

# Globalization and Risk Sharing\*

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## Abstract

We study the effects of globalization on risk sharing and welfare. Like previous literature, we assume that countries cannot commit to repay their debts. Unlike previous literature, we assume that countries cannot discriminate between domestic and foreign creditors when repaying their debts. This creates novel interactions between domestic and international asset markets: (i) globalization increases the fraction of debts held by foreigners, thereby increasing the incentives to default; (ii) deep domestic asset markets facilitate access to international markets. We show how these effects depend on various characteristics of tradable goods and explore the roles of reputation, renegotiation, and borrowing limits.

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What is the effect of globalization on risk sharing and welfare? This is an old question in international trade theory that has gained increased relevance as the world economy becomes more integrated. Textbook predictions notwithstanding, there is a widespread and growing perception that globalization is making the world riskier and this reduces welfare. Newbery and Stiglitz (1984) provided an early and very influential example showing how this might happen. They considered the case of a small country in which individuals face production risk and examined the effects of globalization, which they modeled as a drastic improvement in technology that reduces trade costs from prohibitive to negligible. Before globalization, shocks to production lead to offsetting movements in goods prices that stabilize individual incomes. After globalization, shocks to production no longer affect goods prices and individual incomes become volatile. Newbery and Stiglitz showed that the welfare costs of this worsening in risk sharing exceed the welfare gains from goods trade. This example was meant to suggest that policies that restrict trade might sometimes improve welfare.<sup>1</sup>

Newbery and Stiglitz did not explain why, in their example, individuals cannot insure themselves against income risk. And knowing this turns out to be crucial for their argument. Perhaps small transaction costs are enough to close insurance markets before globalization since individual incomes are stable and the demand for insurance is low. But then, one should expect that insurance markets open after globalization as individual incomes become volatile and the demand for insurance increases. In this case, globalization need not worsen risk sharing and adopting policies that restrict trade would reduce welfare. This modified version of the Newbery-Stiglitz example illustrates the very general point that it is crucial to identify the sources of market incompleteness to understand how globalization affects risk sharing and welfare.

This point has been forcefully made in a series of seminal papers by Dixit (1987, 1989a, and 1989b) who adopts the view that markets are incomplete because of informational problems. In particular, Dixit assumed that individuals have private information about their actions (moral hazard), the state of nature (imperfectly observed outcomes), or their type (adverse selection). The main result that comes out from Dixit's work is that, unless we add exogenous restrictions on the nature of private contracts that are available or the sort of government policies that are feasible, globalization is welfare improving. The intuition is the same as in the modified Newbery-Stiglitz example. If globalization raises the demand for insurance, private arrangements and government policies that allow individuals to share this risk will be naturally adopted. Once we allow markets and governments to optimally react to the changes brought about by globalization there is no

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<sup>1</sup>Eaton and Grossman (1985) make a similar point.

further room for policies that restrict trade.<sup>2</sup>

There is little doubt that private information is pervasive and that this constitutes a major source of market incompleteness. But it cannot be the only one. As Dixit himself points out, the presence of private information can account for the lack of insurance against individual risk but it cannot account for the lack of insurance against aggregate or country risk. The reason is that aggregate shocks are observable and, in the absence of additional frictions, it should be possible to write contracts and design policies that are contingent on them. Yet, there is substantial evidence suggesting that aggregate risk is not well insured across countries.<sup>3</sup>

In this paper, we adopt the alternative but complementary view that markets are incomplete because of enforcement problems. These problems arise when governments have a preference for their own citizens and cannot commit to force them to repay their debts. This time-inconsistency problem is known as sovereign risk and it is widely recognized that this friction can explain why insurance against aggregate or country risk is not available. Moreover, we shall show here that sovereign risk can also explain why insurance against individual risk is not available even if all information is public. Unlike Dixit, we find that the availability of insurance might decline even if globalization increases its demand and markets and governments react optimally to changes in the environment. The reason is that globalization also increases the severity of the underlying friction, namely, sovereign risk. This did not happen in Dixit's models since the amount of private information is not affected by globalization.<sup>4</sup>

We study a world with two symmetric regions. The basic setup also has two periods, youth and old age, although sometimes we re-interpret it as a many-period model with an overlapping-generations structure. During youth, all individuals have identical preferences and own an ex-ante identical project that delivers output during old age. The return to this project is random and this leads to ex-post differences in production bundles during old age. This provides a role for markets to help individuals pool or share production risks. Goods markets open during old age and allow individuals to trade commodities or goods, while asset markets open during youth and

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<sup>2</sup>This view has also played an important role in the recent debate on the effects of globalization on the size of governments. Rodrik (1998) finds a robust relationship between government size and openness. He argues that globalization increases individual risk and, in the absence of appropriate insurance markets, governments must grow to deal with the increased need for social insurance mechanisms. See Epifani and Gancia (2008) for an alternative view of why globalization raises the size of governments.

<sup>3</sup>See Lewis (1999) for a useful survey of the empirical literature supporting this claim. See also Kose, Prasad, and Terrones (2003a and 2003b) and Kose, Prasad, Rogoff, and Wei (2003) who review the evidence on the effects of financial globalization on consumption and income volatility at the country level.

<sup>4</sup>There are three recent papers that deal with some of these issues. McLaren and Newman (2002) and Levchenko (2005) examine the effects of globalization on risk sharing. The first of these papers models globalization as a reduction in search frictions, while the second models it as the removal of restrictions to asset trade that affects only a subset of the population. Dixit (2003) analyzes the effects on contract enforcement of a reduction in the distance between traders.

allow individuals to trade promises or assets. Naturally, asset markets can only open if governments enforce during old age the trades agreed upon during youth. We assume that governments choose their enforcement policy so as to maximize the average utility of the individuals in their region. As usual, this leads governments to prefer different enforcement policies over time. During youth, governments would like to commit to enforce all payments during old age and allow domestic residents to reap all the gains from trade. But during old age, governments prefer not to enforce payments to foreign residents because they lower domestic consumption and welfare.

There are two polar cases that deliver well-known results in this setup. The first one is the perfect commitment model. If governments can credibly commit during youth to enforce all payments during old age, they will always choose to do so. In this case, asset markets are always open and there is perfect domestic sharing of all goods and perfect international sharing of tradable goods. Globalization is welfare-improving because it increases the fraction of goods that can be shared internationally. The other polar case is the perfect discrimination model without commitment. If governments choose during old age which payments to enforce, they will choose a discriminatory policy that enforces payments between domestic residents but does not enforce payments from domestic residents to foreign ones.<sup>5</sup> In this case, asset markets are also open but geographically segmented. As a result, there is perfect domestic sharing of all goods but only imperfect international sharing of tradable goods. Globalization is welfare-improving again because it increases the fraction of goods that are shared internationally, even if imperfectly.<sup>6</sup>

We think that these polar cases leave behind the most interesting effects of globalization, namely, those on the workings of asset markets. To show this, we study here a third polar case in which governments have neither commitment nor the ability to discriminate between domestic and foreign creditors when enforcing payments. In this situation, asset markets are never geographically segmented if open, but some asset markets might be closed. This is the result of governments facing a trade-off when deciding whether to enforce payments that is absent in the other two polar cases. On the one hand, enforcement increases payments from domestic to foreign residents that lower domestic consumption and welfare. On the other hand, enforcement increases payments between domestic residents that contribute to domestic sharing of goods and therefore raise welfare. This trade-off determines the states of nature in which governments choose to enforce payments during old age and, therefore, the set of assets that can be traded during youth. In states of nature in which asset markets are open, there is perfect domestic sharing of all goods and perfect interna-

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<sup>5</sup>Enforcement of payments between domestic residents increases average utility in the region because, in equilibrium, payments are made by individuals with low marginal utility to individuals with high marginal utility.

<sup>6</sup>International sharing of tradable goods is imperfect since it only takes place in goods markets. During old age, regions sell those tradable goods that are relatively abundant in their bundle and buy those that are relatively scarce.

tional sharing of tradable goods. In states of nature in which asset markets are closed, there is not only imperfect international sharing of tradable goods but also imperfect domestic sharing of all goods.<sup>7</sup>

This enforcement trade-off provides a theory of asset market incompleteness based on sovereign risk that we exploit to study the effects of globalization. The most novel aspect of our analysis is to show how globalization affects the degree of asset market incompleteness. In particular, globalization increases payments from domestic to foreign residents, reducing the incentives to enforce payments and increasing asset market incompleteness. We show how this negative effect of globalization depends on the nature of goods that are traded and how these are distributed among individuals. We also show that the extent to which globalization affects asset market incompleteness depends on the importance of domestic payments. Our theory also incorporates other, more standard, effects of globalization on risk sharing that also take place in models where the degree of asset market incompleteness is exogenous. In those states of nature in which asset markets are open, globalization leads to perfect international sharing of newly traded goods without affecting domestic sharing of goods. In those states of nature in which asset markets are closed, globalization still improves international sharing of tradable goods but, unlike in the other polar cases, globalization might now also improve or worsen domestic sharing of goods.

This paper moves the theory of sovereign risk towards greater empirical relevance both in terms of its assumptions and its results. Regarding assumptions, today's institutional setup for international borrowing is arguably closer to the polar case of non-discriminatory enforcement than to the opposite case of perfect discrimination on which all the previous literature has focused.<sup>8</sup> Governments borrow from abroad mostly by selling bonds which are traded in increasingly deep secondary markets, while liberalized capital accounts permit the private sector to access international financial markets directly or through an increasing variety of financial intermediaries. In such an environment, governments' ability to discriminate between domestic and foreign creditors is seriously limited. For example, when borrowing takes place by selling bonds or stocks, even when

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<sup>7</sup>Kremer and Mehta (2000) and Rappoport (2005) also adopt the non-discrimination assumption and study the implications of this trade-off for the determination of government debt and tax policy.

<sup>8</sup>There is an extensive literature on sovereign risk that developed in response to the debt crises of the early 1980's in emerging markets. See Eaton and Gersovitz (1981), Grossman and van Huyck (1988), Bulow and Rogoff (1989a and 1989b), Fernández and Rosenthal (1990), Atkeson (1991), Cole, Dow, and English (1995), Cole and Kehoe (1997), Kletzer and Wright (2000), Kehoe and Perri (2002), Wright (2002), and Amador (2003). See Eaton and Fernández (1995) for an excellent survey. All these papers implicitly assume that there is perfect domestic risk sharing (by assuming that each region contains a representative consumer) and ask when governments have an incentive to enforce international payments. This approach, which is akin to assuming perfect discrimination, was justified since in this period governments borrowed abroad almost exclusively from foreign banks using syndicated loans, while the private sector was largely shut out from international financial markets. This institutional setup clearly facilitates ex-post discrimination, as governments can choose not to pay foreign banks without interfering with domestic asset trade.

foreigners cannot get repaid by the original borrowers they can still get repaid, albeit indirectly, by selling these assets to domestic residents in secondary markets.<sup>9</sup> Even in those cases in which asset trade is intermediated, governments typically do not know the nationality of the clients of banks, mutual funds and other financial intermediaries that hold domestic debt.<sup>10</sup> And even if governments had this information, they might still not be able to control how these intermediaries distribute the losses from not enforcing payments among their domestic and foreign clients. Finally, courts often abide by equal-treatment rules that limit the possibility of discrimination based on nationality.

Not surprisingly, there are many instances in which governments do not discriminate when they choose not to enforce payments or default. With few exceptions, episodes of default on government debts have affected all bondholders regardless of their nationality. The same holds true in the case of generalized defaults on debts issued by firms and/or banks.<sup>11</sup> There are other examples if we go beyond a purely contractual view of default. Most notably, when countries that have committed to a fixed exchange rate devalue their currencies, they are inducing defaults de facto on all contracts that had been signed in domestic currency. Of course, in these cases, as in others, one can argue that some discrimination may be possible and that it sometimes takes place in one form or another. Despite this, the main results of this paper would still hold if governments have some ability to discriminate and only vanish in the polar case of perfect discrimination.

Regarding results, this paper moves the theory of sovereign risk towards greater empirical relevance by allowing it to account for two types of interactions between domestic and international trade in assets. The first one is that increased access to international financial markets may create disruptions in domestic financial markets. There is by now substantial empirical evidence that this is the case for emerging markets and a growing theoretical literature that tries to explain why.<sup>12</sup> The second interaction is that having strong or deep domestic financial markets facilitates

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<sup>9</sup>For a complete analysis of the role of secondary markets in the presence of sovereign risk see Broner, Martin, and Ventura (2006).

<sup>10</sup>For the case of public debt, the most recent issue of the IMF's Global Financial Stability Report (April 2006, pp. 95-96) literally says: "It is difficult to obtain complete data on the composition of investors in sovereign bonds. Unlike bilateral, multilateral, or bank loans, neither issuers nor other data gatherers publish comprehensive decompositions of commercial investors in emerging market sovereign debt. Some sovereigns have needed and compiled this information sporadically, for example, in the context of voluntary debt swaps or distressed debt restructurings, but the full composition of commercial investors in emerging markets debt is rarely known." The report goes on explaining the difficulties of obtaining this information and therefore justifying that "...only a handful of countries could provide detailed information on investor composition." The report focuses on public debt, and it seems reasonable to assume that governments have even less information on the financial intermediaries that hold private debt.

<sup>11</sup>A recent and very visible example is the case of the "pesificación" of bank deposits and loans in Argentina in 2001, which induced a generalized default that affected all depositors.

<sup>12</sup>With respect to the empirical evidence, it has been found that banking crises and reductions in credit to the private sector are associated with globalization (e.g. Diaz-Alejandro (1985) and Kaminsky and Reinhart (1999)), sovereign default (e.g. International Monetary Fund (2002) and Arteta and Hale (2008)), and currency crises (e.g. Glick and Hutchison (2001)). With respect to the theory, see Boyd and Smith (1997), Chang and Velasco (1999),

access to international markets. This is consistent with the contrasting experience of emerging markets and industrial countries that have undergone financial liberalization. Contrary to the former, industrialized countries have been able to take greater advantage of international markets without suffering destabilizing effects. This differential impact of globalization has been analyzed by a number of papers.<sup>13</sup> We are the first ones to recognize that both interactions can be the result of a single friction, namely, sovereign risk.

The rest of the paper is organized as follows. Section one presents the basic setup. Section two introduces sovereign risk. Section three studies the effects of globalization. Section four examines the role of penalties and reputation, renegotiation, and borrowing limits. Section five concludes. There are also three appendices that explain some technical aspects of the solution method with and without borrowing limits, and extend the theory to the case in which governments can issue public debt.

## 1 A benchmark model of risk sharing

In this section, we introduce the economic environment we use throughout the paper. This is a world in which all individuals are ex-ante identical since they all have the same preferences over different goods and they all have access to an ex-ante identical project. The return to this project is random and this generates ex-post differences in the quantity and types of goods produced by the different individuals. This creates a role for markets in helping individuals pool or share risks. We first examine a situation in which these markets work well. This case will serve as a useful benchmark when we introduce enforcement problems in Section 2.

### 1.1 Preferences and technology

The world economy contains two regions: Home and Foreign, indexed by  $j \in \{H, F\}$ . Both regions have identical population size, normalized to 1. Let  $I^W$  be the set of inhabitants of this world, indexed by  $i$ , and let  $I^H$  and  $I^F$  be the sets of Home and Foreign residents, respectively. Naturally,  $I^H \cup I^F = I^W$  and  $I^H \cap I^F = \emptyset$ . Let  $j(i)$  denote the region where individual  $i$  resides. The world and its inhabitants last two periods, which we refer to as youth and old age. There is no uncertainty about youth, but there is uncertainty regarding old age. Let  $S$  be the set of all possible states of

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Aghion, Bacchetta, and Banerjee (2004), Matsuyama (2004, 2007), Aoki, Benigno, and Kiyotaki (2006), Daniel and Jones (2007), and Mendoza and Yue (2008).

<sup>13</sup>For instance, Broner and Rigobon (2006) show that capital flows to emerging markets are much more volatile than those to industrialized countries, that this difference cannot be accounted for by macroeconomic fundamentals, and that it is associated with weak domestic financial markets. This interaction is explored theoretically by Caballero and Krishnamurthy (2001), Tirole (2003), Broner, Martin, and Ventura (2006 and 2008), and Arellano and Kocherlakota (2008).

nature during old age. This set includes all the relevant aspects of the world economy that are not known during youth. We assume that, once realized, all individuals observe the state of nature. We denote by  $\pi_s$  the probability at youth of state  $s \in S$  occurring during old age.<sup>14</sup>

There is a continuum of goods, indexed by  $z \in [0, 1]$ . A fraction  $\tau$  of these goods can be transported between regions at negligible cost. We refer to these goods as “tradable.” The rest of the goods cannot be transported across regions and we refer to them as “nontradable.” The goods are indexed so that tradable goods correspond to low indices, i.e.  $z \in [0, \tau]$ , and nontradable goods correspond to high indices, i.e.  $z \in (\tau, 1]$ . When considering two alternative specifications, we shall say that the world is more globalized the higher  $\tau$  is.

Utility is derived only from old age consumption and individuals are expected-utility maximizers. Let  $c_{is}(z)$  be the quantity of good  $z$  consumed by individual  $i$  in state  $s$ . The objective function of individual  $i$  during old age is assumed to take the popular logarithmic form, i.e.

$$u_{is} = \int_0^1 \ln c_{is}(z) \cdot dz \quad \text{for all } s \in S \text{ and } i \in I^W, \quad (1)$$

while his/her objective function during youth is given by

$$U_i = \int_{s \in S} \pi_s \cdot u_{is} \quad \text{for all } i \in I^W. \quad (2)$$

A standard feature of dynamic decision problems is that the objective function of agents (individuals or governments) varies over time. This gives rise to a standard time-inconsistency problem that plays a central role in this paper.

