 percent and redistributing the revenues as lump-sum transfers, the government could provide full insurance, eliminating the effects of idiosyncratic risk. In such a case, debt would be irrelevant.

Of course, this result is valid only because taxes are nondistortionary. In reality, however, it is not plausible to think that a 100 percent tax is nondistortionary. Once we extend the model to allow for distortions, perfect redistribution is no longer optimal and public debt continues to play an important role.

Suppose that production requires effort h from entrepreneurs according to the production function $F(k, l, h) = (zk)^{\theta\eta}\, l^{(1-\theta)\eta}\, h^{1-\eta}$. Furthermore, the utility of entrepreneurs takes the form $\ln(c - h)$. Workers continue to have the same characteristics as in the baseline two-period model.[9] In addition to issuing public debt, the

consumption would converge to zero in the long run. This outcome differs from the economy with government debt (and no private borrowing) where workers' consumption is strictly positive in the long run even if the government is unconstrained.

[9] We follow the traditional public finance literature in assuming that effort is publicly observable but the government cannot force agents to exert the socially optimal effort. An alternative would be to follow the new public finance literature where effort is private information as in, for example, Golosov, Kocherlakota, and Tsyvinski

government can tax individual income at rate τ_1 in period 1 and at rate τ_2 in period 2. We then have the following proposition.

PROPOSITION 8: *Suppose that* $\Phi = \frac{1-\theta}{\theta}$. *The optimal government policy satisfies* $\tau_1 = 0$, $\tau_2 < 1$, *and* $B \neq 0$.

PROOF:

See online Appendix L.

Because all agents have the same income (net of the disutility of effort) when $\Phi = \frac{1-\theta}{\theta}$, positive taxes in the first period distort effort but do not generate any redistribution. It is then optimal to set them to zero. In the second period, entrepreneurs earn different income, and redistribution would be desirable. However, taxes also discourage effort, which in turn reduces income for both workers and entrepreneurs. The government trades off the gains from redistribution against the costs of distortions and chooses a positive but nonconfiscatory tax rate. Since the insurance provided by taxes is partial and entrepreneurs still face uncertain consumption, issuing public debt in period 1 is still optimal even though the government has access to a richer set of instruments.[10] This result differs from that of Golosov and Sargent (2012), who find that public debt is irrelevant. They reach a different result because, in their model, agents have full access to financial markets. In our model, market incompleteness plays a central role.

B. *Time Consistency*

In the two-period model, optimal policy is time-consistent, since debt is chosen only once. However, when there are more than two periods, public debt is chosen at different dates. Hence, it would make a difference whether debt is chosen under commitment (the optimization problem is solved only in period 1) or under discretion (the problem is solved sequentially).

To illustrate this point, consider a three-period economy: that is, $T = 3$. To simplify the discussion we abstract from uncertainty and assume that $z_t^i = \overline{z}$ for all $t = 1, 2, 3$. Entrepreneurs are endowed with the same initial assets, $k_1^i = \overline{k} = 1$ and $b_1^i = b_1 \geq 0$. Since there is no uncertainty, profits are constant and equal to $\pi_t = \overline{A}$. Consumption of entrepreneurs and workers is defined, respectively, in equations (10) and (11). Because $B_4 = 0$, interest rates satisfy

$$(22) \qquad R_1 = \frac{\overline{A} + \nu\left[(1+\beta)B_2 - \frac{B_3}{R_2}\right]}{\beta(\overline{A} + \nu B_1)} \quad \text{and} \quad R_2 = \frac{\overline{A} + \nu(1+\beta)B_3}{\beta(\overline{A} + \nu B_2)}.$$

(2003); Albanesi and Sleet (2006); and Farhi and Werning (2008). We can then characterize the constrained socially optimal allocation, and public debt could be one of the instruments used to decentralize the allocation.

[10] This is robust to the consideration of progressive taxes as long as the fiscal system is not discriminatory. In particular, lump-sum transfers cannot differ between workers and entrepreneurs. Otherwise, public borrowing could be replicated with positive (negative) transfers to workers (entrepreneurs) in period 1 and the reverse in period 2.

Since we abstract from idiosyncratic shocks, there is no insurance motive for holding debt. As a result, if $b_1 = B_1 = 0$, it is optimal to set $B_2 = B_3 = 0$. However, when initial debt is different from zero, that is, $B_1 > 0$, the government's problem amounts to the optimal timing of repaying B_1. We now show that the optimal B_2 and B_3 differ under commitment and discretion. To simplify the analysis, we focus on the autarky regime with only one country.

