External Imbalances, Gross Capital Flows and Sovereign Debt Crises

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Abstract

The experience of the European monetary union has been characterized by current account imbalances, widening gross external positions and a severe sovereign debt crisis. I argue that institutional features of the European Economic and Monetary Union have contributed to all three. I show in a model that subsidies on holdings of euro-denominated assets contribute to current account imbalances, to gross capital flows and to the severity of the crisis. In a quantitative model with heterogeneous countries, I show that the subsidies account for a substantial fraction of net and gross capital flows in the euro area.

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External imbalances, large gross capital flows and a pervasive sovereign debt crisis have characterized recent experience in the European monetary union. I introduce a framework in which to jointly analyze the determinants of these phenomena. A specific feature of the European Economic and Monetary Union (EMU)—the presence of subsidies on cross-border asset holdings—plays a crucial role in generating widening current account deficit and surplus positions, an expansion of gross capital flows with the rest of the world, and the pervasiveness and severity of a sovereign debt crisis. In addition, in an economic union, trade integration among member countries contributes to the transmission and amplification of a debt crisis.

Three major facts stand out in the recent experience of euro area economies. First, from the inception of the EMU in the early 2000s until the global financial crisis in 2008-09, current account deficits and surpluses widened for its members. Second, gross financial positions expanded in magnitude, with surplus economies in the euro area issuing gross liabilities to the rest of the world and intermediating resources to deficit countries.Third, a sovereign debt crisis took place in deficit countries, which led to severe recessions.

What was the role of institutional features of the EMU in generating widening current account deficits, surpluses, and the expansion of gross external positions of euro area economies? How does trade integration among countries in an economic union affect the severity and transmission of a debt crisis? I address these questions in a theoretical framework of capital flows and policy distortions in a union of countries. In addition, I introduce an infinite-horizon, heterogeneous-countries model to quantitatively assess the importance of the channels highlighted by the theoretical framework, in relation to recent experience in the euro area.

The theoretical framework highlights the main channel through which policy distortions affect capital flows in a union of countries. First, intermediation of gross capital flows emerges as union residents, by expanding their gross liability position against the rest of the world, leverage a subsidy they enjoy on assets issued within the union. Second, countries in the union run wider deficit and surplus positions due to the subsidy. Debtor countries benefit from lower borrowing costs, while policy distortions induce savers to further accumulate net assets. Importantly, the result of a widening current account surplus

in saving countries is not mechanically due to the larger deficit of debtors, as the union is fully integrated in international financial markets. Finally, this framework highlights a novel mechanism leading to amplification of a debt crisis in an economic union. Financial linkages in the form of cross-border exposures transmit the crisis within the union. The interaction of financial linkages with trade integration, in turn, exacerbates the recession in debtor countries. Amplification arises as export destinations of crisis countries coincide with the creditors on whom they default, thus hampering the ability of debtors to export during a crisis.

I develop an infinite-horizon model of an economic union, represented by a continuum of countries trading among themselves and with the rest of the world. The model allows for a quantitative analysis of the effects of policy distortions in the euro area, and it is calibrated to replicate key features of countries in the monetary union. The model's predictions on the effects of policy distortions on capital flows replicate the experience of external imbalances and gross capital flow intermediation observed in the euro area. In the model, the introduction of a subsidy on cross-border asset holdings has non-linear effects on the endogenous choices of the heterogeneous countries that constitute the union, depending on their position in the net foreign asset distribution. In addition, the model replicates the widening of the net foreign asset distribution observed after the inception of the EMU.

The phenomena at the center of this analysis have been very significant in terms of their size and include the occurrence of a rare sovereign debt crisis in advanced economies. First, current account surplus and deficit positions in the core and periphery of the euro area both approached at their peak 3% of the monetary union's GDP.[1] Second, gross external positions widened substantially in key countries of the euro area core. In France, the bilateral external position vis-à-vis the rest of the euro area rose by 24% of GDP, while the same position deteriorated by 33% of GDP against countries outside the monetary union.[2] Finally, the presence of distortions subsidizing residents' purchases of assets

[1]Throughout this paper, I define Austria, Belgium, France, Germany and the Netherlands as core countries and deficit countries Greece, Ireland, Italy, Portugal and Spain as periphery.

[2]Figures are from Waysand et al. (2010). I discuss these further in Section 2.5 and Appendix A.1.

issued by union-member economies in the EMU has been widely documented.[3] These implicit subsidies take the form of favorable financial regulation provisions on holdings of sovereign debt; the ability to use certain types of assets as collateral in transactions with the European Central Bank; and implicit promises of bailouts for asset holders.

A contribution of this paper lies in its analysis of trade in financial assets between a union of countries and the rest of the world. The literature on the Eurozone debt crisis has largely overlooked capital flows between the euro area and the rest of the world. The current account surplus and deficit positions of core and peripheral countries were similar in magnitude in the period leading up to the crisis. Many important contributions to this strand of the literature, then, have typically analyzed the crisis by modeling the monetary union as a set of open economies trading solely among themselves.The euro area, however, is closely integrated with international financial markets, displaying large gross asset and liability positions against the rest of the world. The analysis of trade in financial assets with the rest of the world allows me to address two important questions. First, what factors induced core countries to save in the periphery, intermediating in addition resources borrowed from the rest of the world? Second, in a debt crisis, what are the implications of large gross external positions, as distinct from those of net ones? I show in my model that policy distortions on capital flows lead to intermediation by saving countries. In turn, I show that in an economic union with trade integration, leverage of external lenders is detrimental to debtors in a crisis.

Below, I review the contribution of this paper to the existing literature. In Section 1, I introduce the theoretical model. Section 2 presents the infinite-horizon, heterogeneous-countries model, and its quantitative results. Section 3 concludes.[4]

Literature review. A growing body of research has recently analyzed the European experience of current account imbalances, gross capital flows and sovereign debt crisis. This paper falls into that literature, focusing on the role of policy distortions in contributing to all three aspects of this experience.