During youth, individuals own a project located in their region. Projects deliver a bundle of goods during old age. We refer to this bundle as the production of the project of individual  $i$  or, for short, as the production of individual  $i$ . Let  $y_{is}(z)$  be the production of good  $z$  by individual  $i$  in state  $s$ . To simplify notation, let  $y_s^j(z) \equiv \int_{i \in I^j} y_{is}(z)$  for  $j \in \{H, F\}$  be the regional average productions of good  $z$  in state  $s$ , while  $y_s^W(z) \equiv 0.5 \cdot (y_s^H(z) + y_s^F(z))$  be the corresponding world average.

There is full symmetry between and within regions. First, if there exists a state  $s$  with  $\pi_s = \pi$  and given sets of productions in Home  $\{y_{is}(\cdot)\}_{i \in I^H} = \bar{Y}$  and in Foreign  $\{y_{is}(\cdot)\}_{i \in I^F} = \underline{Y}$ , then there exists a corresponding state  $s'$  with  $\pi_{s'} = \pi$  and sets of productions in Home  $\{y_{is'}(\cdot)\}_{i \in I^H} = \underline{Y}$  and in Foreign  $\{y_{is'}(\cdot)\}_{i \in I^F} = \bar{Y}$ . Second, for every pair of individuals  $i$  and  $i'$  residing in the same region, if there exists a state  $s$  with  $\pi_s = \pi$  and given sets of productions in Home and Foreign in

<sup>14</sup>With some abuse of language, we shall refer to  $\pi_s$  as the probability of state  $s$  even though for continuous state-spaces we are really referring to the probability density function.

which  $y_{is}(\cdot) = \bar{y}(\cdot)$ , then there also exists a corresponding state  $s'$  with  $\pi_{s'} = \pi$  and the same sets of productions in Home and Foreign in which  $y_{i's'}(\cdot) = \bar{y}(\cdot)$ . These assumptions imply that ex-ante productions are the same in both regions and for all individuals within a region. Of course, this need not be the case ex-post and this is why there are gains from trade.

In this world, markets allow individuals to transfer consumption across goods and across states of nature. Some trades might involve the exchange of goods during old age, while some others might involve the exchange of promises during youth to deliver goods during old age. We refer to the former as “goods” trade and the latter as “asset” trade. We start by considering the benchmark case of complete markets. As usual, by “complete” it is meant that the existing set of markets allows all pairs of individuals to carry out all mutually desired trades. There are many possible ways of organizing markets that ensure this. For convenience, we consider a sequential formulation of markets: during youth there are asset (or forward) markets where individuals can trade promises to deliver one unit of the numeraire good in state  $s$  in any of the two regions; and during old age there are goods (or spot) markets where individuals can exchange the different goods. Intuitively, asset markets are used to distribute income across states of nature, while goods markets are used to distribute consumption across goods.<sup>15</sup>

As usual, it is useful to construct the competitive equilibrium recursively, going backwards in time. During old age, individuals take their income as given and choose how to distribute their consumption across goods so as to maximize utility. During youth, individuals choose how to distribute their income across states of nature so as to maximize their expected utility. We study each of these choices in turn.

## 1.2 Goods markets

During old age, the state of nature is known and only goods markets are open. Let  $p_s^j(z)$  be the price of one unit of good  $z$  in state  $s$  in region  $j$ . Let  $y_{is}$  be the value of the production of individual  $i$  in state  $s$ , i.e.  $y_{is} \equiv \int_0^1 p_s^{j(i)}(z) \cdot y_{is}(z) \cdot dz$ ; and let  $x_{is}$  be the value of the assets held by individual  $i$  in state  $s$ . To simplify notation, let  $y_s^j \equiv \int_{i \in I^j} y_{is}$  for  $j \in \{H, F\}$  be the regional average values of production in state  $s$ , while  $y_s^W \equiv 0.5 \cdot (y_s^H + y_s^F)$  is the corresponding world average. Also, let  $x_s^j \equiv \int_{i \in I^j} x_{is}$  for  $j \in \{H, F\}$  be the regional average values of assets in state  $s$ . We need not

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<sup>15</sup>This sequential formulation of markets is sometimes referred to as a Radner equilibrium. The classic Arrow-Debreu equilibrium assumes instead that there is a set of forward markets during youth where individuals can trade promises to deliver one unit of *any* good in state  $s$  in any of the two regions. The Arrow-Debreu equilibrium minimizes the use of spot markets, while the sequential or Radner equilibrium minimizes the use of forward markets. If all markets work well, both equilibria deliver the same allocations. This equivalence breaks down however once we introduce sovereign risk in the next section. This type of risk negatively affects the functioning of forward markets, without affecting the functioning of spot markets. This provides incentives to minimize the use of forward markets and justifies our choice of equilibrium.

define the world average value of assets since assets are nothing but promises and the average value of these promises must be zero. With this notation, we can write the budget constraint of old individuals as follows:

$$\int_0^1 p_s^{j(i)}(z) \cdot c_{is}(z) \cdot dz \leq y_{is} + x_{is} \quad \text{for all } s \in S \text{ and } i \in I^W. \quad (3)$$

The budget constraint states that the value of consumption cannot exceed income, which in turn consists of the value of production plus the value of assets held.

For goods markets to clear, we must impose these conditions:

$$\frac{1}{2} \cdot \int_{i \in I^W} c_{is}(z) = y_s^W(z) \quad \text{and} \quad p_s^H(z) = p_s^F(z) \equiv p_s^W(z) \quad \text{for all } z \in [0, \tau] \text{ and } s \in S, \quad (4)$$

$$\int_{i \in I^j} c_{is}(z) = y_s^j(z) \quad \text{for all } z \in (\tau, 1], s \in S, \text{ and } j \in \{H, F\}. \quad (5)$$

Equations (4) and (5) state that supplies of the different goods must equal their demands. For those goods that are tradable, international arbitrage ensures that the prices of a given good delivered at Home and Foreign are equalized. This international arbitrage does not operate for nontradable goods.

A competitive equilibrium during old age consists of a set of goods prices and quantities such that individuals maximize their utility –Equation (1)– subject to their budget constraint –Equation (3)– and goods markets clear –Equations (4) and (5). Note that the state variables of the old-age problem are individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{is}\}_{i \in I^W}$ .

We show that the equilibrium exists and is unique by construction. It follows from individual maximization that consumption demands are given by  $c_{is}(z) = (y_{is} + x_{is})/p_s^{j(i)}(z)$  for all  $i \in I^W$  and  $z \in [0, 1]$ . Substituting these demands into the market clearing conditions in Equations (4) and (5) we find that prices are given by  $p_s^W(z) = y_s^W/y_s^W(z)$  for  $z \in [0, \tau]$  and  $p_s^j(z) = (y_s^j + x_s^j)/y_s^j(z)$  for  $z \in (\tau, 1]$  and  $j \in \{H, F\}$ . Therefore, equilibrium consumption allocations are given by:

$$c_{is}(z) = \begin{cases} \frac{y_{is} + x_{is}}{y_s^W} \cdot y_s^W(z) & \text{if } z \in [0, \tau] \\ \frac{y_{is} + x_{is}}{y_s^{j(i)} + x_s^{j(i)}} \cdot y_s^{j(i)}(z) & \text{if } z \in (\tau, 1] \end{cases} \quad \text{for all } s \in S, \text{ and } i \in I^W. \quad (6)$$

Equation (6) shows how Home and Foreign residents distribute their consumption across the different goods. In particular, individuals share goods in proportions that are directly related to their incomes. For tradable goods, world production is shared according to world relative incomes. For nontradable goods, regional production is shared according to regional relative incomes. We can

find individual incomes as a share of world income as follows:<sup>16</sup>

$$\frac{y_{is} + x_{is}}{y_s^W} = \int_0^\tau \frac{y_{is}(z)}{y_s^W(z)} \cdot dz + \frac{y_s^{j(i)} + x_s^{j(i)}}{y_s^W} \cdot \int_\tau^1 \frac{y_{is}(z)}{y_s^{j(i)}(z)} \cdot dz + \frac{x_{is}}{y_s^W} \quad \text{for all } s \in S \text{ and } i \in I^W, \quad (7)$$

and, integrating (7) over residents of each region, we also find regional incomes as a share of world income:

$$\frac{y_s^j + x_s^j}{y_s^W} = \frac{1}{\tau} \cdot \left( \int_0^\tau \frac{y_s^j(z)}{y_s^W(z)} \cdot dz + \frac{x_s^j}{y_s^W} \right) \quad \text{for all } s \in S \text{ and } j \in \{H, F\}. \quad (8)$$

A region's income increases with its relative production of tradables and with its assets.<sup>17</sup>

Equations (6), (7) and (8) provide a full description of the consumption allocation as a function of the state variables of this problem, i.e. individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{is}\}_{i \in I^W}$ . Individual productions are determined by nature, but asset holdings are determined by trade during youth and we turn to this now.

### 1.3 Asset markets

During youth, only asset markets are open. Let  $q_s$  be the price of an asset that promises to deliver one unit of the numeraire in state  $s$ , and let  $x_{is}$  be the number of such assets held by individual  $i$ . Therefore, the budget sets of the young are characterized by:

$$\int_{s \in S} q_s \cdot x_{is} \leq 0 \quad \text{for all } i \in I^W, \quad (9)$$

$$x_{is} \geq -y_{is} \quad \text{for all } s \in S \text{ and } i \in I^W. \quad (10)$$

Equation (9) is the budget constraint and says that purchases of assets must be financed by corresponding sales of other assets, while Equation (10) is a borrowing constraint that says that individuals can only issue promises that are backed by their own production. Naturally, during youth asset markets must clear:

$$\int_{i \in I^W} x_{is} = 0 \quad \text{for all } s \in S. \quad (11)$$

Equation (11) states that there is a zero net supply of all assets or promises.

A competitive equilibrium during youth consists of a set of asset prices and quantities such

<sup>16</sup>To see this, substitute prices into the definition of  $y_{is}$ .

<sup>17</sup>Note that assets increase income more than one-to-one if  $\tau < 1$ . The reason is that assets shift purchasing power from foreign to domestic residents. This raises the demand for domestic nontradable goods relative to foreign ones. And this increases the value of domestic production relative to foreign. This additional effect of asset holdings on incomes is known as the "transfer problem."

that individuals maximize expected utility –Equation (2)– subject to their budget and borrowing constraints –Equations (9) and (10)– and asset markets clear –Equation (11). When maximizing their utility, individuals take as given how their individual consumption during old age depends on their individual asset holdings.

We show again that this equilibrium exists and is unique by construction. Note that log preferences imply that a young individual  $i$  will choose asset holdings  $\{x_{is}\}_{s \in S}$  such that  $y_{is} + x_{is} = \lambda_i^{-1} \cdot (\pi_s/q_s)$  where  $\lambda_i$  is the Lagrange multiplier associated with individual  $i$ 's budget constraint. Since all individuals are ex-ante identical (preferences and technology) and have access to the same set of markets, they all have the same multiplier  $\lambda_i \equiv \lambda$  for all  $i \in I^W$ . Integrating this expression over  $i \in I^W$  and using the market clearing conditions in Equation (11) we find  $\lambda^{-1} = (q_s/\pi_s) \cdot y_s^W$ . As a result, we have:

$$x_{is} = y_s^W - y_{is} \quad \text{for all } s \in S \text{ and } i \in I^W. \quad (12)$$

Equation (12) provides the equilibrium asset holdings, i.e.  $\{x_{is}\}_{i \in I^W}$ . During old age income is always equally distributed within and between regions.

We have now a full description of the complete-markets equilibrium. For a given set of individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{is}\}_{i \in I^W}$ , Equations (6), (7) and (8) describe the consumption allocation that come out of goods markets during old age. For a given set of individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$ , Equation (12) describes the asset holdings that come out from asset markets during youth. We describe the welfare properties of this equilibrium next.

#### 1.4 Domestic and international risk sharing with complete markets

Markets allow individuals to share production risks both within and between regions. We can provide a sharper description of how this happens by decomposing production,  $y_{is}(z)$ , as follows:

$$y_{is}(z) = \phi_{is}(z) \cdot \phi_s^{j(i)}(z) \cdot y_s^W(z) \quad \text{for all } z \in [0, 1], s \in S, \text{ and } i \in I^W, \quad (13)$$

where  $\phi_{is}(z) \equiv y_{is}(z)/y_s^{j(i)}(z)$  and  $\phi_s^{j(i)}(z) \equiv y_s^{j(i)}(z)/y_s^W(z)$  for  $z \in [0, 1]$ ,  $s \in S$ , and  $i \in I^W$  are the individual and regional components of production respectively. By construction, these components have a constant mean, i.e.  $\int_{i \in I^j} \phi_{is}(z) = 1$  and  $0.5 \cdot (\phi_s^H(z) + \phi_s^F(z)) = 1$  for all  $z \in [0, 1]$  and  $s \in S$ . We will refer to a (mean-preserving) spread in  $\phi_{is}(z)$  and  $\phi_s^{j(i)}(z)$  as an increase in individual and regional risk for good  $z$  respectively.

With these definitions at hand, we can use Equations (6) and (12) to find equilibrium consump-

tion allocations:

$$c_{is}(z) = \begin{cases} y_s^W(z) & \text{if } z \in [0, \tau] \\ \phi_s^{j(i)}(z) \cdot y_s^W(z) & \text{if } z \in (\tau, 1] \end{cases} \quad \text{for all } s \in S, \text{ and } i \in I^W, \quad (14)$$

and plugging these consumption allocations in Equation (2), we obtain ‘ex-ante’ utility:<sup>18</sup>

$$U = \int_0^1 \left( \int_{s \in S} \pi_s \cdot \ln y_s^W(z) \right) \cdot dz + \int_\tau^1 \left( \int_{s \in S} \pi_s \cdot \ln \phi_s^{j(i)}(z) \right) \cdot dz \quad \text{for any } i \in I^W. \quad (15)$$

Equations (14) and (15) provide a full description of consumption and welfare. There is perfect domestic sharing of all goods, but only perfect international sharing of tradable ones. Naturally, this is because it is not technologically possible to share nontradable goods across regions. Markets work well, but they cannot overcome technological constraints. In fact, it is straightforward to show that the complete-markets consumption allocations are ‘ex-ante’ Pareto efficient and strictly Pareto dominate all other symmetric consumption allocations.<sup>19</sup>

Not surprisingly, welfare increases with world production of all goods  $y_s^W(z)$ . Moreover, Jensen’s inequality shows that a mean-preserving spread in world production lowers welfare. Higher volatility in world production cannot be diversified away and must lead one-to-one to higher volatility in individual consumption. Since individuals are risk averse, they suffer from this.

A feature of the complete-markets equilibrium is that welfare is not affected by an increase in individual risk.<sup>20</sup> Since there is perfect domestic sharing of all goods, the ‘ex-post’ distribution of production among individuals of the same region has no effects on individual consumption or welfare.

Welfare is not affected by an increase in regional risk on tradable goods either, but welfare is affected by an increase in regional risk on nontradable goods.<sup>21</sup> Since there is perfect international sharing of tradable goods, the ‘ex-post’ distribution of tradable production between regions has no effects on consumption or welfare. Since transport costs preclude international sharing of nontradable goods, higher volatility of the regional component of their production must lead one-to-one to higher volatility in the consumption of these goods and this lowers ex-ante utility.

This discussion provides a short but comprehensive description of the complete-markets equi-

<sup>18</sup> All individuals enjoy the same ex-ante utility because of our symmetry assumptions.

<sup>19</sup> Since we shall focus exclusively on symmetric consumption allocations throughout the paper, we refer to those in Equations (14) as “the” Pareto efficient consumption allocations, even though we recognize that there exist asymmetric allocations that are also Pareto efficient.

<sup>20</sup> To see this, simply note that the individual component of production is absent in Equations (14) and (15).

<sup>21</sup> To see the former, simply note that the regional component of tradable production is absent in Equations (14) and (15). To see the latter, use Jensen’s inequality to show that a mean-preserving spread in the nontradable component of regional production lowers ex-ante utility.

librium. Goods and asset markets combine to allow individuals to share production risks. Given technological constraints to trade, this is an ideal world. But this is too rosy a picture of asset markets. There is a fundamental difference in the nature of goods and asset markets that the complete-markets model ignores. In goods markets individuals trade commodities for commodities, while in asset markets individuals trade promises for promises. Unlike commodities, promises are only valuable if individuals can commit to fulfill them later. We have assumed this implicitly in the previous analysis. In the next section we relax this assumption.

## 2 Sovereign risk

The feasibility of the complete-markets consumption allocation rests on society's ability to solve a standard time-inconsistency problem. Even though individuals would like to commit ex-ante to pay their debts, ex-post they have incentives not to do so and enjoy a higher level of consumption. Either old individuals are not maximizing their utility or their true utility cannot be fully represented by Equation (1). The standard way to think about the complete-markets model is as describing a world in which there is also a government that imposes an unbearable utility cost to those individuals that fail to pay their debts. In this situation, Equation (1) can be understood as representing utility only conditional on paying debts. The (very low) level of utility that results from not paying debts can be disregarded since it is never chosen in equilibrium.

Although recognizing the role that governments play in sustaining asset markets is a small step towards greater realism, it begs the question of why governments would always want to enforce payments. To the extent that governments care more about domestic residents than about foreign ones, they are subject to the same type of time-inconsistency problem that individuals are. Even though governments would like to commit ex-ante to enforce payments by domestic residents, ex-post they may have incentives to deviate to allow domestic residents to enjoy a higher level of consumption. This time-inconsistency problem of governments is usually referred to as sovereign risk, and the goal of this section is to analyze how it affects risk sharing and welfare.