Optimal Policy with Commitment.—Under commitment, the government chooses B_2 and B_3 in period 1 to solve the problem

$$\max_{B_2, B_3} \left\{ \Phi\left[\ln c_1^w + \beta \ln c_2^w + \beta^2 \ln c_3^w\right] + \ln c_1^e + \beta \ln c_2^e + \beta^2 \ln c_3^e \right\},$$

subject to (10), (11), and (22). The first-order conditions are

$$(23)\quad B_2 : \Phi\left(\frac{1 - \epsilon(B_2)}{c_1^w R_1} - \frac{\beta}{c_2^w}\right) - \left(\frac{1 - \epsilon(B_2)}{c_1^e R_1} - \frac{\beta}{c_2^e}\right) + \frac{\partial\left(\frac{B_3}{R_2}\right)}{\partial B_2}\beta\left(\frac{\Phi}{c_2^w} - \frac{1}{c_2^e}\right) = 0,$$

$$(24)\quad B_3 : \Phi\left(\frac{1 - \epsilon(B_3)}{c_2^w R_2} - \frac{\beta}{c_3^w}\right) - \left(\frac{1 - \epsilon(B_3)}{c_2^e R_2} - \frac{\beta}{c_3^e}\right) + \frac{\partial\left(\frac{B_2}{R_1}\right)}{\partial B_3}\beta^{-1}\left(\frac{\Phi}{c_1^w} - \frac{1}{c_1^e}\right) = 0.$$

Optimal Policy with Discretion.—Without commitment, the problem can be solved backward starting at $t = 2$ when the government chooses B_3. This solves

$$\max_{B_3} \left\{ \Phi\left[\ln c_2^w + \beta \ln c_3^w\right] + \ln c_2^e + \beta \ln c_3^e \right\},$$

subject to (10), (11), and (22). The first-order condition is

$$(25)\qquad \Phi\left(\frac{1 - \epsilon(B_3)}{c_2^w R_2} - \frac{\beta}{c_3^w}\right) - \left(\frac{1 - \epsilon(B_3)}{c_2^e R_2} - \frac{\beta}{c_3^e}\right) = 0.$$

This characterizes the government policy in period 2, which we denote by $B_3 = \mathsf{B}_3(B_2)$. Because the government takes past decisions as given, it does not internalize the redistributive effects of B_3 on first-period consumption. With commitment, instead, when the government chooses B_3, it takes into account that this policy also affects consumption in period 1 as captured by the last term in equation (24). This term, which is positive, is absent in condition (25).[11] By ignoring this effect, the government would *under-borrow* in period 2 compared to a government that chooses the whole sequence of public debts in period 1.

[11] As in the two-period economy, $\Phi/c_1^w > 1/c_1^e$ is a sufficient condition for the interest rate to be increasing, as will be assumed here. In addition, $\partial(B_3/R_1)/\partial B_3 > 0$, implying that the last term in equation (24) is positive.

Going back to period 1, the government solves the problem

$$\max_{B_2}\left\{\Phi\left[\ln c_1^w + \beta \ln c_2^w + \beta^2 \ln c_3^w\right] + \ln c_1^e + \beta \ln c_2^e + \beta^2 \ln c_3^e\right\},$$

taking as given the optimal policy rule in period 2: that is, $B_3 = \mathsf{B}_3(B_2)$.

The main difference between this problem and the one under commitment is that next period's policy, $B_3 = \mathsf{B}_3(B_2)$, is taken as given. The first-order condition is

$$\text{(26)} \quad \Phi\left(\frac{1-\epsilon(B_2)}{c_1^w R_1} - \frac{\beta}{c_2^w}\right) - \left(\frac{1-\epsilon(B_2)}{c_1^e R_1} - \frac{\beta}{c_2^e}\right) + \frac{\partial\left(\frac{B_3}{R_2}\right)}{\partial B_2}\beta\left(\frac{\Phi}{c_2^w} - \frac{1}{c_2^e}\right) + \frac{\partial\left(\frac{B_2}{R_1}\right)}{\partial B_3}\frac{\partial \mathsf{B}_3(B_2)}{\partial B_2}\left(\frac{\Phi}{c_1^w} - \frac{1}{c_1^e}\right) = 0,$$

which defines the optimal policy rule in period 1, $B_2 = \mathsf{B}_2(B_1)$.