[3] Appendix A.1 reviews these institutional features of the EMU.

[4] Appendix A.1 presents evidence on capital flows in the euro area, on distortions affecting trade in euro-denominated debt and on heterogeneous exposure to intra-union trade for European countries.

First, this paper contributes to the largely empirical strand of the literature that documents the intermediation via the euro-area core to the euro-area periphery of capital flows from the rest of the world. My paper introduces a model where government subsidies induce residents of core countries to engage in intermediation, a mechanism first suggested by Chen, Milesi-Ferretti and Tressel (2013). Waysand, Ross and de Guzman (2010) document the presence of this intermediation pattern, building a dataset of bilateral external positions that expands on the seminal work by Lane and Milesi-Ferretti (2007) on disaggregated external asset and liability positions. Hale and Obstfeld (2016) also document how euro-area-core countries increased their borrowing from the rest of the world to finance lending to the periphery. In addition, they introduce a model to investigate how financial integration leads to intermediation of capital flows and current account deficits. My paper shows the important implications that bailouts in particular have for the current account surplus of core countries, due to their fiscal costs, in addition to their effects on intermediation and current account deficits. Further, the quantitative framework in this paper allows me to analyze the interaction between bailouts, default incentives and the endogenous distribution of net foreign assets.

Second, this paper is related to the literature on capital flows and crises in a union of countries that has analyzed the recent euro-area experience (e.g. Barattieri (2016), Broner, Erce, Martin and Ventura (2014), Corsetti, Kuester, Meier and Müller (2014), Fornaro (2016), Jaccard and Smets (2017), Martin and Philippon (2015), Kollman, Ratto, Roeger, in 't Veld and Vogel (2015), Siena (2016), among others). As mentioned, the majority of papers in this strand of the literature treats the euro area as a closed group of countries.[5] I emphasize the importance of studying trade by union members with the rest of the world, in the absence of which it would neither be possible to analyze intermediation of gross capital flows, nor the current account surplus of core countries independently of the deficit of the periphery. The quantitative model introduced here is related to Fornaro (2016), in its treatment of the euro area as a continuum of small open economies, building on the seminal contribution by Clarida (1990). As in this paper, Barattieri (2016) studies the interaction between trade integration and capital flows in

[5]Kollman et al. (2015) are one notable exception, as the rest of the world is present in their model.

the euro area. In my model, countries in the union differ in terms of specialization in heterogeneous output goods characterized by differences in transport costs, following Sachs (1982).[6] In Broner, Erce, Martin and Ventura (2014), residents of a union share the preferential treatment given to domestic creditors by a sovereign debtor in default. A similar feature characterizes the economic union in this paper, where the presence of distortions on trade in assets induces in equilibrium the creation of financial linkages among union members.[7]

Third, this paper is related to the literature on endogenous sovereign default stemming from the seminal contribution by Eaton and Gersovitz (1981) and from the quantitative framework developed by Aguiar and Gopinath (2006) and Arellano (2008). This paper's main contribution to this strand of the literature lies in the study of the interaction between subsidies and the incentives to borrow, default and intermediate gross capital flows. In addition, I contribute to this field by developing an endogenous sovereign default model calibrated to a group of advanced economies, as well as by analyzing the implications of default and subsidies for the endogenous net foreign asset distribution.[8] Azzimonti and Quadrini (2017) also study how default costs may depend on the identity of holders of sovereign debt. While their focus is on the different implications of domestic versus foreign holders of debt in a two-country model, I analyze the effects of debt being held in neighboring countries rather than in the rest of the world. In my model, the

[6] Asymmetric trade integration follows from lower transport costs that apply to trade in goods within the union. Anderson and van Wincoop (2004) document the dispersion in trade costs across goods and country pairs. Corsetti, Dedola and Leduc (2008) study how the international transmission of business cycles interacts with fluctuations of the real exchange rate, in the presence of heterogeneous final goods. Benigno and Romei (2014) focus on fluctuations of the real exchange rate in a debt deleveraging episode.

[7] Coeurdacier and Martin (2009) and Kalemli-Ozcan, Papaioannou and Peydrò (2010) have also analyzed the impact of the creation of the single currency on financial integration in the euro area.

[8] Arellano, Bai and Bocola (2017) and de Ferra (2016) also calibrate models of endogenous sovereign default to individual advanced economies. Arellano and Bai (2014) calibrate their model to Germany and Greece, focusing on contagion of a debt crisis when several countries borrow from a common lender. Aguiar, Amador, Farhi, Gopinath (2015) study a monetary union where default may occur due to rollover crises. Guler, Hatchondo, Kuruscu and Martinez (2014) study the optimality of international bailouts from the point of view of lending countries, in a two-period default model.

international amplification of default costs takes place because of trade linkages, while the provision of liquidity is the key mechanism in that paper. Finally, in my model, households that are offered a bailout promise do not internalize the effect of their gross asset purchases on the government budget constraint. In Mendoza (2010), Bianchi (2011) and Benigno, Chen, Otrok, Rebucci and Young (2013) a similar pecuniary externality is present. There, however, the externality arises because households do not take into account the effects of their borrowing decision on equilibrium prices that determine the severity of borrowing constraints.

1 Capital Flows, Default Risk and Trade

In this Section, I formally analyze the implications of a subsidy on cross-border holdings of assets for net and gross capital flows. In addition, I study how the interaction between trade integration and financial linkages across countries amplifies the severity of a debt crisis, and I assess the heterogeneous welfare implications of the subsidy. To this end, I introduce a two-period model of two countries in an economic union, which trade in risky assets among themselves and with the rest of the world, with and without subsidies.