### 2.1 The model with sovereign risk

We consider again the world economy described in section 1.1, but now we explicitly model governments and their role as enforcers of private contracts. There are two governments, a Home government which can enforce payments by residents of Home, and a Foreign government which can enforce payments by residents of Foreign. Ex-post, an individual only pays if his/her government forces him/her to pay. Governments only care about the utility of the residents of their

region. In particular, they maximize the average utility of domestic residents, i.e.  $v_s^j = \int_{i \in I^j} u_{is}$  for all  $s \in S$  during old age and  $V^j = \int_{i \in I^j} \pi_s \cdot U_i$  during youth for  $j \in \{H, F\}$ .

If governments could credibly commit to enforce all payments during youth, they would always choose to do so and all asset markets would be open. This is the extreme or polar case of perfect commitment.<sup>22</sup> If governments have some choice over enforcement after the state of nature is revealed, they are tempted not to enforce payments to foreigners when these are high enough. We ensure this temptation is always present by moving to the other extreme and assuming governments cannot commit to enforce at all:

**Assumption 1. LACK OF COMMITMENT:** *Governments simultaneously choose enforcement during old age after the state of nature has been revealed and before markets open.*

The effects of this lack of commitment depend crucially on the degree to which governments can discriminate among creditors when enforcing payments. Assume, for instance, that governments choose ex-post which particular payments to enforce so that they can fully discriminate between creditors. This is the polar case of perfect discrimination without commitment. In the context of our model, this would imply that governments would never enforce any payment from a domestic resident to a foreign one. Asset markets would be geographically segmented and there would be no trade in assets between residents of different regions.<sup>23</sup>

If discrimination is less than perfect, lack of enforcement affects both domestic and international transactions and this creates new and interesting interactions between domestic and international asset trade. We take a first step towards analyzing these interactions by going to the other polar case and assume that governments cannot discriminate among debtors. In particular, we assume:

**Assumption 2. NON-DISCRIMINATORY ENFORCEMENT:** *Governments choose whether to enforce all payments or none.*

There are two aspects to this assumption. The first and crucial one is that governments cannot discriminate by asset holder when deciding enforcement. All of our results depend on this. The second aspect is that governments cannot discriminate by asset issuer when deciding enforcement. This is necessary to keep the competitive nature of the equilibrium and we conjecture that it is

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<sup>22</sup>With perfect commitment, the equilibrium would be identical to the complete-markets model and would therefore be fully described by Equations (6), (7), (8) and (12).

<sup>23</sup>With perfect discrimination without commitment, there would still be international trade in goods since such trade is arms' length and, thus, not affected by sovereign risk. In addition, domestic asset trade would still take place since, in equilibrium, this trade would result in payments from residents with low marginal utility to residents with high marginal utility. Enforcing these payments would raise the average utility of the region. Therefore, the equilibrium with perfect discrimination and without commitment is fully described by Equations (6), (7) and (8) with asset holdings  $x_{is} = y_s^{j(i)} - y_{is}$  for all  $s \in S$  and  $i \in I^W$ .

not crucial for the results that follow.<sup>24</sup> Once again, we construct next the competitive equilibrium recursively going backwards in time.

## 2.2 Goods markets and enforcement

During old age, the state of nature is revealed, then governments enforce payments, and then goods markets open. Define  $x_{j,is}$  as the assets held by individual  $i$  that pay in state  $s$  issued by residents of region  $j$ . Since governments now decide whether to enforce payments independently, it is not sufficient to know the overall asset holdings of an individual, but also the residence of the issuer.

Unlike section 1.2, the budget constraints of old individuals must now reflect the fact that assets are worthless if there is no enforcement. That is, we must replace Equation (3) by the following one:

$$\int_0^1 p_s^{j(i)}(z) \cdot c_{is}(z) \cdot dz \leq y_{is} + e_s^H \cdot x_{H,is} + e_s^F \cdot x_{F,is} \quad \text{for all } s \in S \text{ and } i \in I^W. \quad (16)$$

where  $e_s^j$  is an indicator variable that takes value one if government  $j$  enforces and zero otherwise.

Governments simultaneously choose whether to enforce payments or not so as to maximize the average utility of domestic residents. When considering their enforcement choice, governments take the actions of the other government as given. That is, enforcement decisions are the Nash equilibrium of a game between governments. Their best responses therefore satisfy:

$$e_s^j = \begin{cases} 1 & \text{if } v_s^j(\text{enforce}) > v_s^j(\text{not enforce}) \\ 0 & \text{if } v_s^j(\text{enforce}) < v_s^j(\text{not enforce}) \end{cases} \quad \text{for all } s \in S \text{ and } j \in \{H, F\}. \quad (17)$$

Note that when  $v_s^j(\text{enforce}) = v_s^j(\text{not enforce})$ , the government is indifferent between enforcing or not and both  $e_s^j = 1$  and  $e_s^j = 0$  are best responses. We define  $E^j \subseteq S$  as the set of states in which government  $j$  decides to enforce payments for  $j \in \{H, F\}$ .<sup>25</sup>

A competitive equilibrium during old age consists of a set of goods prices and quantities such that individuals maximize their utility –Equation (1)– subject to their budget constraint –Equation (16)–, governments enforce so as to maximize average utility of their region –Equation (17)– and

<sup>24</sup>We could allow for discrimination by groups of issuers as long as all the groups have many individuals. Then, individuals would still take enforcement as given and behave competitively. If discrimination is instead at the individual level, then individuals would choose their privately optimal level of borrowing. The reason why this would not significantly affect the results is that as long as individuals cannot control who holds the assets they issue, they cannot reduce their borrowing from foreigners without reducing their borrowing from other domestic residents. We conjecture that the equilibrium allocation would be identical to the one with optimal borrowing limits we analyze in Section 4.3.

<sup>25</sup>We are focusing on non-cooperative equilibria in which governments do not take into consideration how their enforcement decisions affect foreigners. As we shall see soon, this leads them not to enforce payments sometimes even though the domestic gains from not enforcing are always smaller than the foreign costs. It might seem therefore that the closure of markets could be avoided if governments could pay each other ex-post to enforce. Section 4.2 explains why this is not the case however.

goods markets clear –Equations (4) and (5). Once again, the state variables of this problem are individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{j,is}\}_{j \in \{H,F\}, i \in I^W}$ .

To compute this equilibrium, replace

$$x_{is} = e_s^H \cdot x_{H,is} + e_s^F \cdot x_{F,is} \text{ for all } s \in S \text{ and } i \in I^W \quad (18)$$

in Equations (6), (7) and (8) to find the equilibrium consumption allocations as functions of enforcement decisions. Then, substitute these consumption allocations into the best responses of governments to find the equilibrium enforcement decisions as a function of the state variables of this problem, i.e. individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{j,is}\}_{j \in \{H,F\}, i \in I^W}$ . Once again, asset holdings are determined during youth as we show next.

### 2.3 Asset markets

During youth, individuals trade in asset markets. The individual maximization problems are as in section 1.3, except that now agents can only sell securities which pay in states in which their government enforces payments. Then, the budget sets in Equations (9) and (10) are replaced by

$$\int_{s \in S} (q_s^H \cdot x_{H,is} + q_s^F \cdot x_{F,is}) \leq 0 \text{ for all } i \in I^W, \quad (19)$$

$$x_{j(i),is} \geq -\hat{y}_{is} \text{ and } x_{-j(i),is} \geq 0 \text{ for all } s \in S \text{ and } i \in I^W, \quad (20)$$

where  $\hat{y}_{is}$  is now pledgeable income, defined as

$$\hat{y}_{is} = \begin{cases} y_{is} & \text{if } s \in E^{j(i)} \\ 0 & \text{if } s \notin E^{j(i)} \end{cases} \text{ for all } i \in I^W. \quad (21)$$

Equation (19) is the budget constraint. Equations (20) and (21) define the borrowing constraint. They say that individuals cannot pledge income in states in which their government does not enforce payments.<sup>26</sup> They also say that individuals cannot issue assets that are enforced by the government of the other region. Note that individuals do not take into consideration how their choice of asset holdings affects the enforcement decision of their government and, consequently, the borrowing constraints of other residents. This externality leads individuals to borrow too much

<sup>26</sup>For example, a Home resident might want to sell assets that pay in a state, say  $s$ , in which his/her production is high in order to purchase assets that pay in states in which his/her production is low. However, if in state  $s$  the Home government does not enforce payments,  $s \notin E^H$ , this resident will not pay his/her debts when state  $s$  materializes. Knowing this ex-ante, other agents would not be willing to purchase any assets that pay in state  $s$  from this Home resident. Therefore, Home production in state  $s$  is not pledgeable. Similarly, no agent would be willing to purchase assets from Foreign residents that pay in states in which the Foreign government does not enforce payments.

from abroad during youth.<sup>27,28</sup>

The market clearing conditions for asset markets are now given by

$$\int_{i \in I^W} x_{j,is} = 0 \quad \text{for all } s \in S \text{ and } j \in \{H, F\}. \quad (22)$$

Equation (22) simply states that there is a zero net supply of each country's assets.

A competitive equilibrium during youth consists of a set of asset prices and quantities such that individuals maximize expected utility –Equation (2)– subject to their budget and borrowing constraints –Equations (19), (20) and (21)– and asset markets clear –Equation (22). Naturally, when maximizing their utility, individuals take as given how their individual consumption during old age depends on their individual asset holdings.

We restrict the analysis to symmetric equilibria.<sup>29</sup> Define a coarse partition of states of nature based on sets of productions in Home and Foreign as opposed to individual productions. Abusing notation, we refer to the set of states  $\{s \in S : \{y_{is}(\cdot)\}_{i \in I^H} = \bar{Y} \text{ and } \{y_{is}(\cdot)\}_{i \in I^F} = \underline{Y}\}$  as a single “state” characterized by regional sets of productions  $(\bar{Y}, \underline{Y})$ . Given our assumption of symmetry within regions, each such “state” is composed of a large number of equiprobable states, one for each way in which these regional sets of productions can be distributed among residents within each region. Given our assumption of symmetry between regions, each state  $s$  characterized by sets of productions  $(\bar{Y}, \underline{Y})$  has a corresponding symmetric state  $s'$  with the same probability and characterized by sets of productions  $(\underline{Y}, \bar{Y})$ . We say that an equilibrium is symmetric if enforcement sets can be defined over this coarser partition of states and  $(\bar{Y}, \underline{Y}) \subset E^H$  if and only if  $(\underline{Y}, \bar{Y}) \subset E^F$ . This restriction is not without loss of generality, since the model also has asymmetric equilibria. But it delivers a high payoff in terms of tractability since it implies that residents in both regions have the same budget constraint multipliers  $\lambda$  during youth and we can therefore analyze pairs of symmetric states independently.

Typically, there are many symmetric equilibria. To see this, consider a pair of symmetric states. If individuals expect enforcement in both regions, it is possible (but not necessary) that asset trade be such that both regions enforce and validate individuals' expectations. If individuals expect non-

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<sup>27</sup>We shall come back to this point in Section 4.3 to show that our results go through even if governments introduce optimal borrowing limits.

<sup>28</sup>This overborrowing externality has played a central role in the literature on sovereign risk. For recent discussions of the problem, see Fernández-Arias and Lombardo (2000), Caballero and Krishnamurthy (2001), Tirole (2003), Kehoe and Perri (2004), Jeske (2006), Uribe (2006), and Wright (2006). This externality is not present in a related literature that assumes that governments never enforce payments and asks instead whether the desire to keep an individual-specific reputation provides sufficient incentives for individuals to repay their debts. See Kehoe and Levine (1993), Kocherlakota (1996), Alvarez and Jermann (2000).

<sup>29</sup>Without loss of generality (see Appendix A), we also impose the restriction that there be no two-way international trade in the same asset. That is, either  $\int_{i \in I^H} x_{F,is}$  or  $\int_{i \in I^F} x_{H,is}$  is zero for all  $s \in S$ .

enforcement in both regions, then there is no asset trade and these individuals' expectations are a consistent belief. Thus, expectations play an important role in this world. But we do not emphasize this feature in what follows. Instead, we focus exclusively on the best symmetric equilibrium and we refer to it as “the” sovereign risk equilibrium. This equilibrium arises when individuals have the most optimistic expectations about enforcement and the maximum number of asset markets are open.

Appendix A provides a detailed description of how we construct this equilibrium. Basically, we do this by checking, for each pair of symmetric states, if there exists an equilibrium in which both governments enforce payments. If it exists, we choose it. Otherwise, we check whether there is an equilibrium in which at least one region enforces. If it exists, we choose it. Otherwise, we conclude that there is no enforcement. We find that the equilibrium constructed in this way sometimes contains states in which there is enforcement in one region but not in the other and, as a result,  $E^H \neq E^F$ . To streamline the exposition, in the main text we focus only on the case in which, in all states, there is enforcement either in both regions or in neither and  $E^H = E^F \equiv E$ . This case generates the following simple and intuitive closed-form solutions for equilibrium asset holdings:

$$x_{is} = \begin{cases} y_s^W - y_{is} & \text{if } s \in E \\ 0 & \text{if } s \notin E \end{cases} \quad \text{for all } i \in I^W \quad (23)$$

That is, income is equally divided among all individuals in those states in which asset markets are open. Naturally, there is no asset trade in those states in which asset markets are closed.

We have now a complete description of the sovereign risk equilibrium. For a given set of individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$  and asset holdings  $\{x_{j,is}\}_{j \in \{H,F\}, i \in I^W}$ , Equations (6), (7), (8), (17), and (18) describe the consumption allocation that come out of goods markets during old age and Equation (17) determines the enforcement set. For a given set of individual productions  $\{y_{is}(\cdot)\}_{i \in I^W}$ , Equation (23) describes the asset holdings that come out from asset markets during youth. We describe the welfare properties of this equilibrium next.

## 2.4 Domestic and international risk sharing with sovereign risk

Sovereign risk destroys some asset markets, and this reduces domestic and international risk sharing. The equilibrium consumption allocations are now given by:

$$c_{is}(z) = \begin{cases} y_s^W(z) & \text{if } z \in [0, \tau] \\ \phi_s^{j(i)}(z) \cdot y_s^W(z) & \text{if } z \in (\tau, 1] \end{cases} \quad \text{for all } s \in E \text{ and } i \in I^W. \quad (24)$$

$$c_{is}(z) = \begin{cases} \phi_{is} \cdot \phi_s^{j(i)} \cdot y_s^W(z) & \text{if } z \in [0, \tau] \\ \phi_{is} \cdot \phi_s^{j(i)}(z) \cdot y_s^W(z) & \text{if } z \in (\tau, 1] \end{cases} \quad \text{for all } s \notin E \text{ and } i \in I^W \quad (25)$$

where  $\phi_{is} \equiv \int_0^\tau (\phi_s^{j(i)}(z)/\phi_s^{j(i)}) \cdot \phi_{is}(z) \cdot dz + \int_\tau^1 \phi_{is}(z) \cdot dz$  and  $\phi_s^j \equiv \tau^{-1} \cdot \int_0^\tau \phi_s^j(z) \cdot dz$ . To interpret these expressions, note that Equations (7) and (8) imply that:

$$\frac{y_{is} + x_{is}}{y_s^W} = \begin{cases} 1 & \text{if } s \in E \\ \phi_{is} \cdot \phi_s^{j(i)} & \text{if } s \notin E \end{cases} \quad \text{for all } i \in I^W \quad (26)$$

That is,  $\phi_{is}$  and  $\phi_s^j$  measure the individual and regional components of incomes when there is no enforcement. By construction, these components have a constant mean, i.e.  $\int_{i \in I^j} \phi_{is} = 1$  and  $0.5 \cdot (\phi_s^H + \phi_s^F) = 1$  for all  $s \notin E$ . In those states in which asset markets are open there are no individual and regional components to incomes because asset trade ensures perfect sharing of income risk. But this is not possible in those states in which asset markets are closed.<sup>30</sup> Plugging the consumption allocations in Equations (24) and (25) into Equation (2), we obtain ex-ante utility:

$$U = \int_0^1 \left( \int_{s \in S} \pi_s \cdot \ln y_s^W(z) \right) \cdot dz + \int_\tau^1 \left( \int_{s \in S} \pi_s \cdot \ln \phi_s^{j(i)}(z) \right) \cdot dz + \int_{s \notin E} \pi_s \cdot \tau \cdot \ln \phi_s^{j(i)} + \int_{s \notin E} \pi_s \cdot \ln \phi_{is} \quad \text{for any } i \in I^W. \quad (27)$$

Finally, it follows from Equation (17) that the enforcement set is given by:

$$E = \left\{ s \in S : - \int_{i \in IR} \ln \phi_{is} \geq \tau \cdot \ln \phi_s^R \right\}, \quad (28)$$

where  $R$  is the rich region in the corresponding state, i.e.  $\phi_s^R = \max\{\phi_s^H, \phi_s^F\}$ . The right- and left-hand sides of the enforcement condition are the cost and benefit of enforcement, respectively. The cost of enforcement equals the number of goods that are shared between regions,  $\tau$ , times the average (across goods) reduction in ex-post welfare that the rich region suffers when it shares them with the poor region,  $\ln \phi_s^R$ . The benefit of enforcement consists of avoiding domestic inequality,  $-\int_{i \in IR} \ln \phi_{is}$ .<sup>31</sup>

Equations (24), (25), (27) and (28) provide a full description of consumption and welfare. As long as there is no enforcement in some states, i.e.  $E \neq S$ , there is imperfect domestic sharing of

<sup>30</sup>Note that, in states without enforcement, individuals are constrained to consuming a bundle of goods whose value is equal to the value of their production. They are not constrained to consuming their own productions because they can still trade in goods markets.

<sup>31</sup>In the absence of goods trade between regions, the cost of enforcement would be larger and equal to  $\int_0^\tau \ln \phi_s^R(z) \cdot dz$ . In the absence of goods trade within regions, the benefit of enforcement would also be larger and equal to  $-\int_{i \in IR} \int_0^1 \ln \phi_{is}(z) \cdot dz$ .

all goods and imperfect international sharing of tradable goods. This is because individuals are forced to choose consumption baskets worth no more than their production bundle in those states in which the corresponding asset market is closed. The sovereign-risk consumption allocations are therefore ‘ex-ante’ Pareto inefficient. This is shown in Equation (27) which differs from (15) by the third and fourth integrals. Jensen’s inequality implies that these two integrals are negative. The third integral reflects the welfare loss from not being able to perfectly share tradable goods between regions, while the fourth integral reflects the welfare loss from not being able to perfectly share all goods within regions.