The last term in equation (26), which is absent in equation (24), captures the "strategic manipulation" of policy in period 2 when the government chooses policy in period 1. The government understands that the future choice of B_3 has an effect on first-period consumption, which it will ignore in period 2 when B_3 will actually be chosen. Anticipating this, the government chooses B_2 to affect (manipulate) the future choice of B_3.

Figure 8 shows the difference in public debt with and without commitment, for particular parameter values. The continuous lines denote the time-consistent solution, while the dashed lines denote the solution with commitment. We can see that, for any initial level of debt B_1, the time-consistent solution lies below the solution with commitment.

IV. Infinite-Horizon Model

In this section we show that the main properties of the two-period model shown in Section II extend to a model with a large number of periods T. In particular, financial liberalization can lead to an increase in public debt and this is exacerbated by a rise in income risk. In addition, by considering more periods, we can also study the transition dynamics induced by capital liberation and a rise in income risk and the evolution of the interest rate.

Since entrepreneurs face idiosyncratic shocks, the model generates a complex distribution of income and wealth. By virtue of the linearity of the production function, the model admits aggregation. An implication of this property is that income and wealth follow random walks and the economy-wide distributions are not stationary. This property becomes problematic if we want to compare the inequality generated by the model with the inequality observed in the data. Thus, to have a stationary distribution of income and wealth, we make the additional assumption that agents survive with some probability $\omega < 1$ and they are replaced by the same number of newborn agents. The discount factor β then results from the product of two

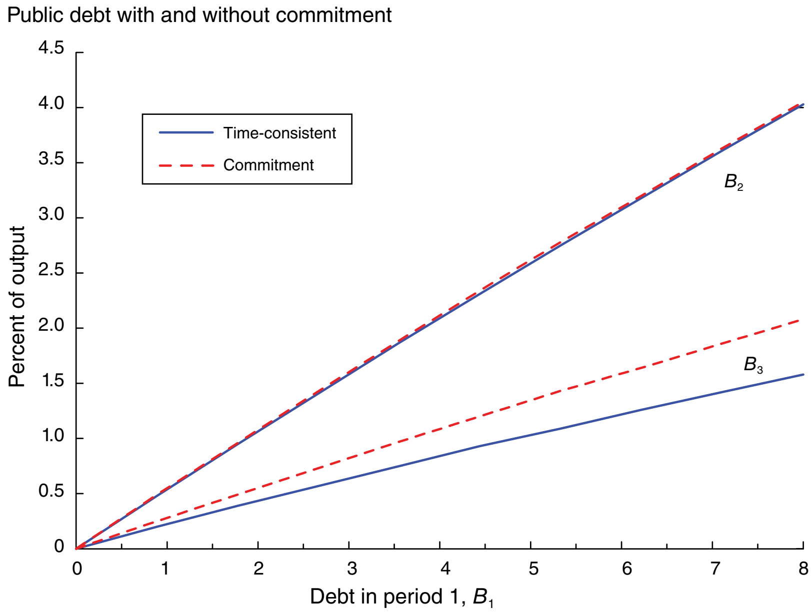

FIGURE 8. TIME-CONSISTENT VERSUS COMMITMENT POLICY FUNCTIONS

Notes: Time horizon is three periods, $T = 3$, and we focus in the autarky equilibrium. Parameters: $\beta = 0.95$, $\theta = 0.2$, $z = 1$ and, $\nu = \Phi/(1 + \Phi) = 0.85$.

terms: the intertemporal discount factor in preferences, $\hat{\beta} \in (0, 1)$, and the survival probability, $\omega \in (0, 1)$. The assets left by exiting entrepreneurs are redistributed equally (lump-sum) to newborn entrepreneurs.[12]

A. *Politico-Economic Equilibrium*

We think of the infinite-horizon model as the limit of $T \rightarrow \infty$. Policies are chosen in every period and they are functions of the relevant aggregate states. Suppose that, at $t = 1$, countries start with the same aggregate excess holdings of bonds: that is, $\tilde{b}_{j,1} = \nu \sum_{j=1}^{N} B_{j,1}$. Using Corollary 1, the sufficient set of states are the stocks of debt issued by the N countries, $\mathbf{B}_1 = (B_{1,1}, \ldots, B_{N,1})$.

To characterize the strategic interaction between governments, we restrict attention to Nash equilibria where each country chooses its own public debt simultaneously and without coordination. The politico-economic equilibrium is characterized by a sequence of policy functions $\mathbf{B}_{t+1} = \mathcal{B}_t(\mathbf{B}_t)$ for $t = 1, \ldots, T$. These functions are determined by solving the model backward, starting at $t = T$. Let's define first the government's objective at t.