1.1 Model

The world economy is inhabited by two small open economies or countries, H and F, and by a large economy representing the Rest of the World, ROW. Time is discrete and it is indexed by $t = 1, 2$. Each country is inhabited by a continuum of identical households. In addition, F is inhabited by a government that can set taxes and transfers on residents of the country itself. Household preferences in each country are given by

$$u\left(c_{i,1}\right) + \beta \mathbb{E} u\left(c_{i,2}\right), \tag{1}$$

where i equals either H or F; β denotes the subjective discount factor; $c_{i,t}$ denotes consumption of a homogeneous good in either period; and $\mathbb{E}$ is the mathematical expectation operator.[9] The utility function $u(c)$ is monotonic and continuously differentiable, with

[9] I consider a version of the model with multiple goods and trade in Section 1.4.

$u'(\cdot) > 0$ and $u''(\cdot) < 0$. In every period, each country receives an endowment $y_{i,t}$ of consumption good. Endowment realizations are known at the beginning of the initial period. The representative household in *ROW* is risk-neutral.[10] The subjective discount factor in *ROW* is again given by β. The next two subsections describe two possible regimes that characterize financial markets in the world economy. The first features no policy distortions on trade in financial assets. The second is characterized by the presence of a subsidy on cross-border holdings of risky assets.

1.2 Undistorted World Economy

In this subsection, I consider the regime of the world economy in which financial markets are not distorted by subsidies on cross-border capital flows. Due to the absence of such subsidies, I will refer to this allocation as the undistorted allocation.

In the initial period $t = 1$, H and F trade one-period bonds with each other or with *ROW*. *ROW* trades any amount of risk-free bonds at the price q equal to the discount factor, β. The optimization problems faced by H and F, respectively, are described below.

H. The representative household in H faces a limited commitment friction when issuing debt. In the initial period, H issues debt but it cannot commit to always repay in the future. Indeed, in the terminal period, H has the option to default. In the event of default, the country suffers from an exogenous default cost ζ, which reduces the amount of output available for consumption. The realization of the default cost is stochastic, and is known only in the terminal period. The default cost can take one of two values, either the positive value $\hat{\zeta}$, with probability π, or zero with probability $1-\pi$. I denote the state in which the default cost takes high value as "normal times," N, and the one in which it takes zero value as the "crisis" state, K.[11] In the initial period, consumption in H is

[10] Equivalently, *ROW* is extremely large relative to H and F. Hence, changes in variables related to the two small open economies have negligible effects on the marginal utility of consumption in *ROW*.

[11] The realization of the default cost is the same for all of the identical households in H. I consider a setup where the default cost process is independently distributed across households in Appendix B.7.

given by the value of the endowment $y_{H,1}$ and by the amount of resources obtained by issuing debt. The initial-period budget constraint is given by:

$$c_{H,1} = y_{H,1} + q_H b_H, \tag{2}$$

where $b_H > 0$ implies that H is issuing debt, and q_H denotes the price at which a unit of debt is sold. In the terminal period, consumption is given by the endowment $y_{H,2}$, net of the smaller of two costs: the cost of repaying debt and the cost of defaulting:

$$c_{H,2} = y_{H,2} - \min\{b_H, \zeta\}. \tag{3}$$

When H issues positive debt, terminal-period consumption takes the value of either $c_{H,2,N} = y_{H,2} - b_H$ in normal times, or $c_{H,2,K} = y_{H,2}$ in the event of crisis and default.[12]

The maximization problem faced by the representative household in H in the initial period is to choose the amount of debt to issue, in order to maximize expected utility across periods and states.[13] The intertemporal Euler condition associated with this problem is given by

$$q_H u'(c_{H,1}) = \beta \pi u'(c_{H,2,N}), \tag{4}$$

which accounts for the fact that debt is repaid only in normal times, with probability π.

F. F can commit to always repay debt in the terminal period. The problem faced by the representative household in F is, again, to choose the amount of debt b_F to issue in order to maximize lifetime utility. The intertemporal Euler condition associated with this problem is given by

$$q u'(c_{F,1}) = \beta u'(c_{F,2}). \tag{5}$$

Since F trades risk-free assets only, its consumption in all periods is determined with certainty.[14] Finally, the government in F plays no role in this regime.

[12]The assumption that $y_{H,1} \leq y_{H,2}$ ensures that $b_H \geq 0$. Households take into account how the default probability affects the debt price. Hence, debt issued is bounded above by $\hat{\zeta}$, and default occurs in the crisis state, only. If $b_H > \hat{\zeta}$, terminal-period default would be certain. The price of debt would be zero, and this choice would be equivalent to issuing zero debt.

[13]This problem and the one of the household in F are presented formally in Appendix B.1.1.

[14]The conjecture that F trades with *ROW* only in this allocation is indeed verified in equilibrium.

Equilibrium. In equilibrium, both H and F trade assets only with ROW.[15] The price of a risk-free asset q is given by the subjective discount factor of ROW β. The price of assets issued by H compensates ROW for the risk of default. Since ROW is risk-neutral, this price is given by $q_H = \beta\pi$.[16] Finally, the quantities of assets traded by the two countries depend on the intertemporal profiles of their endowments.[17] For both countries, the more skewed the endowment profile towards the terminal period, the higher is debt issued in the initial period. While F equates consumption across periods in equilibrium, this is not the case for H. The low price of debt of the latter country induces it to issue few assets and to enjoy relatively low consumption in the initial period.

1.3 Economy with Subsidies on Risky Assets

Now, I consider the regime of the world economy in which households in F receive a subsidy on assets issued by H. First, I describe the nature of the subsidy. Second, I describe the optimization problem of the two countries in this setting. Finally, I describe the equilibrium allocation when the world economy is in this regime. This allocation differs crucially from that of the undistorted economy in terms of asset prices, of the current account balance of both countries and of the gross external positions of F.[18]

Subsidy. The government in F offers households in the same country a bailout promise on risky assets issued by H. The government promises that it will fully compensate households for losses incurred upon default by H in the crisis state.[19] The government in F funds bailout transfers by setting a lump-sum tax τ on all households in the country. The tax is paid only in the terminal period, if the crisis state is realized, and the government finances bailout transfers to households that hold risky assets.

[15] The equilibrium allocation in the undistorted world economy is formally defined in Appendix B.1.2.

[16] Risk aversion implies that F does not purchase risky assets issued by H at the price offered by ROW.