The complete-markets equilibrium can now be re-interpreted as the special case of the sovereign-risk equilibrium in which the enforcement set contains all states of nature, i.e.  $E = S$ , and markets are complete. In general, however, the enforcement set is smaller than the set of all states, i.e.  $E \subset S$ , and markets are incomplete. The number of asset markets that are closed and therefore the inefficiency created by sovereign risk depends on individual and regional income risk. A mean preserving spread in  $\phi_{is}$  in the rich region increases the loss in average utility that results from a breakdown in domestic payments, increasing government incentives to enforce and therefore the size of the enforcement set. A mean preserving spread in  $\phi_s^j$  raises the gains in average utility that result from not paying debts to foreigners, reducing incentives to enforce and therefore the size of the enforcement set.<sup>32,33</sup>

The sovereign-risk equilibrium shares some features with the complete-markets equilibrium. For instance, in both equilibria welfare increases with world production of any good but decreases with a mean-preserving spread in the world production of any good. Also, in both equilibria welfare decreases with an increase in regional risk on nontradable goods. Moreover, the intuitions behind these results are exactly the same in both equilibria since neither world production nor the regional component of the production of nontradables affect the size of the enforcement set.

But the sovereign risk equilibrium differs from the complete-markets equilibrium in that welfare depends on both individual risk and regional risk on tradable goods. This dependence can be quite complex but can always be analyzed as the sum of two different effects. For a given enforcement set, higher volatility in individual and regional tradable production cannot be diversified away in those states in which asset markets are closed and must lead one-to-one to higher volatility in individual

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<sup>32</sup>One must be careful when studying the effects of individual and regional risk for a given good. It is possible that a mean-preserving spread in  $\phi_{is}(z)$  benefits disproportionately poor individuals and reduces the enforcement set. Similarly, it is also possible that a mean-preserving spread in  $\phi_s^j(z)$  benefits disproportionately the poor region and increases the enforcement set.

<sup>33</sup>Note that the default penalties, usually arising from losses of reputation, emphasized by previous literature in sovereign risk are absent and therefore play no role in the decision to enforce. In Section 4.1 we extend the model to account for penalties and show that our results are robust to this extension.

consumption in those states. This first effect of increases in individual and regional risk always lowers welfare. But higher volatility in individual and tradable production also affect the size of the enforcement set. An increase in individual risk tends to increase the enforcement set and this increases welfare. Therefore, the first and second effects tend to work against each other in the case of individual risk. An increase in regional risk for tradables tends to reduce the enforcement set and this lowers welfare. Therefore, the first and second effects tend to reinforce each other in the case of regional risk on tradable goods.

The sovereign-risk equilibrium provides a rich description of international trade in assets. Lack of commitment or trust destroys asset markets and constitutes an impediment to trade. Individuals cannot sell enough assets to finance the purchase of other assets that would protect them from the risks they face. Therefore, this is less than an ideal world given technological constraints to trade.

There exist two important interactions between domestic and international risk sharing. On the one hand, the more domestic risk sharing is needed, the more asset markets are open and the more international risk sharing is possible. After all, it is the fear to destroy domestic risk sharing that induces governments to enforce international payments and thus sustains asset markets. On the other hand, the more international risk sharing is needed, the more asset markets are closed and the less domestic risk sharing is possible. After all, it is the temptation to default on foreigners that induces governments not to enforce payments and thus destroys asset markets. These interactions play a crucial role in determining the effects of globalization, as we describe in the next section.<sup>34</sup>

### 3 The effects of globalization

Globalization is a dynamic process. Thus, in this section we re-interpret the model as describing the life of a typical generation in a world with overlapping generations. The number of generations, which may be infinite, equals  $T$ . Generation  $t$  members are born at time  $t$ , with a project that pays at  $t + 1$ . They maximize expected utility from consumption at  $t + 1$ . At time  $t$  they trade in assets to diversify their production risk. Generation  $t$  members cannot trade assets with members of different generations: at time  $t + 1$ , they are old and the best they can do is to consume all of their income; at time  $t$ , the only other living generation is generation  $t - 1$ , but since this generation is old they cannot trade. As a result, individuals diversify their production risk as much as they can by trading assets with other members of the same generation.<sup>35</sup>

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<sup>34</sup>These interactions were not present in the case without sovereign risk described in Section 1. They would not be present either if enforcement were fully discriminatory.

<sup>35</sup>In this section, we focus on equilibria of this many-period model in which the present actions of governments and/or individuals are independent of past actions. This rules out bubbly and reputational types of equilibria. In this case, the consumption and welfare of each generation is identical to that of the two-period model of Section 2,

The process of globalization consists of an increase of  $\tau$  over time. In particular, we assume  $\tau_0 = 0$ ,  $\tau_{t+1} \geq \tau_t$ , and  $\lim_{t \rightarrow T} \tau_t = 1$ . We define the gains from globalization as  $G(\tau) \equiv U(\tau) - U(0)$ , where we have made explicit that the utility of any given generation depends on the fraction of goods that are tradable. A generation born in autarky would be indifferent between experiencing growth in world production and consumption (of all goods in all states) by a factor  $\exp \{G(\tau)\}$  and experiencing an increase in the fraction of traded goods from 0 to  $\tau$ . It follows from Equation (27) that:

$$G(\tau) = - \int_0^\tau \left( \int_{s \in E(\tau)} \pi_s \cdot \ln \phi_s^{j(i)}(z) \right) \cdot dz - \int_0^\tau \left( \int_{s \notin E(\tau)} \pi_s \cdot \ln \left( \frac{\phi_s^{j(i)}(z)}{\phi_s^{j(i)}} \right) \right) \cdot dz + \quad (29)$$

$$+ \int_{s \notin E(\tau)} \pi_s \cdot \ln \phi_{is} \quad \text{for any } i \in I^W.$$

Equation (29), together with Equation (28), provides a full description of the gains from globalization. In autarky, sovereign risk is not a problem and all asset markets are open. There is perfect domestic sharing of all goods, but technological constraints to trade prevent international sharing. As a result  $i$ 's consumption of good  $z$  fluctuates across states following regional production. Globalization removes technological constraints to trade but also creates sovereign risk that leads to the closing of asset markets. In those states in which asset markets are open, i.e.  $s \in E$ , globalization allows perfect international sharing of tradable goods without affecting domestic sharing. This gain is captured by the first term in Equation (29). In those states in which asset markets are closed, i.e.  $s \notin E$ , globalization allows imperfect international sharing of tradable goods, but it reduces domestic sharing of all goods. The second and third terms in Equation (29) capture this gain and loss from globalization. In this section, we study how all of these forces combine to determine the effects of globalization on risk sharing and welfare.<sup>36</sup>

### 3.1 Globalization, enforcement and welfare (I): main results

We start our analysis with the case in which both regions have the same relative supplies of goods so that there are no terms-of-trade effects. This case provides a natural benchmark since, as in most of modern macroeconomics, the world economy behaves as if there were a single aggregate or

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and is fully described by Equations (24), (25), (27) and (28). In Section 4.1 we analyze reputational equilibria.

<sup>36</sup>In the polar case of perfect commitment, all asset markets would be open and all the gains from globalization would come from being able to perfectly share a larger fraction of goods, i.e.  $G(\tau) = - \int_0^\tau \left( \int_{s \in S} \pi_s \cdot \ln \phi_s^{j(i)}(z) \right) \cdot dz \geq 0$  for any  $i \in I^W$ . In the polar case of perfect discrimination without commitment, asset markets would be geographically segmented and the gains from globalization would come from being able to imperfectly share a larger fraction of goods, i.e.  $G(\tau) = - \int_0^\tau \left( \int_{s \in S} \pi_s \cdot \ln(\phi_s^{j(i)}(z)/\phi_s^{j(i)}) \right) \cdot dz \geq 0$  for any  $i \in I^W$ . Both of these polar cases therefore yield a smooth and conventional picture of globalization gradually increasing welfare because globalization does not affect the degree of market incompleteness.

composite good. The results that come out of this case are the main insights or predictions of the theory.

Since individual or regional production bundles, i.e.  $\{y_{is}(\cdot)\}_{i \in I^W}$ , are exogenous to the analysis, globalization can only affect the relative values of these bundles, i.e.  $\phi_{is}$  and  $\phi_s^j$ , through changes in goods prices. When this is the case, we say that globalization has terms-of-trade effects. We ensure next that globalization has no terms-of-trade effects by assuming that regional production bundles have the same proportions of all goods:

$$\phi_s^j(z) = \phi_s^j(0) \text{ for all } z \in [0, 1], s \in S, \text{ and } j \in \{H, F\}. \quad (30)$$

This condition implies that  $\partial \phi_{is} / \partial \tau = 0$  and  $\partial \phi_s^j / \partial \tau = 0$ . That is, globalization affects neither the within- nor the between-region inequality that would occur in the absence of enforcement.<sup>37</sup> In this case, the gains from globalization are

$$G(\tau) = -\tau \cdot \int_{s \in E(\tau)} \pi_s \cdot \ln \phi_s^{j(i)} + \int_{s \notin E(\tau)} \pi_s \cdot \ln \phi_{is} \text{ for any } i \in I^W. \quad (31)$$

For a given enforcement set, welfare is non-decreasing in  $\tau$ . In those states in which asset markets are open, i.e.  $s \in E$ , globalization permits international sharing in a growing fraction of goods. In those states in which asset markets are closed, i.e.  $s \notin E$ , globalization does not affect domestic or international sharing of goods. This is all standard and well known.

But the enforcement set is itself a non-increasing function of  $\tau$ . To see this, consider a pair of symmetric states  $\{s, s'\}$ . The top panel of Figure 1 shows the benefit and cost of enforcement in these states (see Equation (28)). While the benefit of enforcement does not depend on  $\tau$ , the cost of enforcement is proportional to  $\tau$ . If individual risk is not too high, i.e.  $-\int_{i \in I^R} \ln \phi_{is} < \ln \phi_s^R$ , there exists a threshold  $\tau_s^* (= \tau_{s'}^*)$  such that, if  $\tau \leq \tau_s^*$  both asset markets exist, but if  $\tau > \tau_s^*$  both asset markets are missing. This threshold is obtained by equating the cost and benefit of enforcement:

$$\tau_s^* = \frac{-\int_{i \in I^R} \ln \phi_{is}}{\ln \phi_s^R} \quad (32)$$

This threshold is increasing in individual risk, but decreasing in regional risk. This is a direct implication of the already familiar trade-off behind enforcement decisions. If  $\tau_s^* > 1$ , globalization never closes the market for assets that pay in state  $s$ . If  $\tau_s^* < 1$ , globalization closes this market on the first date in which  $\tau_t > \tau_s^*$  and it never reopens again. This effect of globalization on

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<sup>37</sup>In this world of symmetric regions and individuals, asset trade ensures that all incomes are equalized when there is enforcement.

enforcement is new and uncovering it is one of the main contributions of this paper.

Our symmetry assumptions allow us to study the contribution to overall welfare of each pair of symmetric states separately. The bottom panel shows how the contribution of a pair of states  $s$  and  $s'$  changes as globalization proceeds. Assume  $\tau_s^* < 1$  and let  $t_s^*$  be the generation such that  $\tau_{t_s^*} \leq \tau_s^* < \tau_{t_s^*+1}$ . All generations born at date  $t \leq t_s^*$  open the asset markets for this pair of states. Therefore globalization allows international sharing on a growing number of goods and increases the contribution of this pair of states to welfare. But this also requires growing payments between regions in these states. When generation  $t_s^*$  arrives, these payments would have grown too large and the temptation to default would have been irresistible. Since individuals anticipate this, the asset markets for this pair of states close. This eliminates all international sharing of tradable goods and worsens domestic sharing of goods. As a result, the contribution to welfare of this pair of states drops discretely to a level that is below that of autarky. All the generations born at dates  $t > t_s^*$  share this low level of welfare in this pair of states.

It is now straightforward to use the theory to provide an account of the effects of globalization. This is shown in Figure 2. Let the set of all pairs of symmetric states be denoted as  $S = \{(s_1, s'_1), (s_2, s'_2), \dots, (s_P, s'_P)\}$ . Let  $\tau_p^*$  be defined as above for the pair of states  $(s_p, s'_p)$ . In a given date  $t$ , asset markets exist for the pair of states  $(s_p, s'_p)$  if and only if  $\tau_t \leq \tau_p^*$ . Without loss of generality, we order pairs of symmetric states according to  $\tau_p^*$ , i.e.  $\tau_1^* \leq \tau_2^* \leq \dots \leq \tau_P^*$ .

The effects of globalization on welfare are illustrated in the three panels of Figure 2.<sup>38</sup> Assume that there exists some  $(s_p, s'_p)$  such that  $\tau_p^* < 1$  and, for these pairs, let  $t_p^*$  be the period such that  $\tau_{t_p^*} \leq \tau_p^* < \tau_{t_p^*+1}$ . All generations born in date  $t \leq t_1^*$  benefit from globalization because all asset markets are open and globalization enlarges the set of goods that are shared internationally. At  $t = t_1^*$ , the asset markets corresponding to the pair of symmetric states  $(s_1, s'_1)$  close leading to a reduction in both domestic and international sharing in these states. This leads to a discrete loss of welfare that persists forever since these asset markets never re-open. All generations born in dates  $t_1^* < t < t_2^*$  benefit from further globalization as, once again, it enlarges the set of goods that can be shared internationally. Note however that this effect is smaller than in earlier generations because the newly tradable goods cannot be shared in the pair of states  $(s_1, s'_1)$ . At  $t = t_2^*$ , the asset markets corresponding to the pair of symmetric states  $(s_2, s'_2)$  close and this leads to another discrete and persistent loss of welfare. After this, subsequent generations benefit from further globalization until the following pair of asset markets close. This process continues until the world is fully globalized.

The theory therefore predicts that globalization worsens enforcement. It also highlights the

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<sup>38</sup>The jagged line shows the case of a finite number of states (as explained in the text) while the smooth line shows the limiting case in which the number of states approaches infinity.

interplay of two opposing forces that shape the net effect of globalization on welfare. On the one hand, globalization removes technological constraints to trade and improves international sharing of goods. These are the classic gains from trade and their size grows with regional endowment differences. On the other hand, globalization creates sovereign risk and worsens domestic and international sharing of goods. These costs of trade are new to this paper and their size grows with regional endowment differences and declines with individual endowment differences. The top panel of Figure 2 shows the case in which the balance of these effects is always positive and welfare increases monotonically with globalization. The middle panel shows the opposite case in which the balance of these effects is negative and welfare falls monotonically with globalization. Finally, the lower panel shows a case in which the balance of these effects changes sign many times and the effects of globalization on welfare are not monotonic.

The benchmark case in which globalization does not generate terms-of-trade effects provides a sharp picture of the effects globalization.<sup>39</sup> When we go beyond this benchmark case and generalize the theory, we find that the basic picture remains robust, although it requires some interesting qualifications. We show this next.

### 3.2 Globalization, enforcement and welfare (II): terms-of-trade effects

If condition (30) does not hold, globalization creates changes in the terms of trade that affect the relative values of individual and regional production bundles, i.e.  $\phi_{is}$  and  $\phi_s^j$ . That is, we have now that globalization can affect within- and between-region inequality in the absence of enforcement, i.e.  $\partial\phi_{is}/\partial\tau \neq 0$  and  $\partial\phi_s^j/\partial\tau \neq 0$ .

For a given enforcement set, welfare no longer needs to be non-decreasing in  $\tau$ , as shown by Equation (29). Increases in  $\tau$  still permit international sharing of a larger fraction of goods in all states and this raises welfare. But now, in addition, globalization affects domestic sharing of goods in those states in which the corresponding asset market is closed, i.e.  $s \notin E$ . For instance, a change in the terms of trade that increases individual risk worsens domestic sharing of goods and lowers welfare.

Terms-of-trade effects also have implications for the shape of the enforcement set, as shown by Equation (28). Without terms-of-trade effects, enforcement only takes place at low values of  $\tau$ . This is because in this case the cost of enforcement grows proportionally with globalization, while the benefit of enforcement is not affected by globalization. But this need not be the case if globalization creates terms-of-trade effects. For instance, it is possible that terms-of-trade effects

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<sup>39</sup>Note that we have assumed much less than in standard macroeconomics models since we allow for individual differences in relative productions. We have only assumed that there are no differences in regional relative productions so that there is no scope for international trade in goods.

reduce regional risk so fast that the cost of enforcement falls with globalization. It is also possible that terms-of-trade effects increase individual risk so that the benefit from enforcement grows with globalization.

### 3.2.1 Regional terms-of-trade effects

It is useful to proceed step-by-step and consider first the case in which globalization creates terms-of-trade effects that alter between-region inequality in the absence of insurance, but do not alter the within-region inequality. This happens when the production bundles of all individuals within a region have the same proportions of all goods:

$$\phi_{is}(z) = \phi_{is}(0) \text{ for all } z \in [0, 1], s \in S, \text{ and } i \in I^W. \quad (33)$$

When this condition applies, we have that  $\partial\phi_{is}/\partial\tau = 0$ .

For a given enforcement set, welfare is non-decreasing in  $\tau$  like in the previous section. In those states in which asset markets are open, i.e.  $s \in E$ , globalization allows perfect international sharing of a larger fraction of goods. In those states in which asset markets are closed, i.e.  $s \notin E$ , globalization does not affect domestic sharing but allows imperfect international sharing of a larger fraction of goods.