[12] All the properties of the competitive equilibrium derived earlier apply to the model with stochastic survival. We only need to reinterpret the discount factor as $\beta = \hat{\beta}\omega$. If public debt stays constant over time, the distributions of income and wealth converge to a steady state.

PROPOSITION 9: *Given current states* $\mathbf{B}_t$ *and policy function* $\mathcal{B}_{t+1}(\mathbf{B}_{t+1})$ *for next-period policies, the problem solved by government j at time t is*

$$\max_{B_{j,t+1}} \left\{ \Phi W_{j,t}(\mathbf{B}_t, \mathbf{B}_{t+1}) + V_{j,t}(\mathbf{B}_t, \mathbf{B}_{t+1}) \right\}, \tag{27}$$

where the functions $W_{j,t}$ *and* $V_{j,t}$ *are defined recursively as*

$$W_{j,t}(\mathbf{B}_t, \mathbf{B}_{t+1}) = \ln\left(\overline{w} + \frac{\nu B_{j,t+1}}{R_{j,t}} - \nu B_{j,t}\right) + \beta W_{j,t+1}(\mathbf{B}_{t+1}; \mathcal{B}_{t+1}(\mathbf{B}_{t+1})),$$

$$V_{j,t}(\mathbf{B}_t, \mathbf{B}_{t+1}) = \ln(1-\eta_t) + \left(\frac{1}{1-\eta_t}\right)\left[\mathrm{E}\ln(A(z^i_{j,t}) + \nu B_{j,t} + p_{j,t}) + \eta_t \ln\left(\frac{\eta_{j,t}\,\phi_{j,t}}{p_{j,t}}\right)\right]$$
$$+ \beta \mathrm{E} V_{j,t+1}(\mathbf{B}_{t+1}, \mathcal{B}_{t+1}(\mathbf{B}_{t+1})).$$

PROOF:

See online Appendix M.

In solving problem (27), the government of country j takes as given the level of debt chosen by all other countries, the vector $\mathbf{B}_{-j,t+1}$. The solution, denoted by $B_{j,t+1} = \varphi_{j,t}(\mathbf{B}_t, \mathbf{B}_{-j,t+1})$, represents the optimal response function to the policies chosen by the other governments.[13]

DEFINITION 2 (Nash Policy Game): *For given states* $\mathbf{B}_t$*, the solution to the Nash policy game at time t is the vector* $\mathbf{B}^*_{t+1}$ *that satisfies* $B^*_{j,t+1} = \varphi_{j,t}(\mathbf{B}_t, \mathbf{B}^*_{-j,t+1})$*, for all* $j = 1, \ldots, N$.

The solution to the policy game at time t provides the policy function $\mathbf{B}_{t+1} = \mathcal{B}_t(\mathbf{B}_t)$. Starting from $t = T$ and taking into account the terminal condition $\mathcal{B}_T(\mathbf{B}_T) = 0$, we can then construct the whole sequence of policy functions backward. The infinite horizon is obtained as $T \to \infty$. Assuming convergence, the politico-equilibrium is characterized by an invariant policy function $\mathcal{B}(\mathbf{B}) = \lim_{T\to\infty} \mathcal{B}_1(\mathbf{B}_1)$. Because of the complexity of the model, we are unable to find a closed-form solution. Thus, we will only provide a numerical characterization by solving the model for a large but finite number of periods T.

B. *Quantitative Analysis*

To show the impact of financial liberalization, we start from a steady-state equilibrium without mobility of capital and compute the transition dynamics following financial integration. Similarly, to show the impact of rising income risk, we start from a steady state with low income risk and compute the transition dynamics

[13] Newborn agents do not appear separately in the welfare functions because of the aggregation result and the assumption that assets left by existing entrepreneurs are distributed to newborn entrepreneurs.