[17] I provide analytical expressions for the equilibrium amounts of assets issued and for the current account balance of the two countries in Appendix B.1.3 .

[18] Appendix B.4 discusses subsidies' implications for the current account of the union of H and F.

[19] The government does not promise a bailout if default occurs in normal times. Hence, the bailout promise is not offered if the amount of assets issued by H is above $\hat{\zeta}$.

F. In the presence of the subsidy on risky assets, the representative household in F trades assets with both H and ROW. The initial-period budget constraint of the F-household is as follows:

$$c_{F,1} + q_H b_{H,F} = y_{F,1} + q b_{F,ROW}. \tag{6}$$

In the initial period, the household purchases consumption goods $c_{F,1}$ and assets $b_{H,F}$ issued by H. The price at which these assets are traded is given by q_H. In addition, the household issues risk-free bonds $b_{F,ROW}$ to ROW, at price q. In the terminal period, resources available to the F-household are given by its endowment $y_{F,2}$, augmented by gross assets and net of gross liabilities and taxes. The terminal-period budget constraint of this household is given by

$$c_{F,2} = y_{F,2} - b_{F,ROW} + b_{H,F} - \tau. \tag{7}$$

From the perspective of the F-household, debt that both the H-household and itself issue is risk-free. In the crisis state, however, households pay a lump-sum tax that enables the government to finance bailout transfers to the households themselves. Households do not take into account how their individual choices affect the tax that the government seta in equilibrium, since each individual household in F has negligible size. In normal times, all bonds pay off and $c_{F,2,N} = y_{F,2} - b_{F,ROW} + b_{H,F}$. In a crisis, households bear losses on assets issued by H via taxation and, in equilirium, $c_{F,2,K} = y_{F,2} - b_{F,ROW}$. The intertemporal first-order conditions associated with the household choice over the assets it trades are as follows:[20]

$$\begin{aligned} q u'(c_{F,1}) &= \beta \left[\pi u'(c_{F,2,N}) + (1-\pi) u'(c_{F,2,K})\right] \\ q_H u'(c_{F,1}) &= \beta \left[\pi u'(c_{F,2,N}) + (1-\pi) u'(c_{F,2,K})\right]. \end{aligned} \tag{8}$$

Given that F-households consider both assets risk-free, the two first-order conditions in (8) imply that, in equilibrium, the prices of the two assets must be equal.

H. The problem of the representative household in H is unaffected by the subsidy. The first-order condition associated with the problem of the household is again given by (4).

[20] The full maximization problem is presented formally in Appendix B.2.1.

Prices in the equilibrium with subsidies on risky assets differ, in general, from those in the equilibrium of the undistorted world economy. Hence, equilibrium choices made by the representative household in H differ across the two allocations.

Equilibrium. In equilibrium, only F purchases assets issued by H. In turn, F issues debt to ROW to partly finance its gross asset purchases. In the crisis state, the government of F raises taxes to fund bailout transfers. I now describe in detail the key properties of this equilibrium allocation.[21]

Asset prices. Debt issued by H is traded at the risk-free debt price. This asset is risk-free for F-households. Hence, in equilibrium, (8) implies that $\tilde{q} = q = \beta$ must hold.

Current account in H. Proposition 1 establishes the effect of the subsidy on the current account in H.[22]

Proposition 1. *The current account balance of country H is lower in the economy with subsidies on risky assets than in the undistorted world economy.*

This result holds because H can issue assets at a higher price in this allocation. The probability of debt repayment by H is always given by π. However, H can issue debt at the price of a risk-free asset in the presence of the subsidy. Hence, the first-order condition (4) can now be written as:[23]

$$\beta u'\left(y_{H,1} + \beta b_{H,D}\right) = \beta \pi u'\left(y_{H,2} - b_{H,D}\right), \tag{9}$$

implying that consumption is relatively skewed towards the initial period. Intuitively, two forces induce a higher current account deficit in H. First, a higher price of assets induces households to issue a higher amount of them.[24] Second, households obtain more resources in the initial period for any amount of assets issued, given the higher price.

[21] The equilibrium is formally defined in Appendix B.2.2.

[22] The proof is relegated to Appendix B.3.1. Appendix B.3.1 also presents an analytical solution for the current account and for the amount of assets issued by H under CRRA utility.

[23] Henceforth, the subscript D denotes equilibrium values in the allocation distorted by subsidies.

[24] This force operates only if the intertemporal substitution effect dominates.

Intermediation and gross external positions in F. The gross asset and liability positions of F vis-a-vis H and ROW, respectively, both expand in the equilibrium allocation of the economy with subsidies on risky assets.

First, the bilateral gross asset position of F against H becomes positive, as F purchases all debt issued by H. This result arises because households in ROW do not benefit from the subsidy. Hence, they do not buy risky assets at the high price q. On the other hand, households in F are willing to buy such assets, due to the bailout promise that they enjoy.

Second, the bilateral position of F against ROW deteriorates. Proposition 2 establishes this result.[25]

Proposition 2. *The bilateral position of F against ROW is worse in the allocation with a bailout promise than it is in the undistorted allocation.*

F expands its gross liability position against ROW to finance its purchases of gross assets. The expansion of both sides of the external balance sheet of F amounts to an intermediation of international capital flows by households in this country. Households in F leverage the subsidy implied by the bailout promise by borrowing from ROW. Thanks to the additional resources obtained by borrowing, F-households can fully absorb the supply of assets issued by H.[26] This result holds, independently of the implications of the bailout promise for net saving, which are discussed in the paragraph below.

Current account in F The current account balance of F is higher in the economy with subsidies than in the undistorted one. Proposition 3 establishes the result.[27]

Proposition 3. *The current account balance of country F is higher in the equilibrium of the economy with subsidies on risky assets than in the undistorted world economy.*

[25]The proof is relegated to Appendix B.3.2.