But the effects of globalization on enforcement are richer than in the previous section. Since condition (33) ensures that  $\partial\phi_{is}/\partial\tau = 0$ , we still have that the benefit of enforcement is independent of  $\tau$ . But now the cost of enforcement need not be proportional to  $\tau$ . If globalization increases (decreases) regional risk, i.e.  $\partial\phi_s^R/\partial\tau > 0$  ( $\partial\phi_s^R/\partial\tau < 0$ ), the cost of enforcement will increase more (less) than proportionally with  $\tau$ . And whether globalization increases or reduces regional risk depends on whether the marginal tradable good is more or less procyclical than the average tradable one, i.e. on whether  $\phi_s^R(\tau) > \phi_s^R$  or  $\phi_s^R(\tau) < \phi_s^R$ .<sup>40</sup>

To develop further intuition, consider a pair of states in which:

$$\phi_s^R(z) = \begin{cases} \phi(0) & \text{for } z \in [0, 0.5] \\ \phi(1) & \text{for } z \in (0.5, 1] \end{cases}$$

with  $\phi(0) > 1$ . In this example, the cost of enforcement grows proportionally with  $\tau$  until  $\tau = 0.5$  since, in this range, the marginal tradable goods have the same cyclical properties as the average one. After  $\tau = 0.5$ , this is no longer the case. Does this make a difference? If the marginal tradable

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<sup>40</sup>To see this note that  $\partial\phi_s^R/\partial\tau = \tau^{-1} \cdot (\phi_s^R(\tau) - \phi_s^R)$ .

goods are either procyclical or mildly countercyclical,<sup>41</sup> then the picture of globalization remains essentially the same as in the previous section. If  $\phi(1) > \phi(0)$ , the cost of enforcement grows more than proportionally with  $\tau$ . If  $\phi(1) < \phi(0)$ , the cost of enforcement grows less than proportionally with  $\tau$ . In any case, globalization raises the cost of enforcement and might eventually lead to the closure of the corresponding asset markets.

It is possible however that the marginal tradable goods be so countercyclical that the cost of enforcement declines over some range. This case is shown in Figure 3, where we have assumed that  $\phi(1) = 2 - \phi(0)$ . After  $\tau = 0.5$ , the cost of enforcement starts declining and reaches zero when  $\tau = 1$ . The benefit of enforcement is independent of  $\tau$  since condition (33) applies. If individual risk is not too high, i.e.  $-\int_{i \in IR} \ln \phi_{is} < 0.5 \cdot \ln \phi(0)$ ; enforcement takes place at low and high levels of globalization, but not at intermediate levels. The threshold values at which enforcement changes are labelled  $\tau_s^*$  and  $\tau_s^{**}$ .

The contribution of this pair of states to welfare at different stages of globalization is shown in the bottom panel of Figure 3. Let  $t_s^*$  and  $t_s^{**}$  be the generations such that  $\tau_{t_s^*} \leq \tau_s^* < \tau_{t_s^*+1}$  and  $\tau_{t_s^{**}} \leq \tau_s^{**} < \tau_{t_s^{**}+1}$ , respectively. Let also  $t_s^{0.5}$  be the generation such that  $\tau_{t_s^{0.5}} \leq 0.5 < \tau_{t_s^{0.5}+1}$ . All generations born at date  $t \leq t_s^*$  open the asset markets for this pair of states. Therefore globalization allows international sharing on a growing number of goods and increases the contribution of this pair of states to welfare. But this also requires growing payments between regions in these states. When generation  $t_s^*$  arrives, these payments would have grown too large and the temptation to default would have been irresistible. Since individuals anticipate this, the asset markets for this pair of states close. This eliminates all international sharing of tradable goods and reduces domestic sharing of all goods. The contribution of this pair of states to welfare drops discretely to a level that is below that of autarky. All the generations born in  $t \in [t_s^*, t_s^{0.5})$  share this very low level of welfare. Generations born in  $t \in [t_s^{0.5}, t_s^{**})$  benefit from globalization. Although asset markets remain closed, goods markets now allow imperfect international sharing of tradable goods. Note also that changes in the terms-of-trade raise the relative income of the poor region and reduce the payments that would be required to achieve perfect international sharing of tradable goods. When generation  $t_s^{**}$  arrives, these payments are low enough and enforcement is possible again. Asset markets re-open and both domestic and international sharing is reestablished. This leads to a discrete increase in welfare. For  $t \geq t_s^{**}$ , asset markets are always open and globalization enlarges the fraction of goods that can be shared internationally.<sup>42</sup>

<sup>41</sup>More precisely, assume that  $\phi(1) > \bar{\phi}$ , where  $\bar{\phi} \equiv \phi(0) \cdot (1 - \ln \phi(0)) < 1$  (this inequality follows from  $\phi(0) > 1$ ).

<sup>42</sup>Note that asset markets are not used when globalization has been completed since the value of production in each region is the same in all states. The model of Cole and Obstfeld (1991) can be re-interpreted as the particular case of this example in which  $\phi^R(0) = 2$  and  $\tau = 1$ .

To sum up, this section shows how the effects of globalization on enforcement depend on the cyclicity of the marginal tradable goods relative to the average tradable one. If the marginal goods are more (less) procyclical than the average one, the cost of enforcement grows faster (slower) than in the benchmark case. It is possible that the marginal tradable goods be so countercyclical that the cost of enforcement falls with globalization in some range. In this case, it is also possible that globalization improves enforcement.

### 3.2.2 Individual terms-of-trade effects

Finally, if we relax Condition (33) globalization creates terms-of-trade effects that alter both between- and within-region inequality in the absence of enforcement. The effects of globalization on the cost of enforcement are as described in the previous section. What is new here is that globalization also affects the benefit of enforcement.

Should we expect globalization to increase or decrease within-region inequality in the absence of enforcement? The answer, once again, depends on whether the marginal tradable goods are more or less procyclical than the average one.<sup>43</sup> But it also depends now on the importance of the marginal tradable goods in the bundles of rich and poor individuals. To see this, consider first how globalization affects the price of these goods in the absence of enforcement. If they are less procyclical than the average one (i.e. they are relatively scarce in the rich region), their price declines relative to other goods. In turn, if these goods are abundant in the production bundles of poor (rich) individuals, within-region inequality increases (falls). A similar reasoning applies to the case in which the marginal tradable goods are more procyclical than the average one. Therefore, for globalization to increase the benefits of enforcement two conditions are necessary. The first one is that globalization change goods prices. This requires that the cyclical properties of the marginal tradable goods be different from those of the average one. The second condition is that this change in goods prices negatively affect poor individuals. This requires that their production bundles be relatively abundant in those goods whose price falls with globalization.

We conclude this section by showing an example in which terms-of-trade effects take us as far away from the benchmark as possible. Consider a simple modification of the previous example in which, instead of all individuals within a region producing the same bundle of goods, half of the residents produce low-index goods and half of the residents produce high-index ones. Namely,

$$\phi_i(z) = \begin{cases} 2 \text{ for } z \in [0, 0.5] \text{ and } 0 \text{ for } z \in (0.5, 1] & \text{with prob. } 0.5 \\ 0 \text{ for } z \in [0, 0.5] \text{ and } 2 \text{ for } z \in (0.5, 1] & \text{with prob. } 0.5 \end{cases} \quad \text{for all } i \in I^j \text{ and } j \in \{H, F\}.$$

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<sup>43</sup>Remember that when  $\phi_s^R(\tau) = \phi_s^R$ , then  $\partial\phi_{is}/\partial\tau = 0$  for all  $i$ .

Note that, in this example, full domestic sharing of all goods is achieved in autarky without asset trade, since the value of the production bundle of all the residents of a region is the same. That is, the value of asset markets in autarky is zero.

The top panel of Figure 4 shows the benefit and cost of enforcement both as functions of  $\tau$ . The cost of enforcement is as in the previous case, since it only depends on regional risk. But the benefit of enforcement now depends on  $\tau$  since changes in  $\tau$  affect individual risk. This benefit starts at zero when  $\tau = 0$  since asset markets are not used in autarky. Globalization does not create any international goods trade when  $\tau \leq 0.5$  and, as a result, the relative prices of high- and low-index goods are not affected in this range. Without terms-of-trade effects, the benefit of enforcement continues being zero throughout this range. When  $\tau > 0.5$ , regions start to trade goods and terms-of-trade effects start to kick in. In particular, international trade in goods raises the prices of low-index goods relative to high-index ones. This reduces domestic risk sharing and increases the benefit of enforcement (this also reduces the cost of enforcement, as explained in the previous subsection). As  $\tau$  increases, terms-of-trade effects grow stronger and the benefit of enforcement increases. There is therefore a threshold level  $\tau_s^*$  such that there is enforcement only for  $\tau \geq \tau_s^*$ .

The bottom panel shows how the contribution to welfare of this pair of states changes with globalization. Generations born in  $t \leq t_s^{0.5}$  are not affected by globalization. There is no enforcement but goods prices are such that there is perfect domestic sharing of all goods. As discussed above, there is no international sharing of tradable goods. Globalization has two opposing effects on the welfare of generations born in  $t \in [t_s^{0.5}, t_s^*)$ . On the one hand, globalization improves sharing of tradable goods between regions. On the other hand, globalization worsens domestic sharing of nontradable goods.<sup>44</sup> In this range, the negative effect of globalization on domestic sharing raises the benefit of enforcement. Also, the cost of enforcement declines as the same terms-of-trade effects that increase individual risk also reduce regional risk. When generation  $t_s^*$  arrives, the benefit of enforcement has increased enough and the cost of enforcement has decreased enough that enforcement becomes possible again and asset markets open. At this point there is a discrete increase in welfare. All generations born after  $t_s^*$  open asset markets and benefit from globalization as it enlarges the fraction of goods that can be shared internationally.

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<sup>44</sup>This negative effect of globalization on domestic sharing of goods was first noted by Newbery and Stiglitz (1984).

## 4 Robustness

In this section, we extend our model by incorporating three ingredients that have been emphasized in the literature on sovereign risk. In the first extension, we introduce default “penalties,” which can take the form of the seizure of valuable collateral, the application of trade embargoes, or the loss of reputation. We show that such penalties can improve enforcement and lower market incompleteness to some extent, but none of the qualitative results described in the previous sections are affected. In the second extension, we assume that governments can tax their residents and make payments to each other in order to avoid the deadweight losses associated with default. We show that such ex-post renegotiation does not have any effect on the workings of asset markets because it can be anticipated by individuals. In the third extension, we assume that governments can limit ex-ante borrowing by their residents. We show that such borrowing limits make little difference to our results. The reason is that enforcement problems are due to too much borrowing from foreigners, so limits on overall borrowing are too blunt of an instrument.

### 4.1 Penalties and reputation

Assume that the government of region  $j \in \{H, F\}$  suffers a penalty  $\kappa_s^j$  if it defaults on payments to foreigners in state  $s \in S$ . Also assume that  $\kappa_s^j$  satisfies the same between-region symmetry conditions that productions satisfy. Furthermore, to preserve the competitive nature of the equilibrium, assume that penalties are conditional on default taking place on a positive measure of payments.

Equilibrium consumption allocations are still given by Equations (24) and (25) and welfare is still given by equation (27). The only difference is that the enforcement set now depends on penalties, i.e.  $E(\{\kappa_s^H, \kappa_s^F\}_{s \in S})$ . For short, we shall write  $E(\kappa)$  and  $E(0)$  to denote the enforcement sets with and without default penalties respectively. Therefore, we replace Equation (28) with

$$E(\kappa) = \left\{ s \in S : - \int_{i \in I^R} \ln \phi_{is} + \kappa_s^R \geq \tau \cdot \ln \phi_s^R \right\}. \quad (34)$$

The penalty  $\kappa_s^j$  can be a direct penalty that each government can impose on the other government if it defaults. It can also be a cost associated with disruptions in trade in goods if governments have the ability to restrict trade in response to defaults. In this case, the penalty is given by

$$\kappa_s^R = \int_0^\tau \ln \left( \frac{\phi_s^R(z)}{\phi_s^R} \right) \cdot dz + \left( \int_{i \in I^R} \ln \phi_{is} - \int_{i \in I^R} \ln \phi'_{is} \right), \quad (35)$$

where  $\phi'_{is} \equiv \int_0^1 \phi_{is}(z) \cdot dz$ . The first term, which is positive, represents the losses due to having to consume tradable goods in proportion to their domestic production as opposed to world production.

The second term, which might be positive or negative, represents the changes in domestic inequality as a result of the changes in goods prices that results from closing down trade in goods. In general, we would expect the first term to dominate and trade sanctions to have its usual positive effects on enforcement. We can calculate  $\kappa_s^R$  for each state using Equation (35) and then replace it in Equation (34) to find the enforcement set  $E(\kappa)$ .

The two interpretations of exogenous penalties and trade sanctions have the problem that governments must either be “forced” to impose the penalties if and only if defaults takes place or else have access to a technology that would let them commit ex-ante to impose the penalties if and only if default takes place.

A more common way of endogenizing  $\kappa_s^j$  is to assume that governments play a repeated game and then focus on reputational equilibria. For instance, assume that governments agree to enforce if  $s \in E(\kappa)$  and that, if one deviates, they revert to the one-stage Nash equilibrium analyzed in the rest of the paper in which governments only enforce if  $s \in E(0) \subseteq E(\kappa)$ . The discount factor is  $\beta < 1$ . For a given enforcement set  $E$ , the loss from default is given by

$$\kappa(E) = \frac{\beta}{1-\beta} \cdot \left[ -\tau \cdot \int_{s \in E-E(0)} \pi_s \cdot \ln \phi_s^H - \int_{s \in E-E(0)} \pi_s \cdot \ln \phi_{is} \right]. \quad (36)$$

The two terms inside the bracket, which are positive, represent the future losses in international and domestic risk sharing in the states in which enforcement is lost respectively.<sup>45</sup> To find the reputational equilibria we must find fixed points  $(\kappa, E)$  of the mapping given by Equations (34) and (36). The best reputational equilibrium can be found with the following procedure. Set  $E_1 = S$ . Find  $\kappa_1$  and eliminate from  $E_1$  those states for which the enforcement condition is not satisfied, obtaining a new  $E_2 \subseteq E_1$ . Find  $\kappa_2 \in [0, \kappa_1]$  and eliminate from  $E_2$  those states for which the enforcement condition is not satisfied, obtaining a new  $E_3 \subseteq E_2$ . And so on. Since this is a contraction mapping the procedure must converge. That it converges to the best possible reputational equilibrium follows from the fact that if the enforcement condition fails for a state at any iteration it will fail for all later iterations since the condition gets tougher to satisfy as states are eliminated and, thus, the cost of default becomes lower.

The introduction of default penalties does not affect significantly the effects of globalization on risk sharing and welfare. In the case of exogenous penalties, they increase the benefit of enforcement by an amount independent of  $\tau$ , delaying the disappearance of markets and hastening their

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<sup>45</sup>There are two points worth noting. First, we have assumed that the reputational loss of default is not a function of the state  $s$ . Second, we have also assumed that  $\tau$  is constant over time. Both assumptions are common in the literature and it is straightforward to see that none of the qualitative results would be affected if we relaxed either one of them.

reappearance. For example, consider the case of no terms-of-trade effects that was illustrated in Figure 1. In the top panel, the benefit of enforcement shifts up by an amount equal to the default penalty. As a result, when generation  $t_s^* + 1$  arrives, asset trade does not disappear. Instead, asset markets remain open and welfare keeps increasing until a later time at which international payments become so large that they more than compensate for both the destruction of domestic payments and the default penalty.

When penalties take the form of disruptions in goods trade, the size of the penalties depend on the types and fraction of goods that are tradable. For example, in the case of no terms-of-trade trade sanctions have no effect whatsoever because there are no incentives to trade in goods. In the case of regional terms-of-trade that was illustrated in Figure 3 trade sanctions do have important effects. In the top panel, the benefit of enforcement is not affected for low values of  $\tau$  since there are no incentives to trade these goods internationally. Beyond  $\tau = 0.5$ , on the other hand, the benefits of enforcement increase with  $\tau$  as regions start trading in goods. As a result,  $\tau_s^*$  is unaffected but  $\tau_s^{**}$  decreases. The effects of globalization are now as follows. When generation  $t_s^* + 1$  arrives, asset markets still close for this pair of symmetric states. However, asset markets reopen before the arrival of generation  $t_s^{**} + 1$ . This example illustrates a more general point. The times at which markets appear and disappear are not much affected for low values of  $\tau$ . However, for higher values of  $\tau$  markets disappear later and reappear sooner.

When penalties take the form of losses of reputation the analysis is more involved. First, note that Equation (36) is correct only when  $\tau$  increases very slowly. Even in this case, the value of reputation may either increase or decrease with  $\tau$ , depending on how it affects the values under cooperation and non-cooperation. When  $\tau$  increases faster, Equation (36) must be replaced by one that correctly accounts for the net present value of reputation. We conjecture that, relative to the case of slow globalization, faster globalization hastens both the disappearance and reappearance of markets.

Interestingly, although the introduction of penalties does not affect qualitatively our results, our model suggests a new potential benefit from a strengthening of penalties. In our model default penalties not only improve international risk sharing but also domestic risk sharing. This is in sharp contrast with previous literature that assumed that countries can discriminate between domestic and foreign creditors. In this literature, asset markets are geographically segmented and there is perfect domestic risk sharing. Increases in penalties increase international risk sharing, but have no effect on domestic risk sharing.

## 4.2 Renegotiation

We have assumed so far that governments decide enforcement policies non-cooperatively and do not take into account how their decisions affect foreigners. This policy externality leads markets to close whenever the costs of making foreign payments are greater than the benefit of keeping domestic payments. At first sight, this might seem an easy problem to solve. After all, the gains that the rich region obtains from not enforcing are always smaller than the losses that the poor region suffers. Allowing regions to renegotiate their debts ex-post should therefore ensure that there is always enforcement. Unfortunately, this argument is wrong and we explain next why.