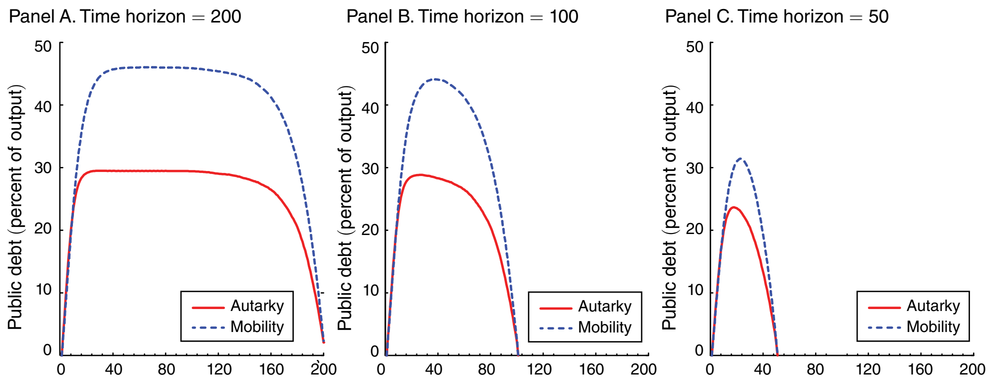

Figure 9. Evolution of Government Debt for Different Time Horizons

following the increase in the volatility of the idiosyncratic shock. We solve the model numerically using a global approach based on the discretization of the state space (the stocks of public debt in the N countries) and grid search optimization. The detailed description of the numerical procedure is in the online Appendix. To find a steady state, we solve the model for a large number of periods T and simulate the model for $t = 1, \dots, T/2$. The steady state is the equilibrium in period $t = T/2$. Provided that T is large, the stock of debt converges to the level reached at $t = T/2$ relatively quickly (see Figure 9).

Parameterization.—We fix the number of countries to $N = 2$ and assume that they are symmetric. Although the numerical simulation is not meant to provide a rigorous quantitative exercise but to illustrate the qualitative dynamic features of the model, we try as much as possible to choose the parameters according to observed empirical targets. More specifically, we choose variables observed pre-1980s as the initial calibration targets. This is motivated by the view that the process of international financial liberalization started in the 1980s. The pre-1980s period can then be considered as closer to a regime of financial autarky. Also, as can be seen from Figure 1, the average income inequality in industrialized countries started to increase toward the end of the 1970s and early 1980s. This motivates our choice to calibrate the autarky version of the model to the early 1980s. In particular, we focus on two targets: a ratio of public debt over income of 30 percent and a share of income earned by the top 1 percent of the population equal to 6 percent. These are the approximate numbers reported in Figure 1 for the OECD countries in the 1970s. We will describe below how these calibration targets can be used to pin down some of the key parameters.

A period in the model is one year and the discount factor is set to $\beta = 0.9466$, which results from an intertemporal discount rate of 3 percent and a survival probability $\omega = 0.975$. The value of ω implies an average (active) life of 40 years.

For the production function we would like to use a Cobb-Douglas specification: that is, $F(z, k, l) = z^{\theta} k^{\theta} l^{1-\theta}$, with $\overline{z} = Ez$ normalized to 1. However, the amount of idiosyncratic risk generated by this specification is bounded by the nonnegativity of z. In order to have more flexibility, we assume that the shock z also affects the effective quantity of land after production. Thus, the total income generated by the entrepreneur is $z^{\theta}\, k^{\theta}\, l^{1-\theta} + (z - \overline{z})kp$. The first component is pure production while the second component can be interpreted as capital gains (or losses if negative). Notice that in aggregate the capital gains or losses are zero. Thus, the aggregate production is exactly the same when z multiplies only production or land. Also, in both cases θ represents the capital income share, which we set to 0.2. This is lower than the typical number used in the literature because there is no depreciation in the model.

The shock is uniformly distributed in the domain $1 \pm \Delta$, where Δ is chosen so that the share of income earned by the top 1 percent is equal to 6 percent in the autarky steady state.[14] However, this also depends on Φ, which in turn is chosen to have a steady state of public debt over income of 30 percent in the autarky steady state. These are the approximate numbers for income concentration and public debt in the OECD countries pre-1980, reported in Figure 1. To reach these two targets, the values of Δ and Φ are chosen simultaneously through an iterative procedure. The resulting values are $\Delta = 0.14$ and $\Phi = 3.902$. They imply that the standard deviation of entrepreneurial income is about 15 percent of the value of land used in production, pk, and the population share of workers is slightly below 80 percent.

Results.—Figure 9 shows the evolution of public debt over time for different time horizons under autarky and mobility. Debt is smaller when the horizon is short (panel C). This is because high borrowing in the initial periods will result in low workers' consumption in the terminal periods, when debt needs to be repaid. Given the concavity of the utility function, this will reduce welfare. As the horizon expands, so does the number of periods over which debt can be repaid, which increases the desire to borrow initially. The infinite-horizon economy can be well approximated with $T = 200$. As panel A of Figure 9 indicates, B converges after about 40 periods. The figure also shows that financial integration has stronger effects when the horizon is longer.