[26]The bilateral position of F vis-a-vis ROW may be positive. If $y_{F,2} \geq y_{F,1}$ this bilateral position is weakly negative in the undistorted economy equilibrium. Then, it is again negative and of larger magnitude, in the economy with subsidies. If $y_{F,2} < y_{F,1}$ the bilateral position with ROW also deteriorates, but starting from a positive value. F then saves strictly less in ROW to purchase debt issued by H.

[27]The proof is presented in Appendix B.3.3.

The presence of the bailout promise induces households in F to save more. This result does not occur because F must absorb the supply of assets issued by H. Indeed, the latter could, in principle, finance the whole amount of asset purchases by borrowing from ROW. The increase in saving occurs instead because households in F wish to transfer resources from the initial to the terminal period. In the allocation with subsidies, the expected value of taxes paid by households in the terminal period is positive, while it is zero in the undistorted allocation. Taxes are present because of the government's need to fund bailout transfers to domestic bondholders. By saving, households in F partly shift the burden of taxation from the terminal to the initial period. Hence, the increase in gross debt issued by F is smaller than the increase in gross assets purchased, and a fraction of asset purchases is funded by an increase in net saving.

1.4 Trade Integration and the Severity of Debt Crises

Subsidies on risky assets can increase the severity of a crisis for the debtor country H by causing adverse relative price fluctuations in a crisis. The economic intuition behind this result is related to the "secondary" burden of a transfer suggested by Keynes (1929), following from a feedback effect between international transfers and changes in relative demand for goods. I introduce a version of the world economy in which the two countries receive endowments of heterogeneous goods, allowing for the joint analysis of trade and financial integration within the union. I show in this framework that subsidies make a default crisis more severe for a debtor who relies on union partners as key export destination markets. This result occurs because the debtor country causes a reduction in the demand for its exports by defaulting on its creditors, if the creditor and export destination countries coincide due to the bailout promise.

The world economy is similar to the one in Section 1.1, but for the presence of two types of goods, labeled A and B. All households in all countries enjoy consumption of both goods. Consumption in each country is given in each period by a combination of consumption of the two goods through a CES aggregator.[28] In each period, each country

[28] Appendix B.5 describes the CES aggregator and the derivations behind the results discussed here.

may receive endowments of both goods. Good A is the numeraire of the economy, and all assets are denominated in units of this good. p_B denotes the relative price of good B.

The union of H and F is characterized by strong trade integration among its members. Trade integration allows countries in the union to exchange goods among themselves in the absence of transport costs. Trade in good B between either H or F and ROW is impaired instead by the presence of an iceberg transport cost ν. Due to transport costs, the relative price of good B that prevails in the union can differ in equilibrium from the one in ROW. In the union, the price p_B is determined by the relative scarcity of the two goods in the two countries, and it is increasing in the amount of good A available for consumption in the union, given the aggregate endowment of good B.

The bailout promise affects the relative price of goods in all periods and states, due to its implications for capital flows and for the amount of good A available in the union. Adverse fluctuations in relative prices can lead to an increase in the severity of the default crisis in the debtor country H. The following proposition establishes this result.

Proposition 4. *Crisis-state consumption of the the debtor country H is lower in the allocation with subsidies on purchases of risky assets, if the country is relatively abundant in good B that is traded only within the union.*

This result arises in three steps. Subsidies affect the relative scarcity of goods. In turn, scarcity determines relative prices and, finally, these determine consumption in H.

First, in the crisis, the bailout promise makes good A scarcer within the union. Default is a transfer of resources from creditors to debtors. In the allocation with subsidies where F is the sole lender to H, default is an intra-union transfer of resources. Instead, default would constitute a net transfer to the union in the undistorted allocation since H borrows only from ROW in that allocation. Due to the lack of this net transfer, the amount of good A available in the union in the crisis state is lower in the allocation with subsidies.

Second, the relative price of B in the union is lower in the crisis state. The bailout promise makes F poorer in the event of a crisis, as it owes debt to ROW, but its assets yield no return. The higher the amount borrowed by F, the poorer is the union as a whole. In turn, the poorer the union, the lower is the relative price of good B in the

crisis state.

Third, consumption by H decreases as p_B falls if the decline in this relative price constitutes a deterioration of the terms of trade of this country. This is the case if good B accounts for a large share of the country's endowment of resources.

Finally, the interaction between the effects of relative prices and subsidies in a crisis has opposite implications for H and F. First, in H, subsidies would have no effect on crisis consumption in an economy in which the relative price of goods is constant.[29] Relative prices are the only channel through which subsidies affect autarky consumption in this country. Second, subsidies make the crisis detrimental to F, independently of fluctuations in goods' prices. The subsidies induce the country to suffer losses on external assets. Fluctuations in relative prices can be beneficial for F and dampen these losses if they lead to an improvement in the terms of trade.

1.5 Welfare

The bailout promise has heterogeneous effects on welfare of the households in H and F. First, the bailout promise leads to a welfare gain in H. Second, the same subsidy unambiguously reduces welfare in F, instead. Finally, the bailout promise can lead to higher aggregate welfare in the union, but only at the expense of F.[30]

Welfare in H The introduction of subsidies on risky assets benefits H through two main channels, affecting average consumption in this country and its volatility.

First, average consumption of H is higher in the allocation with subsidies. The bailout promise allows H to borrow cheaply, while issuing risky debt. This opportunity leads to a first-order welfare gain that increases with debt issued and in the default probability.

Second, by affecting consumption volatility, the bailout promise increases or decreases the welfare of H. The bailout promise allows H to insure against income fluctuations and to transfer more resources from the terminal period to the initial one.[31] However,

[29] This would be true in the absence of transport costs on all goods, or in the one-good economy.

[30] Appendix B.6 details the results introduced here, and it presents the relevant analytical expressions.

[31] This transfer is welfare-increasing if the endowment of H is scarcer in the initial period.

the bailout promise also induces H to "overborrow"—i.e., to issue more debt to exploit the favorable borrowing terms. The latter effect induces higher volatility of consumption, whose path becomes skewed towards the initial period. Hence, consumption in H is more or less volatile in the allocation with subsidies, depending on the relative strength of incentives to insure against income fluctuations and to exploit the high price of debt.