Consider a pair of symmetric states for which we concluded there is no enforcement in the best symmetric equilibrium. We reached this conclusion by contradiction. Assume individuals expect enforcement, then asset trade would be as in the complete-markets model and the government of the rich region would have an incentive not to enforce. Therefore, individuals cannot expect enforcement. This leads us to the conclusion that the only possible outcome is that individuals do not expect enforcement. In this case, there is no asset trade and expecting governments not to enforce is a consistent “off-equilibrium” belief.

This argument does not formally consider the possibility that regions cooperate during old age and the question now is whether this omission matters or not. To be concrete, assume the poor region can make a transfer to the rich region in exchange of enforcement. To raise revenue for this transfer, the poor region levies lump-sum taxes on its residents. Ex-post, the poor region would be willing to offer a transfer to the rich region that is as large as the payments that its residents are due. But the transfer need not be as large for it to work. Since not enforcing destroys valuable domestic payments, the value of not enforcing for the rich region is smaller than the foreign payments it saves by not enforcing. This observation could lead us to conclude that enforcement should be the only outcome of any efficient (and also some inefficient) ex-post bargaining between regions.

But this conclusion would be unwarranted, since it assumes that free or unobstructed asset trade during youth can lead to imperfect sharing ex-post. To see this, consider again a pair of states for which we decided there is no enforcement in the best symmetric equilibrium. Assume now that individuals were to expect that there is enforcement in old age and that this enforcement requires a transfer. But then asset trade would not be as in the complete-markets model. Anticipating the transfer, domestic residents would now feel richer and sell more assets to foreign residents which now feel poorer. In particular, asset trade would be such that fully offsets the transfer and achieves perfect domestic sharing of all goods and perfect international sharing of tradable goods *after* the transfer has been paid. But we know already that in this case the rich region has an incentive not

to enforce and therefore individuals cannot expect that the transfer be enough to induce the rich region to enforce.

This argument shows that the expectation of a debt renegotiation cannot sustain the opening of asset markets, and leads us to conclude that allowing ex-post cooperation between regions does not affect the equilibrium of the model.

### 4.3 Borrowing limits

In our model, market incompleteness results in individuals not being able to issue assets that pay in states in which there is no enforcement. This follows, in part, from an overborrowing externality. In particular, individuals do not take into consideration how their choice of asset holdings affects the enforcement decision of their government and, consequently, the borrowing limits of other residents. This leads individuals to borrow so much from abroad during youth that governments prefer not to enforce in old age.

In principle, the solution to this problem consists of imposing limits to foreign borrowing. But this solution is not available if government policy cannot discriminate between asset holders, as we have assumed throughout the paper. The same reasons (opaque financial intermediaries and deep secondary markets) that impede governments to discriminate between asset holders when enforcing payments also impede them to discriminate between asset holders when imposing borrowing limits. We therefore assume that governments can only impose limits on overall borrowing.<sup>46</sup>

Assume governments limit private borrowing using asset-specific issuance rights. Governments choose the number of issuance rights for each asset, denoted  $\bar{x}_s^j$  for  $s \in S$  and  $j \in \{H, F\}$ , which they distribute equally among their domestic residents. During youth agents trade in both issuance rights and assets, under the constraint that their issuance is limited by the issuance rights they hold. Therefore, the budget sets during youth in Equations (19) and (20) are replaced by

$$\int_{s \in S} \left( q_s^H \cdot x_{H,is} + q_s^F \cdot x_{F,is} + \iota_s^{j(i)} \cdot \left( \bar{x}_{is} - \bar{x}_s^{j(i)} \right) \right) \leq 0 \quad \text{for all } i \in I^W, \quad (37)$$

$$x_{j(i),is} \geq -\min \{ \hat{y}_{is}, \bar{x}_{is} \} \quad \text{and} \quad x_{-j(i),is} \geq 0 \quad \text{for all } s \in S \text{ and } i \in I^W, \quad (38)$$

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<sup>46</sup>With discriminatory borrowing limits, governments could achieve a constrained efficient equilibrium in which there is perfect domestic risk sharing and constrained international risk sharing. In particular, for each state the rich region would impose no limits on domestic borrowing and the loosest limit  $\bar{x}_s^R$  on foreign borrowing such that the corresponding enforcement condition

$$-\int_{i \in I^R} \ln \phi_{is} \geq \tau \cdot \ln \phi_s^R - \tau \cdot \ln \max \left\{ 1, \frac{y_s^R + \bar{x}_s^R}{y_s^W} \right\}$$

holds. In this constrained optimum, globalization would never have negative effects on domestic risk sharing, although it may (locally) tighten the borrowing constraint and worsen international risk sharing. It would still be true that the higher the importance of domestic risk sharing the more international risk sharing there can be.

where  $\bar{x}_{is}$  denotes the state- $s$  issuance rights held by individual  $i$  after the market for issuance rights closes,  $\iota_s^j$  denotes the price of state- $s$  issuance rights in country  $j$ , and we used the fact that before the market for issuance rights opens individual  $i$  holds  $\bar{x}_s^{j(i)}$  state- $s$  issuance rights. In addition to the market clearing conditions for assets in Equation (22) we now also have market clearing conditions for issuance rights, which are given by

$$\int_{i \in I^j} \bar{x}_{is} = \bar{x}_s^j \text{ for all } s \in S \text{ and } j \in \{H, F\}. \quad (39)$$

A competitive equilibrium with borrowing limits during youth consists of a set of asset prices and quantities such that individuals maximize expected utility –Equation (2)– subject to their budget and borrowing constraints –Equations (37), (38) and (21)– and asset markets clear –Equations (22) and Equation (39). Naturally, when maximizing their utility, individuals take as given how their individual consumption during old age depends on their individual asset holdings.

In Appendix B we analyze the equilibrium with optimal borrowing limits and show that it contains three types of states. In those states in which there is enforcement even in the absence of borrowing limits, it is optimal not to impose binding limits and the price of issuance rights is zero in both regions. In the remaining states, it is possible (but not necessary) that borrowing limits in the rich region allow enforcement and trade. In those states in which this happens, we have that the price of issuance rights is positive in the rich region and asset markets are open. Paying issuance rights introduces a wedge between the ex-post incomes of borrowers and lenders and, even though asset markets are open, both domestic and international sharing of goods is imperfect. In those states in which there is no borrowing limit that would lead to enforcement and trade, the price of issuance rights is zero in both regions and asset markets remain closed.

The effects of globalization with optimal borrowing limits are illustrated in Figure 5. The left two panels refer to the case of no terms-of-trade effects illustrated in Figure 1. The top panel shows the optimal issuance rights price in the rich region as a function of  $\tau$  (this price is always zero in the poor region), which we denote  $\iota_s^*(\tau)$ . For  $\tau \leq \tau_s^*$ , borrowing limits are not needed for enforcement to take place so  $\iota_s^*(\tau) = 0$ . In addition, for  $\tau$  sufficiently higher than  $\tau_s^*$  borrowing limits are not useful either since the issuance rights price would need to be so high for enforcement to take place that no resident of the rich region would sell assets anyway. The optimal issuance rights prices are positive only for values of  $\tau$  that are a bit above  $\tau_s^*$ . The effects of globalization on welfare for this pair of symmetric states is shown in the bottom panel. These effects are quite similar to those in the absence of borrowing limits. The difference is that when generation  $t_s^* + 1$  arrives, instead of asset trade disappearing the rich region imposes borrowing limits that lead to

a positive issuance rights price  $\iota_s^*(\tau_{t_s^*+1})$ . Although asset markets remain open, there is imperfect domestic and international sharing of goods. Each new generation requires higher issuance rights prices to keep enforcement. Conditional on issuance rights prices and enforcement, globalization improves international sharing of newly tradable goods. However, domestic sharing of goods and international sharing of inframarginal tradable goods worsen as a result of higher issuance rights prices. The net effects of globalization on welfare are ambiguous. At some point, enforcement is impossible even with borrowing limits, so the price of issuance rights fall to zero and globalization eliminates all domestic and international sharing of goods. Borrowing limits delay the date in which enforcement breaks down.

The middle two panels refer to the case illustrated in Figure 3 in which there are only regional terms-of-trade effects. The top panel shows that the optimal issuance rights price is positive only for values of  $\tau$  that are a bit above  $\tau_s^*$ , and also for values of  $\tau$  that are a bit below  $\tau_s^{**}$ . The bottom panel shows that the effects of globalization on welfare for this pair of symmetric states are not qualitatively affected by borrowing limits. Borrowing limits delay the time at which enforcement breaks down and bring forward the time at which enforcement reappears. The right two panels refer to the case illustrated in Figure 4 in which there are regional and individual terms-of-trade effects. The top panel shows that the optimal issuance rights price is positive only for values of  $\tau$  that are a bit below  $\tau_s^*$ . Once again, the bottom panel shows that the effects of globalization on welfare for this pair of symmetric states are not qualitatively affected by borrowing limits. Borrowing limits simply bring forward the time at which enforcement appears.

This discussion shows that borrowing limits, though welfare-improving, have little effect on the picture of globalization we presented in Section 3.<sup>47</sup>

## 5 Final Remarks

This paper has developed a novel theory of endogenous asset market incompleteness based on sovereign risk. The key innovation is our assumption that governments cannot discriminate between domestic and foreign creditors when choosing enforcement. Previous theory had instead assumed that governments can perfectly discriminate between domestic and foreign creditors. The results presented in this paper show that this choice of assumption shapes the analysis in a fundamental way:

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<sup>47</sup>In Appendix C, we allow governments to shut down private asset markets and directly control the amount of borrowing by issuing public debt. We show that such public intervention would also have little effect on the picture of globalization presented here. The reason is that governments can control how much they borrow but cannot control who they borrow from. In fact, the outcome with optimal public borrowing is inferior to the one with optimal borrowing limits.

- If a country can perfectly discriminate between domestic and foreign creditors, sovereign risk keeps all asset markets open but geographically segmented. Domestic asset trade is not affected by sovereign risk and can only be limited by other financial market imperfections. International asset trade is not feasible unless the country can offer some collateral.<sup>48</sup> Increases in collateral should improve international risk sharing, without affecting domestic risk sharing. Reductions in trade costs improve the functioning of goods markets without affecting the functioning of asset markets, and always raise welfare.<sup>49</sup>
- If a country cannot discriminate between domestic and foreign creditors, sovereign risk closes some asset markets but keeps those that are open global. Even in the absence of other financial market imperfections, domestic asset trade is limited. Even in the absence of collateral, some international asset trade is possible. Increases in collateral should improve both international and domestic risk sharing. Reductions in trade costs improve the functioning of goods markets but might either improve or worsen the functioning of asset markets, and the effects on welfare can go either way.

Therefore, our assumption of no discrimination: (i) provides a new explanation for why countries can borrow abroad; (ii) shows that there are crucial interactions between domestic and international asset trade; and (iii) accounts for much richer effects of globalization on risk sharing. In addition, the assumption of no discrimination seems to us more realistic than the previous one of perfect discrimination. Although reality surely lies somewhere between these two polar cases, we argued in the introduction that the institutional setup of international borrowing during the 1990's and 2000's is one in which governments find it difficult to discriminate between domestic and foreign creditors. In any case, it seems also evident that the main theoretical results of this paper would still apply even if governments have some ability to discriminate between creditors and only vanish in the polar case of perfect discrimination.

What are the effects of globalization on risk sharing and welfare? The paper started with this question and it seems fair to end it reviewing what we have learned about it. We have studied a

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<sup>48</sup>We use here a broad concept of collateral. This concept includes the narrow view of collateral, i.e. the value of the real assets that foreign creditors can directly seize in the event of default. It also includes the effects of default penalties, i.e. the value of the payments that foreign creditors can elicit through the threat of applying penalties of various sorts. Conceptually, narrow collateral and penalties play the same role in the theory and therefore makes sense to treat them jointly.

<sup>49</sup>The trade theorist will immediately recognize that this statement needs a few words of qualification. In the model of this paper, globalization with perfect discrimination would raise the ex-ante welfare of all regions because they are ex-ante identical and a reduction in trade costs has no ex-ante terms-of-trade effects. With asymmetric regions, it is possible to construct examples in which there are ex-ante terms-of-trade effects that lead some regions to gain and some to lose as a result of globalization. But even in this case, the world as a whole would still gain from globalization and, as a result, there would always exist a set of (international) ex-ante transfers that ensure that globalization leads to a Pareto-improvement. See Ventura (2005) for a comprehensive analysis of the effects of globalization (as modelled here) on trade, growth and welfare.

world in which individuals face production risk and examined the effects of a gradual improvement in technology that reduces trade costs from prohibitive to negligible. Before globalization, insurance markets work well and individuals are able to perfectly share risks domestically. International risk sharing is not possible since trade costs are prohibitive. As globalization proceeds, a number of simultaneous changes take place in the world economy. The new ability to engage in international trade changes supplies and demands and therefore the behavior of commodity prices. Although this might (or might not) increase individual income volatility, it would not constitute a problem if insurance markets continued working well. To the contrary, the ability to ship goods internationally would allow individuals to use these markets not only to share risk domestically but also to share them internationally. But globalization also has the negative side effect of creating sovereign risk. Opportunistic governments have the temptation to default in order to redistribute consumption from foreign to domestic citizens. The only countervailing force against this temptation is given by the destruction in domestic risk sharing that default would bring about. As international risk sharing grows relative to domestic risk sharing, markets collapse since individuals correctly anticipate that default would take place and debts would not be paid back. This destruction of markets worsens risk sharing and creates welfare costs that might (or might not) exceed the welfare gains from goods trade. This result applies even if we allow markets and governments to react optimally to the changes brought about by globalization.<sup>50</sup>

We therefore took on Dixit's challenge to study the effects of globalization on risk sharing in a model that explicitly identifies the sources of market incompleteness. Unlike him, we found that even in this case it is possible (but not necessary) that globalization worsens risk sharing and reduces welfare. The reason is that globalization increases the severity of the underlying friction, namely, sovereign risk. Naturally, that something can happen in a model does not mean that it does happen in reality. Knowing what is theoretically possible is key to reach a deep understanding of any problem. But we are still far from this point in the case of the effects of globalization on risk sharing and welfare. Existing evidence is not yet conclusive and the theory is still in its infancy. At this stage, a study like this one raises as many questions as it solves. For instance, we have assumed throughout that globalization affects neither governments' objectives nor their ability to commit. There might be substantial payoffs to developing additional theories of how globalization affects markets, institutions and political structure.

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<sup>50</sup>Sometimes though globalization lowers international risk sharing relative to domestic one and leads to the opening of insurance markets. In this case, globalization has doubly positive effects on risk sharing and welfare.

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## Appendix A: Construction of the sovereign risk equilibrium

In this appendix, we construct the sovereign risk equilibrium used in the text. With complete markets, there are equilibria that share the same prices and quantities, but differ in the distribution of assets among individuals. This multiplicity is clearly irrelevant since it does not matter whose assets an individual holds. With sovereign risk, the distribution of assets may be relevant since it can affect the governments’ incentives to enforce payments ex-post. To simplify the exposition, we impose the condition that there be no state in which Home residents receive payments from Foreign and Foreign residents receive payments from Home. That is, either  $\int_{i \in I^H} x_{F,is}$  or  $\int_{i \in I^F} x_{H,is}$  is zero for all  $s \in S$ . This restriction is without loss of generality since it can be easily shown that if a given allocation can be supported as an equilibrium in which this condition is not satisfied, then this allocation can also be supported as an equilibrium in which this condition is satisfied.

It follows from the symmetry assumption that we can analyze pairs of symmetric states independently. For each pair of symmetric states  $s$  and  $s'$  there are three possible symmetric enforcement levels: (i) both regions enforce:  $s \in E^H \cap E^F$  and  $s' \in E^H \cap E^F$ ; (ii) one region enforces: either  $s \in E^F - E^H$  and  $s' \in E^H - E^F$ , or  $s \in E^H - E^F$  and  $s' \in E^F - E^H$ ; and (iii) no region enforces:  $s \notin E^H \cup E^F$  and  $s' \notin E^H \cup E^F$ . We construct the best symmetric equilibrium and this is the one in which enforcement levels are as high as possible. To find this equilibrium, we take each pair of symmetric states  $s$  and  $s'$  and follow three steps:

STEP 1: We check whether in equilibrium both regions can enforce payments simultaneously.<sup>51</sup> Assume this is the case. Then, asset holdings are as in the complete-markets model and consumptions are given by Equation (14). Using these consumption allocations and the fact that utility is logarithmic, we find that the enforcement condition is given by:

$$-\int_{i \in I^j} \ln \left( \frac{y_{is}^{N^j} + x_{-j,is}}{y_s^{j,N^j} + x_{-j,s}^j} \right) \geq \tau \cdot \ln \left( \frac{y_s^{j,N^j} + x_{-j,s}^j}{y_s^{W,N^j}} \right) \quad \text{for all } j \in \{H, F\},$$

<sup>51</sup>Since states  $s$  and  $s'$  are symmetric, we just perform these steps on state  $s$ .

where  $y^{N^j}$  stands for the value of income in case of unexpected non-enforcement by the government of region  $j$ . The left hand side measures the loss in average utility that results from a breakdown in domestic risk sharing in region  $j$ , while the right hand side measures the gains in average utility that result from not paying debts to foreigners. The left hand side is nonnegative for both regions, while the right hand side is zero for the poor (or creditor) region and positive for the rich (or debtor) region. Therefore, the poor region has no incentive to deviate. Has the rich region an incentive to deviate? Let  $R$  be the rich region. Since nobody in this region holds assets issued by residents of the poor region, i.e.  $x_{P,is} = 0$  for all  $i \in I^R$ , individual and regional incomes of the rich region if it deviates are obtained by setting  $x_{is} = 0$  in Equations (7) and (8). If, given these values of productions, the Equation above holds we conclude that the government of the rich region enforces payments. In this case,  $s \in E^H \cap E^F$  and  $x_{is} = y_s^W - y_{is}$  for all  $i \in I^W$ . Otherwise, we move to the next step.