Figure 10 plots the transition dynamics for government debt induced by international capital market liberalization and increased income inequality. The initial equilibrium is the steady state under autarky. This is the middle point of panel A of Figure 9. The increase in income inequality is generated by a higher volatility of the idiosyncratic risk, which changes from $\Delta = 0.14$ to $\Delta = 0.1725$. As described above, $\Delta = 0.14$ was chosen to generate the 6 percent concentration of income at the top 1 percent in the autarky steady state. The new value is chosen to have a share of 7.5 percent for the top income earners in the steady state with capital mobility. As shown in Figure 1, this is about half the increase in concentration for the OECD countries during the sample period: The top 1 percent share is about 9 percent toward the end of the sample. Since we do not know which part of the increase in inequality is driven by income risk (as opposed to cross-sectional inequality that is predictable at the individual level), we have assumed that the increase in risk contributed only 50 percent. The targeted number has been replicated in the steady state with

[14] Entrepreneurial income is equal to $A(z_t^i)k_t^i + (z_t^i - \overline{z})k_t^i p_t + b_t^i - b_t^i/R_t + \tau_t$: that is, profits, interests, and transfers. The income of an individual worker is equal to $w_t/\Phi + \tau_t$: that is, labor income plus transfers.

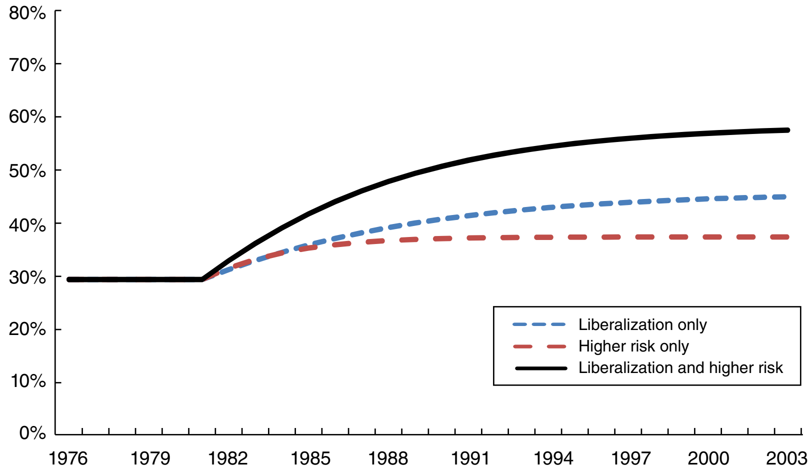

Figure 10. Responses of Public Debt Financial Liberalization and Increased Income Risk

mobility because the 2000s are characterized by a high degree of financial integration among industrialized countries.

Before continuing, we would like to explain why we make the assumption that inequality increases in both countries even if, in the data, the increase is observed only in some countries (see Atkinson, Piketty, and Saez 2011). Our choice is motivated by computational considerations. When countries have different Δ, Corollary 1 no longer holds. Thus, we cannot impose the condition that domestic and foreign entrepreneurs hold the same $\tilde{b}$. This implies that, to compute the equilibrium, we have to add another state variable: $\tilde{b}_1$ or $\tilde{b}_2$. With capital mobility this increases the computational complexity significantly. However, limiting the analysis to the symmetric case is not a major shortcoming because, as shown in Section II with the two-period model, the change in inequality in only one country also affects the debt chosen by the other country when financial markets are integrated. Thus, using the average change in inequality as the target for all countries provides a reasonable approximation to the response of public debt in all integrated economies when the change is asymmetric.

As can been seen in Figure 10, capital liberalization (ignoring higher risk) increases long-term debt from 30 percent of income to about 46 percent of income. If we focus instead on the change in risk alone (keeping the economies in autarky), long-term debt increases to 38 percent of income. When the two changes are considered together, long-term debt increases to 59 percent.

To compare the dynamics of the model to the empirical series, panel A of Figure 11 plots the public debt predicted by the model (in response to both liberalization and increased risk) and the empirical data for the average of OECD countries, Europe, and the United States. The dynamic path of public debt generated by the model (continuous line) resembles the dynamics observed in the data (dashed lines). Panel B of Figure 11 reports the response of the interest rate, which is also qualitatively similar to the data. In particular, we see interest rate hikes at the beginning of the 1980s, with a subsequent decline later in the sample.