Finally, the bailout promise increases welfare in H. Even if it induces a more volatile consumption path, its effects are beneficial for households. Indeed, consumption volatility arises only because households leverage the welfare gain due to the high debt price.

Welfare in F The bailout promise reduces the welfare of households in F. Subsidies on risky assets lead to lower average consumption and to higher volatility since households in F take on exposure to the risk of default by H. First, the mirror image of the gain in average consumption in H is given by a fall in average consumption in F. Second, higher consumption volatility is also detrimental to welfare. Both effects of the bailout promise on consumption in F are detrimental to F's welfare.

Aggregate welfare The bailout promise has ambiguous effects on aggregate welfare in the union of H and F.[32] First, the bailout promise leads to aggregate welfare gains if it induces a transfer of resources from the poorer to the richer country. This result hinges on the presence of gains from redistribution, which occur if the marginal utility of consumption is higher in H, as the bailout promise causes a transfer of resources to this country. Second, in the absence of gains from redistribution, aggregate welfare rises only if the bailout promise induces H to reduce its volatility of consumption. For this to occur, the preference for a smooth consumption path must dominate H's desire to increase average consumption by overborrowing. Subsidies are detrimental to welfare of the union as a whole if they have only moderate effects on consumption volatility in H. In this instance, welfare gains in H would largely occur at the expense of F, and the welfare loss in the latter country dominates the gain in the former.

[32] I consider the perspective of an utilitarian planner who cares about the sum of welfare in H and F.

2 Quantitative Effects of Subsidies on Capital Flows

I develop a quantitative model of heterogeneous countries in an economic union, trading among themselves and with the rest of the world. The calibrated model allows me to assess how policy distortions on trade in financial assets in the euro area can account for the recent experience with capital flows. In the model, subsidies on cross-border holdings of assets generate predictions for current account and gross external positions that are in line with the empirical evidence on the euro area. In particular, the subsidy induces a widening of gross asset and liability positions of 5% of GDP in high-income countries. In addition, the subsidy induces a deterioration and an improvement of the current account balance of 2% of GDP for low- and high-income countries, respectively.

The next subsection presents the infinite-horizon model. I consider two model economies that differ in terms of the treatment of risky assets within the economic union. Thereafter, I calibrate the model to euro area countries prior to the inception of the EMU. Finally, I compare the two model economies along three key dimensions. First, I describe the heterogeneous effects of the subsidies on countries' current account balance. Second, I show that subsidies lead to an expansion of gross capital flows. Third, I detail how the distribution of net external assets across countries widens because of the subsidies.

2.1 Infinite-horizon Model

The world economy is inhabited by a continuum of small open economies or countries and by a large country representing the Rest of the World (ROW). The continuum of countries representing the economic union has unit measure and it is denoted by I. Each country is inhabited by a continuum of identical households and by a government and it is denoted by $i \in I$. Time is discrete and indexed by $t = 0, 1, 2, \ldots$ Preferences of the representative household in a country i are summarized by the following utility function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_{i,t}\right), \tag{10}$$

where $c_{i,t}$ denotes consumption of a homogeneous good; β is the subjective discount factor; and the period utility function u is continuous and twice differentiable, with derivatives

satisfying $u' > 0$, $u'' < 0$. $\mathbb{E}_t$ denotes the mathematical expectation operator, conditional on information available at time t. Each country receives a stream of endowments of homogeneous good, according to an stochastic Markov process that is identically and independently distributed across countries. The realization of the endowment process in country i and period t is denoted by $y_{i,t}$.

Countries in the world economy trade assets in international financial markets. Financial markets are characterized by two frictions: lack of commitment and market incompleteness. First, households cannot commit to repay their liabilities in all future contingencies. Second, only a limited set of securities can be traded on financial markets.

Two alternative regimes characterize financial markets, as in the model in Section 1. First, in the undistorted world economy regime, countries trade assets among themselves, in the absence of government-imposed subsidies. The equilibrium allocation of this economy serves as a benchmark against which to evaluate the implications of subsidies for capital flows. Second, I consider a regime with a subsidy on lending across countries in I. The subsidy again takes the form of a bailout promise. The next two subsections present in detail the two regimes in which the world economy can operate.

2.2 Undistorted World Economy

In the undistorted world economy, the government of each country does not raise taxes or pay transfers to domestic households.[33] A subset of countries in I have access to international financial markets. The complementary subset of countries is excluded from international financial markets. Countries that have access to financial markets trade assets among themselves and with ROW. Markets are incomplete, and countries can trade only one-period bonds. In addition, countries cannot commit to repay debt.The budget constraint of country i with access to international financial markets is given by:[34]

$$c_i = y_i + n_i - q\left(y_i, n_i'\right) n_i'. \tag{11}$$

[33]Here, the government can be ignored. I characterize actions of each representative household as those of the country itself. The problem of a country in this economy largely follows the model in Arellano (2008). The quantitative model presented here differs substantially in terms of empirical targets.

[34]I omit time subscripts, and make use of recursive notation. Primes denote next-period variables.

Consumption of the representative household in country i is denoted by c_i. Resources available for consumption in each period are given by the endowment of good y_i, by the holdings of net external assets n_i and by the revenue from borrowing on international financial markets. Country i can issue bonds at price $q(y_i, n_i')$. The price of bonds is a function of the amount issued and of the endowment realization. These variables help predict the probability that country i will default in the following period. The amount of bonds issued is given by $-n_i'$, the opposite of the next-period net external asset position. Hence, the revenue raised from external borrowing is given by $-q(y_i, n_i')\, n_i'$.