STEP 2: We check whether the poor region enforces payments, even though the rich region does not. Assume this is the case. Since the rich region does not enforce payments, there are some residents of this region that would like to sell assets but cannot do so. Typically, there are also some “poor” residents of the rich region that purchase assets from “rich” residents of the poor region. Therefore, the rich region becomes the creditor while the poor region becomes the debtor. Let  $R$  and  $P$  be the rich and poor regions. Then, we have that asset holdings are given by

$$x_{is} = \begin{cases} \max \{y_s^P + x_s^P - y_{is}, 0\} & \text{if } i \in I^R \\ y_s^P + x_s^P - y_{is} & \text{if } i \in I^P \end{cases}$$

and the market clearing condition in Equation (11). These asset holdings imply that there is full risk sharing among those individuals for which the borrowing constraint is not binding. This includes all residents of the poor region and the “poor” residents of the rich region. The “rich” residents of the rich region are forced to consume all of their production. Substituting these asset holdings into Equations (6), (7) and (8), we obtain incomes and consumption allocations. Moreover, this allows us to write the enforcement condition for the poor region as:

$$-\int_{i \in I^P} \ln \left( \frac{y_{is}^{N^P}}{y_s^{P,N^P}} \right) \geq \tau \cdot \left[ \ln \left( \frac{y_s^{P,N^P}}{y_s^{W,N^P}} \right) - \ln \left( \frac{y_s^P + x_{P,s}^P}{y_s^W} \right) \right].$$

Once again, the left hand side measures the loss in average utility that results from a breakdown in domestic risk sharing in the poor region, while the right hand side measures the gains in average utility that result from not paying debts to residents of the rich region. Both the left and right hand

sides are nonnegative. Since residents of the rich region cannot sell assets, individual and regional incomes of the poor region if it deviates are obtained by setting  $x_{is} = 0$  in Equations (7) and (8). If, given these values of productions, the condition above holds, we conclude that  $s \in E^P - E^R$  and asset holdings are determined as described above. Otherwise, we move to the next step.

*STEP 3:* If we arrive to this step, it means that none of the regions enforce payments and we conclude that  $s \notin E^H \cup E^F$  and  $x_{is} = 0$  for all  $i \in I^W$  and  $j \in \{H, F\}$ . We then obtain incomes and consumption allocations by substituting these asset holdings into Equations (6), (7) and (8).

This procedure delivers the best equilibrium. This follows from two observations. First, the enforcement level in a given pair of states does not affect enforcement or welfare in any other pair of states. This is because we focus on symmetric equilibria and in all of them the relative wealth of individuals is the same. Second, the welfare in any pair of states increases with the enforcement level. This is because there are gains from trade and the larger the number of markets the more of these gains individuals reap.

We can generate other symmetric equilibria by switching the order in which we perform the three steps above. For instance, moving step one to the end and then alternating between starting the procedure in steps two and three generates equilibria in which there is at least one missing market. Or moving step two to the end and then alternating between starting the procedure in steps one and three generates equilibria in which there are either two open markets or none.<sup>52</sup>

## Appendix B: Borrowing limits

In this appendix, we analyze the equilibrium with optimal borrowing limits. Instead of finding the optimal issuance rights directly, we first find the optimal issuance rights prices  $\{\iota_s\}_{s \in S}$ . Given these prices and resulting asset issuance, the optimal issuance rights are given by

$$\bar{x}_s^j = \int_{i \in I^j} \max\{0, -x_{is}\} \text{ for all } s \in S \text{ and } j \in \{H, F\}.$$

As before, we can analyze pairs of symmetric states independently. To simplify the analysis of the effects of globalization and make it comparable to those in Section 3, we assume that either there is enforcement in both regions or there is not enforcement in either region. We only consider cases in which the issuance rights prices in the poor region are  $\iota_s^P = 0$ . This condition will be

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<sup>52</sup>Following this procedure until we have tried all possible orderings allows us to construct all symmetric equilibria except for those in which the rich region enforces but the poor region does not. If we added an additional step in which we checked whether the rich region enforces payments while the poor region does not, the procedure would generate the entire set of symmetric equilibria.

satisfied at the optimum because it is the government of the rich region which might have ex-post incentives not to enforce payments. So let us denote the issuance rights prices in the rich region by  $\iota_s$ . Equilibrium in asset markets in state  $s$  is characterized by

$$x_{is} = \begin{cases} (1 + \iota_s) \cdot (y_s^P + x_s^P) - y_{is} & \text{if } (1 + \iota_s) \cdot (y_s^P + x_s^P) < y_{is} \\ 0 & \text{if } y_s^P + x_s^P \leq y_{is} \leq (1 + \iota_s) \cdot (y_s^P + x_s^P) \\ y_s^P + x_s^P - y_{is} & \text{if } y_{is} < y_s^P + x_s^P \end{cases} \quad \text{if } s \in E \text{ for all } i \in I^R, \quad (40)$$

$$x_{is} = y_s^P + x_s^P - y_{is} \quad \text{if } s \in E \text{ for all } i \in I^P, \quad (41)$$

and  $x_{is} = 0$  if  $s \notin E$  for all  $i \in I^W$ ; and the asset market clearing condition  $x_s^R + x_s^P = 0$ . These conditions imply that, when there is enforcement, the richest residents of the rich region make payments to the poorest residents of the rich region and to the residents of the poor region. Borrowing limits introduce a wedge between the ex-post incomes of individuals in these two groups.

Whether or not there is enforcement in state  $s$  depends on asset holdings, which in turn depend on borrowing limits. Let  $x_{is}(\iota_s)$  be the amount of assets individual  $i$  purchases when issuance rights prices are  $\iota_s$ , if all individuals expect enforcement. Then  $x_s^P(\iota_s) \equiv \int_{i \in I^P} x_{is}(\iota_s)$  is a decreasing function of  $\iota_s$ . This is because, as  $\iota_s$  increases, both the set of richest residents in the rich region who want to sell assets and the amount of assets that each such resident wants to sell decreases. It also follows that  $x_s^P(\iota_s)$  is continuous in  $\iota_s$  and that there exists a high enough  $\iota_s$  such that  $x_s^P(\iota_s) = 0$ . Let us define  $\bar{\iota}_s \equiv \min \{ \iota_s : x_s^P(\iota_s) = 0 \}$ , which we call the prohibitive issuance rights price for state  $s$ . Let  $\iota_s^E$  be the set of issuance rights prices such that enforcement takes place, namely

$$\iota_s^E \equiv \{ \iota_s : v_s^R(\text{enforce}) + \kappa_s \geq v_s^R(\text{not enforce}) \text{ when } x_{is} = x_{is}(\iota_s) \text{ for } i \in I^W \} \text{ for all } s \in S.$$

Let the optimal issuance rights price be denoted  $\iota_s^*$ . Then  $[\bar{\iota}_s, \infty) \subseteq \iota_s^E$  and, since the optimal issuance rights prices are those that maximize asset trade,  $\iota_s^* \leq \bar{\iota}_s$ . The optimal issuance rights price will be such that there is enforcement in all states except in those in which the issuance rights prices need to be so large for enforcement that no issuance takes place (i.e.  $\iota_s^E = [\bar{\iota}_s, \infty)$ ) and  $x_{is}(\bar{\iota}_s) \geq 0$  for all  $i \in I^R$ ). The optimal issuance rights prices are then given by

$$\iota_s^* \equiv \begin{cases} \min \{ \iota_s^E \} & \text{if } \min \{ x_{is}(\min \{ \iota_s^E \}) : i \in I^R \} < 0 \\ 0 & \text{if } \min \{ x_{is}(\min \{ \iota_s^E \}) : i \in I^R \} \geq 0 \end{cases} \quad \text{for all } s \in S.$$

Clearly,  $\iota_s^* = 0$  for those states in which there was enforcement in the equilibrium without

borrowing limits, and  $\iota_s^* \in [0, \bar{\iota}_s]$  for the other states. If  $\min_{i \in IR} \{x_{is}(0)\} < x_s^P(0)$ , then when  $\iota_s = \bar{\iota}_s$  there are no payments to residents of the poor region while there are payments from the richest residents of the rich region to the poorest residents of the rich region. As a result, the government of the rich region strictly prefers to enforce payments. By continuity,  $\iota_s^* < \bar{\iota}_s$ . As a result, if  $\min_{i \in IR} \{x_{is}(0)\} < x_s^P(0)$  ex-ante utility is strictly higher with optimal borrowing limits than without them. In addition, there is some international sharing of goods since  $x_s^P(\iota_s^*) > 0$ . If  $\min_{i \in IR} \{x_{is}(0)\} \geq x_s^P(0)$ , then when  $\iota_s = \bar{\iota}_s$  there are neither payments to residents of the poor region nor payments to the poorest resident of the rich region. Whether or not there exists an issuance rights price  $\iota_s < \bar{\iota}_s$  such that there is enforcement depends on the distribution of individual shocks in the rich region and the fraction of goods that are tradable  $\tau$ . In all cases, even with optimal borrowing limits sovereign risk still leads to imperfect domestic and international sharing of goods.

## Appendix C: Public debt

In this appendix, we allow governments to address the problem of private overborrowing by replacing private borrowing with public debt. Assume that at the beginning of youth governments issue contingent public debt. Governments choose the number of public bonds contingent on each state of nature, denoted  $b_{j,s}$  for  $s \in S$  and  $j \in \{H, F\}$ , which they distribute equally among their domestic residents. Assume for now that governments prohibit agents from trading private assets. During old age, instead of an enforcement choice, governments choose whether to repay their debt or not. If a government chooses to repay, it imposes non-distortionary lump-sum taxes on its domestic residents  $t_{j,s} = b_{j,s}$ . If a government chooses not to repay, taxes  $t_{j,s} = 0$ . The governments' budget constraints during old age are then given by

$$t_{j,s} = e_{j,s} \cdot b_{j,s} \text{ for all } s \in S \text{ and } j \in \{H, F\}, \quad (42)$$

where  $e_s^j$  is an indicator variable that takes value one if government  $j$  repays its debt and zero otherwise. We assume that governments cannot discriminate among domestic residents when imposing taxes and cannot discriminate between domestic and foreign residents when repaying its debt. During youth, agents trade in a market for government debt, selling bonds that pay in states in which their production is high and buying bonds that pay in states in which it is low.

The budget sets during youth in Equations (19), (20), and (21) are replaced by

$$\int_{s \in S} (q_s^H \cdot b_{H,is} + q_s^F \cdot b_{F,is}) = \int_{s \in S} q_s^{j(i)} \cdot b_{j(i),s} \text{ for all } i \in I^W, \quad (43)$$

where  $b_{j,is}$  denotes the number of public bonds that pay in state  $s$  issued by government  $j$  held by individual  $i$  after the market for public debt closes,  $q_s^j$  denotes the price of public bonds that pay in state  $s$  issued by government  $j$ , and we used the fact that before the market for public debt opens individual  $i$  holds  $b_{j(i),s}$  bonds that pay in state  $s$ . The market clearing conditions in Equation (22) are replaced by

$$\int_{i \in I^W} b_{j,is} = b_{j,s} \text{ for all } s \in S \text{ and } j \in \{H, F\}. \quad (44)$$

Finally, the budget constraints of old individuals reflect both payments from holding public debt and taxes. We thus replace Equation (16) with

$$\int_0^1 p_s^{j(i)}(z) \cdot c_{is}(z) \cdot dz \leq y_{is} + e_s^{j(i)} \cdot (b_{j(i),is} - b_{j,s}) + e_s^{-j(i)} \cdot b_{-j(i),is} \text{ for all } s \in S \text{ and } i \in I^W, \quad (45)$$

where we used the fact that governments can default on their debts and also the governments' budget constraint in Equation (42) to find taxes.

Note that a higher level of public debt leads in principle to more risk sharing (conditional on repayment) since it allows individuals to make higher payments in more states. At one extreme, if  $b_{j,s} = 0$  residents of region  $j$  cannot make any payment in state  $s$ . At the other extreme, if  $b_{j,s}$  is very high residents of  $j$  can make very high payments. Public debt issuance thus plays a similar role as issuance rights in the previous section.

As before, we can analyze pairs of symmetric states independently. To simplify the analysis of the effects of globalization and make it comparable to those in Section 3, we will assume that either both governments repay or neither does. With some abuse of notation, we will denote the set of states in which both governments repay as  $E$ . We will only consider cases in which the government of the poor region issues enough public debt so that their residents are unconstrained in the amount of payments they make during old age. This condition will be satisfied at the optimum because it is the government of the poor region which might have ex-post incentives not to repay its debt.

Equilibrium in the market for government debt that pays in state  $s$  is characterized by

$$b_{is} = \begin{cases} 0 & \text{if } y_s^P + b_s^P + (b_{R,s} - b_{P,s}) \leq y_{is} \\ y_s^P + b_s^P + (b_{R,s} - b_{P,s}) - y_{is} & \text{if } y_{is} < y_s^P + b_s^P + (b_{R,s} - b_{P,s}) \end{cases} \quad \text{if } s \in E \text{ for all } i \in I^R, \quad (46)$$

$$b_{is} = y_s^P + b_s^P - y_{is} \quad \text{if } s \in E \text{ and } i \in I^P, \quad (47)$$

and  $b_{is}$  undetermined if  $s \notin E$  for all  $i \in I^W$ ; and the asset market clearing condition  $b_s^R + b_s^P = b_{H,s} + b_{F,s}$ . To make the outcome more transparent, note that consumption levels are given by

$$c_{is} = \begin{cases} y_{is} - b_{R,s} & \text{if } y_s^P + b_s^P + (b_{R,s} - b_{P,s}) \leq y_{is} \\ y_s^P + (b_s^P - b_{P,s}) & \text{if } y_{is} < y_s^P + b_s^P + (b_{R,s} - b_{P,s}) \end{cases} \quad \text{if } s \in E \text{ for all } i \in I^R, \quad (48)$$

$$c_{is} = y_s^P + (b_s^P - b_{P,s}) \quad \text{if } s \in E \text{ for all } i \in I^P, \quad (49)$$

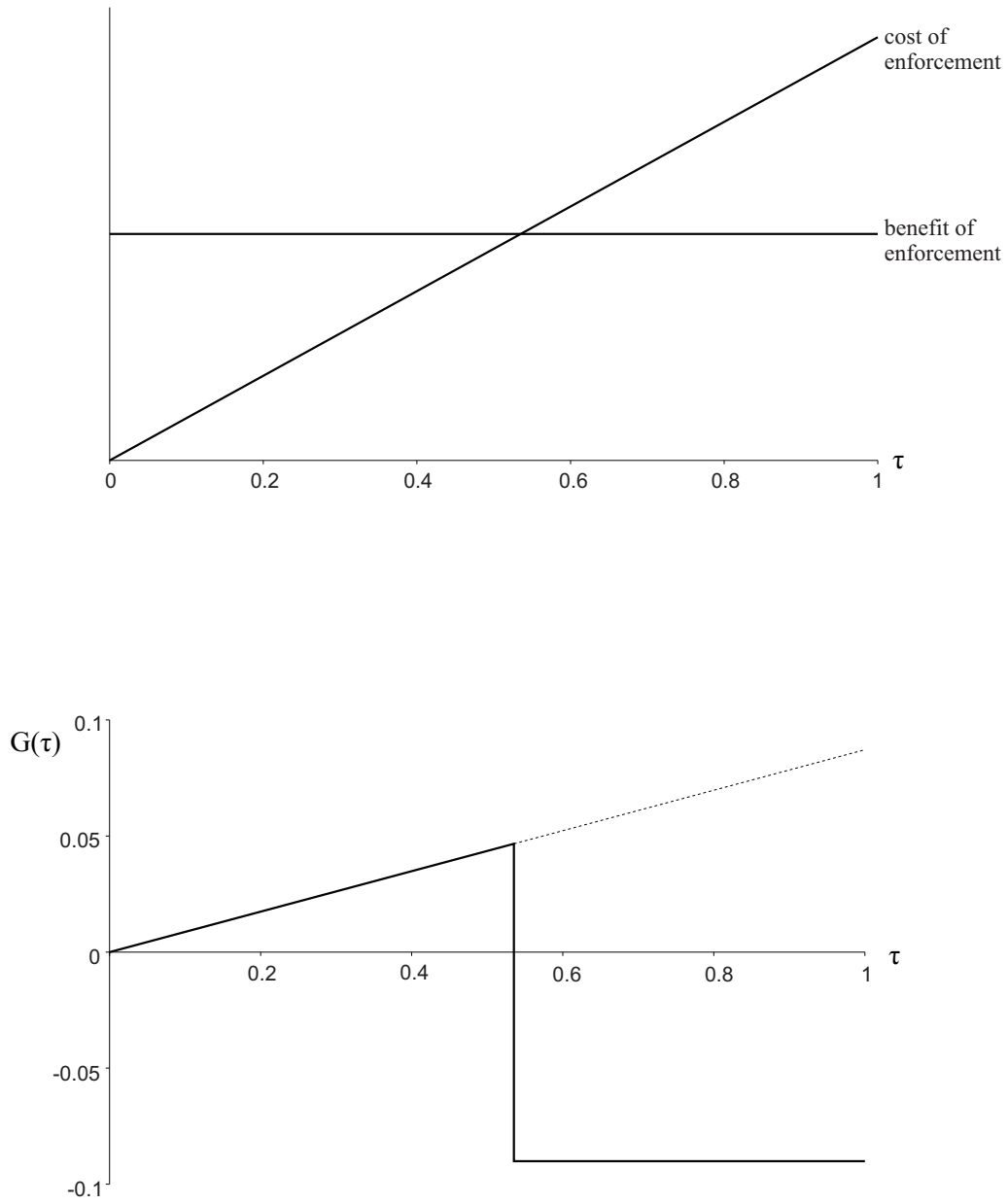
and  $c_{is} = y_{is}$  if  $s \notin E$  for all  $i \in I^W$ . This shows that the richer residents of the rich region make payments (through taxes) to the poorer residents of the rich region and to the residents of the poor region.