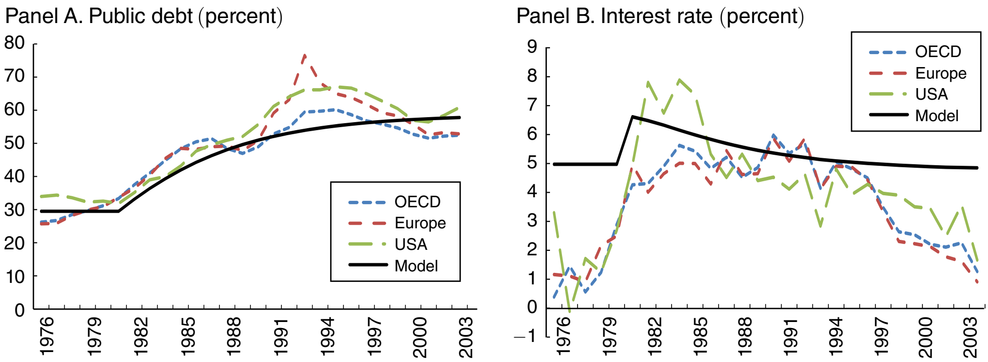

FIGURE 11. RESPONSES OF PUBLIC DEBT AND REAL INTEREST RATES TO LIBERALIZATION AND INCREASED INCOME RISK

The initial jump in the interest rate generated by the model is necessary to make bonds attractive to entrepreneurs who are the buyers of the additional bonds. Since the government continues to increase 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.[15]

We would like to emphasize that the comparison of the interest rate dynamics generated by the model with the empirical series is not meant to show that the interest rate dynamics can be fully explained by capital market liberalization and increased income risk. Of course, many other factors contributed to the interest rate dynamics, especially the hike in the early 1980s. We only want to show that the pattern predicted by the model is not inconsistent with the pattern observed in the data. Also, if the changes in capital mobility and income risk were gradual, then the response of the interest rate generated by the model is likely to also be more gradual.

In our model, governments increase debt as a result of financial liberalization because they perceive the interest rate elasticity (to their own debt) to be lower than it was under autarky. To test whether this key mechanism is consistent with the US experience, we can quantify the decline in elasticities predicted by our model and, possibly, compare it to the data. This is done as follows. We first calculate the elasticity of the interest rate to a country's debt in the steady state under autarky. That is, we consider an arbitrary 1 percent increase in the debt of country 1 and calculate the resulting increase in its equilibrium interest rate (assuming that debt is chosen optimally from then on). Notice that the response of the equilibrium interest rate to

[15] The dynamic of the interest rate can be understood by looking at the Euler equation for bonds for a representative entrepreneur, $1 = \beta R_t \mathrm{E}_t(c_t/c_{t+1})$. As long as the government borrows more in response to liberalization, the consumption growth increases (since current consumption must decline in order to buy additional bonds). Then we can see from the Euler equation that the interest rate R_t increases. After the initial increase, the growth rate of consumption declines gradually and converges back to steady state. This implies that the interest rate declines after the initial jump. In response to an increase in income risk, however, it is more difficult to illustrate the dynamics of the interest rate because there are two contrasting effects. The first is the effect already described. The second derives from the fact that, since entrepreneurs face higher risk, the term $\mathrm{E}_t(c_t/c_{t+1})$ increases (as a result of the higher volatility of c_{t+1}). This tends to reduce the interest rate, as we can see from the Euler equation. Since there are two effects, we cannot say which one dominates. However, we have conducted some numerical sensitivity analysis and found that the initial jump and the subsequent decline are quite robust.

the current debt deviation will take into account the whole transition path induced by the one-time deviation in the current period. We then compute the elasticity in the regime with capital mobility by considering a similar deviation from the steady state. With capital mobility it is also important what happens to the debt of country 2. We assume that in the current period the debt of country 2 does not respond to the debt deviation in country 1 but remains at the steady state. Starting from the next period, however, both countries choose their debt optimally.

For the autarky low-risk regime, the model generates an elasticity of 0.68: that is, a 1 percent increase in public debt is associated with an interest rate increase of 0.68 percent. For the regime with capital mobility and high risk, the model generates an interest rate elasticity of 0.41. These numbers confirm the theoretical result that capital mobility is associated with lower interest rate elasticity to the debt of one country.