In every period, each country chooses whether to repay debt issued to foreigners and to retain access to international financial markets or to default on external debt and lose access to markets. First, if a country chooses to repay debt, its problem is given by:

$$V^C(y_i, n_i) = \max_{n_i'} \left\{ u\left(y_i + n_i - q(y_i, n_i')\, n_i'\right) + \beta \mathbb{E}\left[V(y_i', n_i') \,|y_i\right] \right\}, \tag{12}$$

where V^C denotes the value function of a country that repays foreign investors and issues debt $-n'$. When the country chooses the amount of debt to issue, it understands how its choice affects the debt price, via the function $q(y_i, n_i')$. In the following period, the country has the option to repay or to default on debt, which is associated with the value function V.[35] I define the policy function $n'(y_i, n_i)$ as the argument that solves the problem in (12) given the state variables y_i and n_i.

Second, if a country defaults on debt owed to foreigners, it is excluded from financial markets and it cannot issue new debt. The country is readmitted in the following period with probability λ. In addition, the country suffers from an output cost of default $\delta(y_i)$. The country sustains the default cost as long as it is excluded from financial markets, and the severity of the default cost is increasing in the current realization of the endowment. Hence, consumption of an excluded country is given by the endowment realization, net of the default cost. The value function of a country that defaults on its debt is given by:

$$V^D(y_i) = u\left(y_i - \delta(y_i)\right) + \beta \mathbb{E}\left[\lambda V(y_i', 0) + (1-\lambda) V^D(y_i') \,|y_i\right]. \tag{13}$$

If readmitted to financial markets, the country starts again with zero external assets.

[35] The function is defined below, in (14).

Finally, a country defaults if the value of retaining access to markets is lower than the value of defaulting. The discrete choice default problem is formally given by:

$$V(y_i, n_i) = \max\left\{V^D(y_i), V^C(y_i, n_i)\right\}, \tag{14}$$

which also defines the value function V. The policy function for default is given by the indicator $D(y_i, n_i)$, which takes the value of unity in the region of the state space where it is optimal to default—i.e. where $V^D(y_i) > V^C(y_i, n_i)$, and zero otherwise.

The representative household in ROW is risk-neutral.[36] ROW-households buy assets issued by a country i with endowment y_i and next-period net external assets n_i' at price:[37]

$$q(y_i, n_i') = \beta_{ROW}\mathbb{E}\left[1 - D(y_i', n_i') \,|y_i\right]. \tag{15}$$

The price that compensates ROW for default risk is equal to the probability of repayment in the next period, discounted by the subjective discount factor β_{ROW}.

I define $\phi_C(y, n)$ as the marginal joint distribution of countries with access to financial markets over values of the endowment and of net external assets. I similarly define $\phi_D(y)$ as the marginal distribution of countries with no access to international financial markets over values of the endowment. The policy functions for assets $n'(y, n)$ and for default $D(y, n)$, the law of motion of the endowment process, and the exogenous probability of re-admission into financial markets jointly determine the evolution of these two distributions. Formally, I define the transition function Γ, which solves the functional equation:

$$\begin{pmatrix} \phi_C' \\ \phi_D' \end{pmatrix} = \Gamma \begin{pmatrix} \phi_C \\ \phi_D \end{pmatrix}, \tag{16}$$

where ϕ_C' and ϕ_D', respectively, denote the next-period values of the two distributions.

The equilibrium in the undistorted world economy is a set of value and policy functions, prices and distributions that are consistent with optimality for all households and with the law of motion of the stochastic processes.[38] Finally, I define a stationary allocation in the undistorted world economy as an equilibrium allocation in which all aggregate

[36] The assumption of risk-neutrality is without loss of generality. Since ROW is large, choices by countries in I do not affect its marginal utility of consumption.

[37] It can be shown that, in equilibrium, countries trade assets only with ROW, if at all.

[38] The equilibrium in the undistorted world economy is formally defined in Appendix C.1.

variables are constant. In particular, the distributions ϕ_C, ϕ_D are constant over time and are given by the fixed point of the functional equation (16).

2.3 World Economy with Subsidies on International Lending

I introduce a world economy in which governments offer subsidies to households that buy assets on international financial markets.[39] The subsidy takes the form of a bailout promise that the government extends to households, in the event of losses on external assets. I first present the bailout promise offered by each government to subsidize lending across countries in I. Second, I introduce the problem of households in all countries. The next subsection describes the calibration of the model to euro area countries. The following one presents the key quantitative results.

Each government offers a partial bailout promise to households in the same country that buy risky assets issued by other countries in I. A generic household in i can purchase bonds issued by another country s. These bonds are associated with a probability of repayment π_s. In the absence of a bailout promise, the return on bonds is given by unity with probability π_s and by zero otherwise. The bailout promise states that in the event of default by the borrower s, the government will transfer an amount of good $\xi \leq 1$ to the household, for each unit of assets issued by s that it holds. Given the bailout promise, the return on assets as perceived by the household in i is given by unity with probability π_s and by ξ with complementary probability $1 - \pi_s$. Finally, the bailout promise is not offered if the probability of repayment by the borrower is lower than a threshold $\bar{\pi}$.

Households in all countries interact with financial markets in one of four possible ways. Specifically, households can decide to borrow from ROW, to borrow from other countries in I, to purchase gross assets issued by countries in I, or to default on external liabilities. $\hat{V}$ denotes the value function for the household that has the option to choose between the four alternatives. Having chosen the type of assets to exchange on international financial markets, each household chooses the amount of such assets to trade.