In principle, we could do a full analysis of the case of optimal public debt policy. However, it is easy to see that in terms of sharing of goods and welfare it falls in between the cases of no ex-ante policies and optimal borrowing limits. With respect to the case of no ex-ante policies, it is easy to see that for states in which there would be enforcement with private debt the same outcome can be obtained by setting  $b_{j,s}$  high enough (in particular, as high as the largest payment a domestic resident would have made in that state). In addition, in states in which there would not be enforcement, it is sometimes possible to get some asset trade with public debt. With respect to the case of optimal borrowing limits, in states in which enforcement is gained with both optimal public debt and optimal borrowing limits the outcome with optimal public debt is no better and in general worse than the outcome with optimal borrowing limits. This is because with optimal borrowing limits payments are made by the richest residents of the rich region (and, among these, the higher the value of production the higher the payment). This is reflected in the fact that consumption levels are equalized among the richest residents of the rich region. With optimal public debt, however, residents are constrained in the payments they can make by the size of taxes. This constraint binds for the richest residents and that is why consumption levels are not equalized among them. In addition, since the resulting domestic sharing of goods is worse with public debt, governments have fewer incentives to tax and pay the debt held by domestic residents and, thus,

there are some states in which enforcement is gained with optimal borrowing limits but not with optimal public debt.

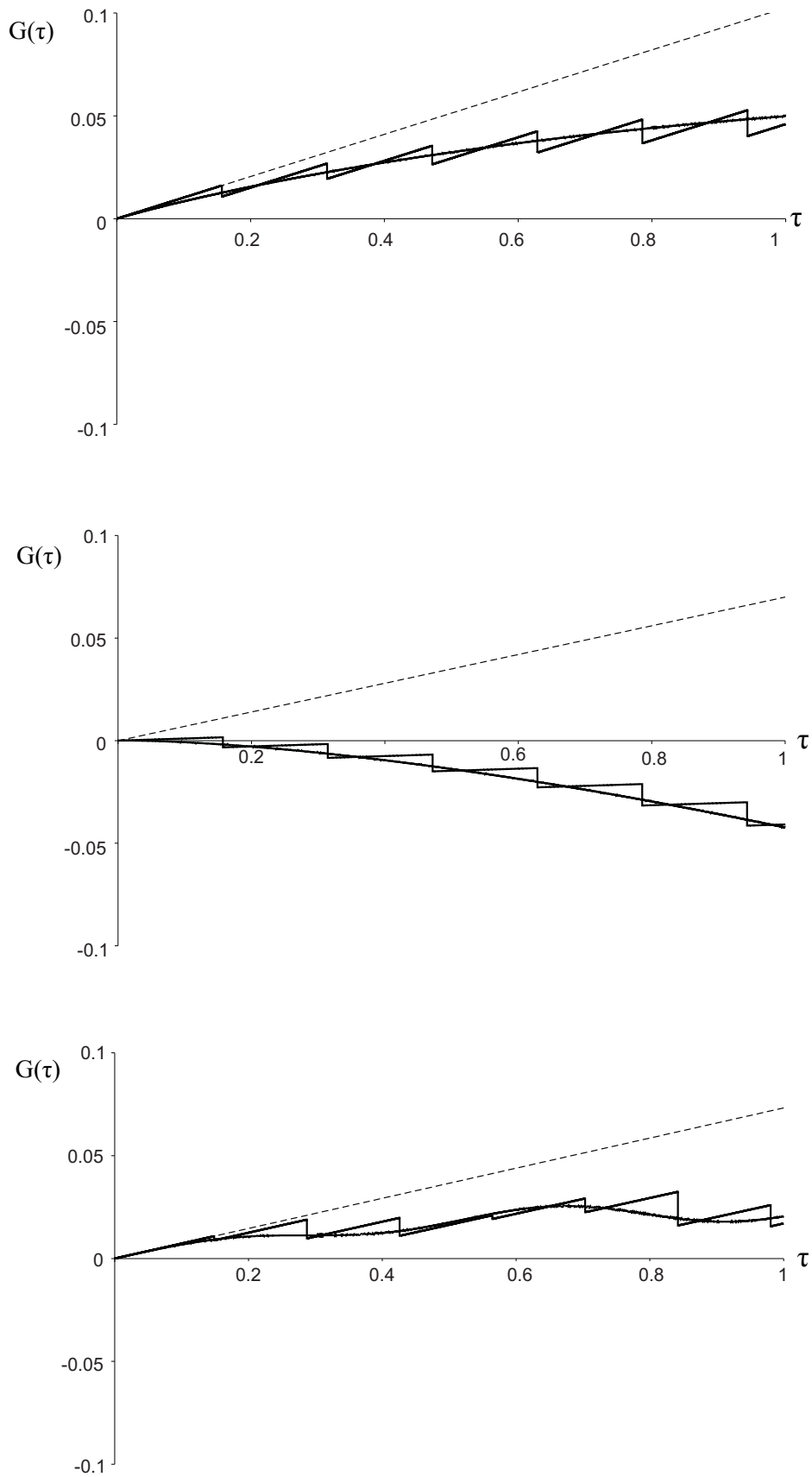
Finally, is it possible to obtain a better outcome by allowing private markets to operate in parallel with public debt markets? The answer is no. First, in states in which borrowing needs to be constrained for enforcement to take place agents cannot expect enforcement of private contracts and repayment of government debt. If they did, the outcome would be as in the complete markets case and, thus, ex-post governments would prefer not to enforce private payments and/or not to repay government debt. Second, in these states agents cannot expect enforcement of private contracts and no repayment of public debt for the same reason. So even if governments allowed private markets, they would be irrelevant in states in which borrowing needs to be constrained. In other states, optimal public debt can be partly or even totally replaced by private assets without affecting the fact that the outcome is as in the complete markets case.

Figure 1



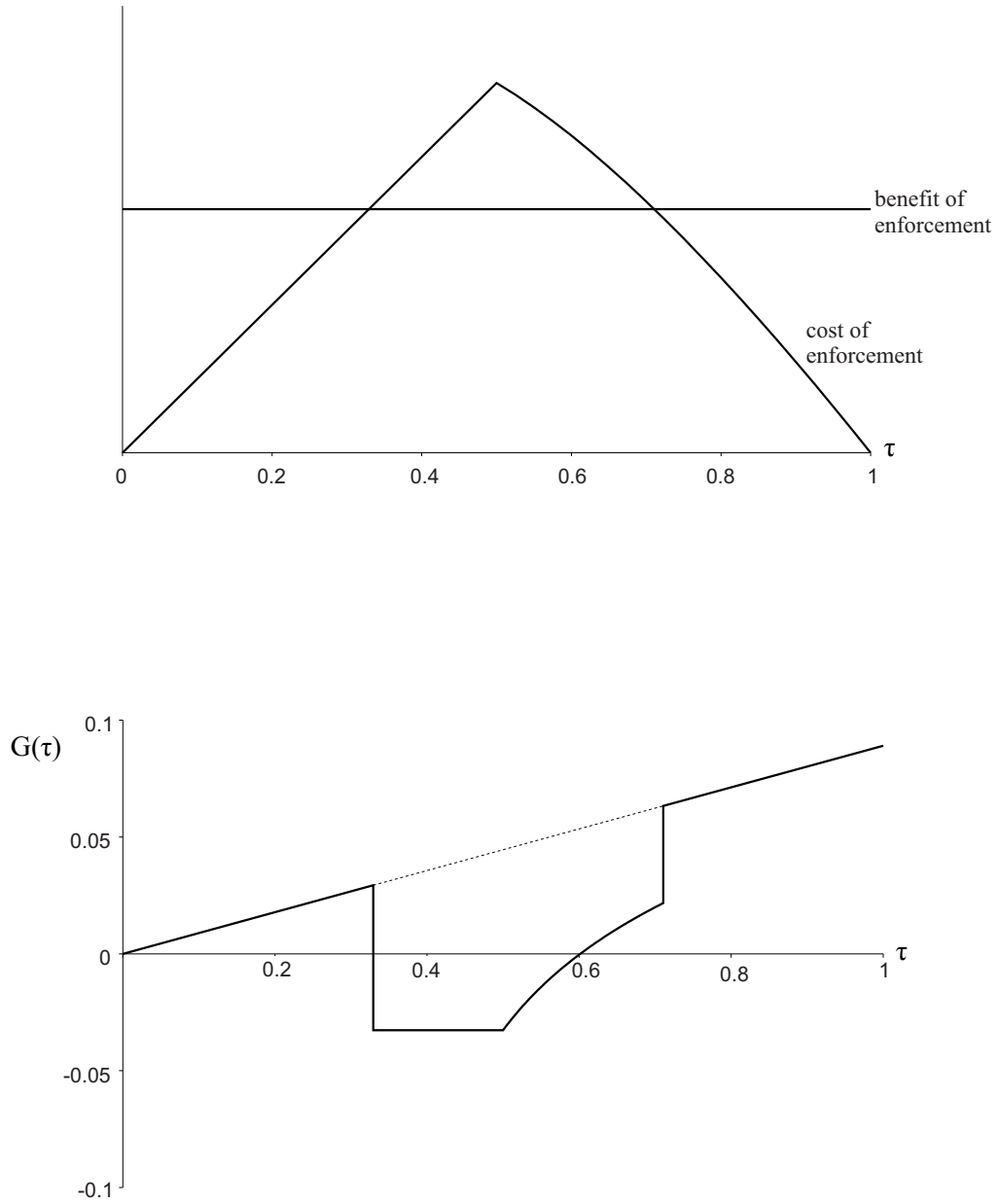
This case is constructed with one pair of symmetric states and no terms-of-trade effects. The regional component of production is such that  $\phi^R(z) = 1.4$  and  $\phi^P(z) = 0.6$  for all  $z \in [0,1]$ . The individual component of production satisfies  $\phi_{is}^R(z) = 1.55$  for half of the residents in R and  $\phi_{is}^R(z) = 0.45$  for the other half. There is no individual risk in the poor region.

Figure 2



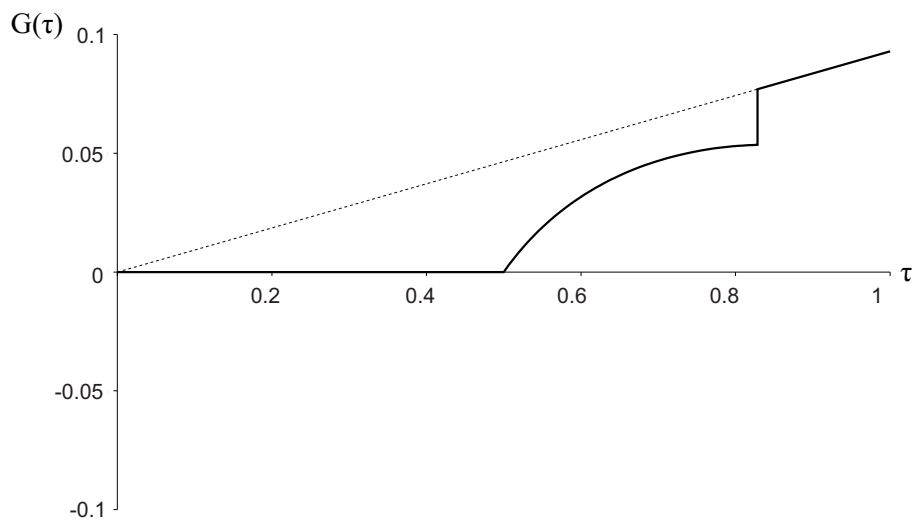
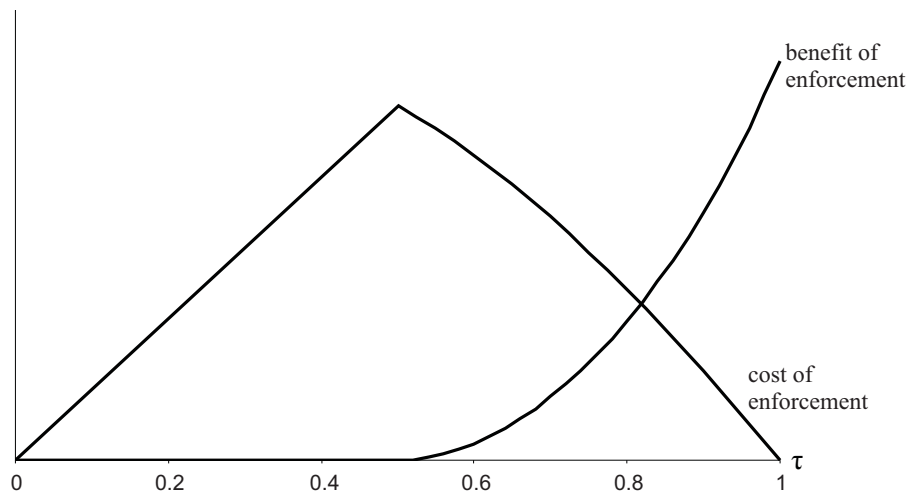
These panels illustrate the effects of globalization on welfare with many pairs of symmetric states. The top panel uses uniformly distributed pairs of states (14 for the jagged line and 20,000 for the smooth line) with a large mass of states satisfying  $\tau_p^* > 1$ . The middle panel is obtained by setting  $\tau_p^* < 1$  for a large number of states. The bottom panel is constructed with the same number of states as before but distributed according to a sinusoidal probability density function.

Figure 3



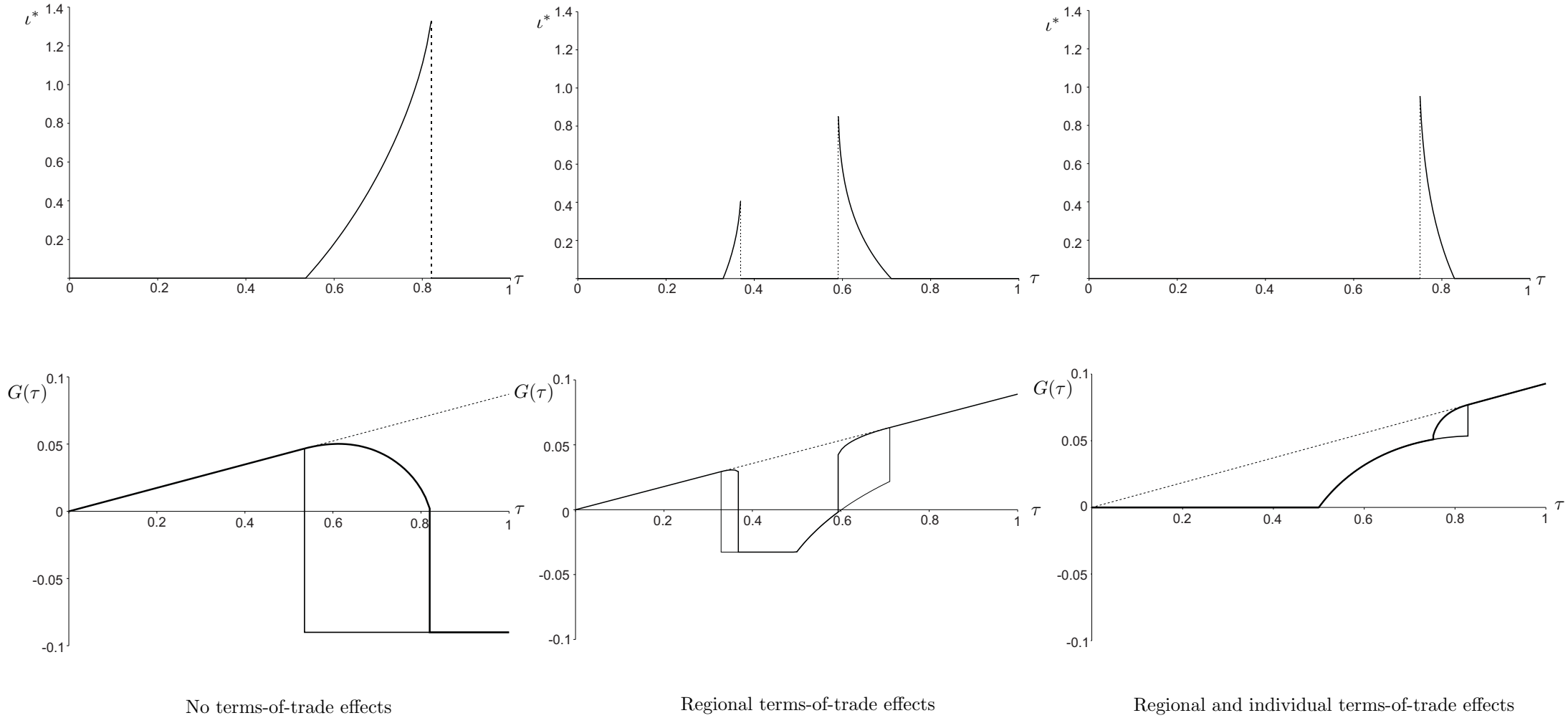
This case illustrates the behavior of the model with regional terms-of-trade effects and one pair of symmetric states. The regional component of production is characterized by  $\phi^R(L)=1.58$ . The individual component of production satisfies  $\phi_{is}^R(z)=1.51$  for half of the residents in R and  $\phi_{is}^R(z)=0.49$  for the other half. There is no individual risk in the poor region.

Figure 4



This case illustrates the behavior of the model with regional and individual terms-of-trade effects and one pair of symmetric states. The regional component of production is characterized by  $\phi^R(L)=1.58$ . The individual component of production in the rich region is specified in section 3.2.2. There is no individual risk in the poor region.

Figure 5



This figure replicates the examples presented in figures 1, 3 and 4 with optimal borrowing limits