To compare the elasticities generated by the model with the data, the online Appendix regresses the percentage change in the real interest rate on the percentage change in real debt, its interaction with the index of financial liberalization, and other controls. The interest rate elasticity is the sum of the coefficients for the debt change and its interaction with the financial index. The time dependence of the elasticity is then captured by the change in the financial index. For the pre-1980s period—that is, the period characterized by limited international mobility of capital—the average (over the years) of the estimated elasticity is 0.046. For the post-1980s period—that is, the period characterized by greater mobility of capital—the average elasticity is 0.007.

We should be cautious, however, in comparing the empirical elasticities to those generated by the model. As already remarked in footnote 1, the empirical estimation provides only suggestive evidence about the dependence of the demand elasticity on financial liberalization since movements in the interest rate can be the result of movements in both demand and supply. Only if the position (but not necessarily the slope) of the demand function has remained stable during the sample period—relative to the supply—can the estimated elasticities reflect the slope of the demand function. With this in mind, we observe that the estimated elasticities are much smaller than the elasticities generated by the model. However, we should take into account that the interest rate considered in the model is the short-term rate, that is, the interest rate on one year debt. The interest rate used in the estimation, instead, is for ten-year government bonds. Although we do not consider explicitly in the model the government issuance of ten-year bonds, we can still price it since, in the model, there is a simple relation between the interest rate or yield on a long-term bond and the short-term rates.

Denote by R_t^{10} the annualized interest rate at time t on a ten-year bond and by R_{t+j}^1 the interest rate at time $t+j$ on a one-year bond. The interest rate on the ten-year bond is related to the interest rates on one-year bonds by the equation $R_t^{10} = (\Pi_{j=0}^9 R_{t+j}^1)^{\frac{1}{10}}$. Using this equation to derive the interest rate on a ten-year bond, the interest rate elasticities in the two regimes become, respectively, 0.041 and 0.028. These numbers are significantly closer to the empirical elasticities of 0.046 for the preliberalization period and 0.007 for the postliberalization period. In particular, the preliberalization elasticities are remarkably similar. The postliberalization elasticity predicted by the model, however, is larger than the estimated average elasticity. Nevertheless, we should take into account that, in the model, a country accounts for half of the world economy while the average size of the countries included in the data sample is much smaller. If we recalibrate the model so that the first country accounts for a smaller share of the world economy, the interest rate elasticity of this country would be significantly smaller when the financial markets are internationally integrated.

V. Conclusion

The stock of public debt has increased in most advanced economies during the last 30 years, a period also characterized by extensive liberalization of international capital markets and a sustained increase in income inequality. In this paper we study a multicountry politico-economic model where the incentives of governments to borrow increase both when financial markets become internationally integrated and when inequality rises if this is associated with higher income risk. We propose these mechanisms as two of the possible explanations for the growing stocks of government debt observed in most advanced economies since the early 1980s.

Of course, we do not claim that the two mechanisms studied in this paper are the only factors explaining the rising public debt in industrial countries. Most likely, other factors may have also played some role. For example, the economic growth of emerging countries and, especially China, may have contributed to the rising public debt in industrialized countries. The increasing demand for government bonds issued by advanced economies, and the United States in particular, may have lowered the world interest rate, making government borrowing cheaper. In support of this hypothesis there is the observation that the share of US public debt held abroad has grown significantly during the last 30 years. It is also important to point out that the international liberalization of capital markets took place in tandem with the growing sophistication of domestic financial markets, especially in developed countries. This trend could have counterbalanced the effects of the two forces emphasized in the paper (integrated capital markets and greater risk). At the same time, however, the greater demand for safe assets from emerging economies has tilted the composition of the foreign portfolio of industrialized countries toward riskier assets as documented in Gourinchas and Rey (2007) and Lane and Milesi-Ferretti (2007). Therefore, even if financial markets have become more sophisticated in industrialized countries, this does not necessarily mean that these countries are facing less risk overall.[16]

The final remark relates to the relevance of the analysis conducted in this paper for understanding the recent difficulties in sovereign borrowing. If debt crises are more likely to arise when the stock of public debt is higher, then the growth in government borrowing induced by capital market liberalization and increased income inequality may contribute to triggering a sovereign debt crisis. An extension that explicitly studies the possibility of default on sovereign debt is left for future research.

[16] Effectively, the ability to better insure the risk in developed countries may have induced these countries to take more risk in emerging economies. See Mendoza, Quadrini, and Ríos-Rull (2009) for a model that captures this idea.

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