First, if a household borrows only from ROW, its problem is similar to that of a

[39] Appendix A.1 provides a discussion of subsidies implicit in the EMU regulatory framework.

household in the undistorted world economy. $\hat{V}^R(y_i, N_i, n_{i,j})$ denotes the value function for household j in country i conditional on borrowing from ROW:

$$\begin{aligned}\hat{V}^R(y_i, N_i, n_{i,j}) = \max_{n'_{i,j}, b'_{i,j}} & \; u\left(y_i + n_{i,j} - \tau(y_i, N_i) + \hat{q}\left(y_i, N_i, n'_{i,j}\right) b'_{i,j}\right) \\ & + \beta \mathbb{E}\left[\hat{V}\left(y'_i, N'_i, n'_{i,j}\right) | y_i\right] \\ \text{s.t. } & n'_{i,j} = -b'_{i,j}, \quad N'_i = N'(y_i, N_i).\end{aligned} \tag{17}$$

The state variables for this problem are given by the endowment realization in country i y_i, by assets held by the household $n_{i,j}$ and by the aggregate amount of assets held by households in country i N_i.[40] Aggregate assets held in the country are a state variable because they determine, in equilibrium, the amount of tax $\tau(y_i, N_i)$ that each household pays. The household chooses the amount of debt to issue to ROW $b'_{i,j}$ which equals the opposite of net foreign assets to carried into the following period: $n'_{i,j} = -b'_{i,j}$. Consumption is given by the endowment, net of taxes and augmented by holdings of net foreign assets and by resources obtained from borrowing. The price of debt issued by the household to ROW is given by $\hat{q}\left(y_i, N_i, n'_{i,j}\right)$, which is a function of assets carried by the household into the next period and of country i state variables y_i and N_i. All these variables help predict the probability of next-period default by the household. The continuation value for the household is given by the expectation over the value function $\hat{V}$. The household takes as given the law of motion $N'(y_i, N_i)$ for the aggregate amount of assets held in the country.

Second, if a household borrows from other countries in I, its problem differs slightly from that of borrowers from ROW. The key difference lies in the price at which households issue bonds. This price is given by $\tilde{q}$ for households that borrow from countries in I, and it differs, in general, from $\hat{q}$. The value function of this household is given by:

$$\begin{aligned}\hat{V}^J(y_i, N_i, n_{i,j}) = \max_{n'_{i,j}, \tilde{b}'_{i,j}} & \; u\left(y_i + n_{i,j} - \tau(y_i, N_i) + \tilde{q}\left(y_i, N_i, n'_{i,j}\right) \tilde{b}'_{i,j}\right) + \\ & \beta \mathbb{E}\left[\hat{V}\left(y'_i, N'_i, n'_{i,j}\right) | y_i\right] \\ \text{s.t. } & n'_{i,j} = -\tilde{b}'_{i,j}, \quad N'_i = N'(y_i, N_i).\end{aligned} \tag{18}$$

[40] Formally, the aggregate amount of assets is defined as $N_i = \int_0^1 n_{i,j} dj$.

Debt issued by the household to the other countries in I is denoted by $\tilde{b}'_{i,j}$. Again, this equals the opposite of net foreign assets carried into the next period.[41]

Third, the problem of a household that buys subsidized gross assets differs substantially from that of borrowers. The key difference is that this household trades assets with residents of both I and ROW. Its bilateral position vis-a-vis countries in I is positive, while that against ROW can be negative. Its value function is given by:

$$\begin{aligned} \hat{V}^S\left(y_i, N_i, n_{i,j}\right) = & \max_{n'_{i,j}, \breve{b}'_{i,j}, b'_{i,j}} u\left(y_i + n_{i,j} - \tau\left(y_i, N_i\right) + \hat{q} b'_{i,j} - \breve{q} \breve{b}'_{i,j} - \chi\left(\breve{b}'_{i,j}\right)\right) \\ & + \quad \beta \mathbb{E}\left[\hat{V}\left(y'_i, N'_i, n'_{i,j}\right) | y_i\right] \\ & \text{s.t. } \hat{q} = \hat{q}\left(y_i, N_i, n'_{i,j}\right), \ \breve{b}'_{i,j} \geq 0, \ n'_{i,j} = \breve{b}'_{i,j} - b'_{i,j}, \ N'_i = N'\left(y_i, N_i\right). \end{aligned} \tag{19}$$

The household issues bonds $b'_{i,j}$ to ROW at price $\hat{q}$ and buys assets $\breve{b}'_{i,j}$ issued by countries in I. It is costly for the household to hold assets, and it pays an intermediation cost χ that depends on the amount of gross assets it holds.[42] Specifically, the household purchases assets issued by all the countries that borrow from I, that it combines into a bundle of assets $\breve{b}'_{i,j}$.[43] The price of the bundle is denoted by $\breve{q}$. The bailout promise affects the price that the household pays for the individual bonds that compose the bundle, which, for a borrower z in s, with repayment probability $\pi_{s,z}$ is given by:[44]

$$\tilde{q}\left(y_s, N_s, n'_{s,z}\right) = \breve{q}\, \mathbb{E}\left[\pi_{s,z} + \xi\left(1 - \pi_{s,z}\right)\right], \tag{20}$$

where the larger the bailout promise ξ, the less default risk lowers the debt price. Consumption is given again by the endowment net of taxes, augmented by net foreign assets

[41] In principle, this household could borrow from both I and ROW. However, this does not occur in equilibrium. At the margin, above a threshold for debt issued, debt prices are higher if borrowing from I: $\tilde{q} > \hat{q}$. Countries that optimally borrow from I always issue debt above this threshold.

[42] Intermediation costs ensure that gross bilateral positions remain bounded. A similar outcome would result if a country could retain some of its gross assets in the event of default. This assumption would be computationally costly, increasing the number of state variables. Monitoring costs are well established in the literature on financial intermediation—e.g., in Holmstrom and Tirole (1997).

[43] Diversification across a continuum of borrowers implies that the bundle is risk-free. Households do not purchase individual risky bonds because of their risk-aversion.

[44] Appendix C.2 describes the optimality conditions associated with (19), from which (20) follows.

and by net resources obtained on international financial markets. The amount raised is given by the revenue from issuing bonds, net of gross asset purchases and of intermediation costs. Net foreign assets carried by the household into the following period are given by gross assets purchased, net of gross debt issued.

Fourth, each household can default on debt. The value function of a defaulting household in country i is given by:

$$\begin{aligned}\hat{V}^D(y_i, N_i) =& u(y_i - \delta(y_i) - \tau(y_i, N_i)) + \\ & \beta\mathbb{E}\left[\lambda\hat{V}(y_i', N'(y_i, N_i), 0) + (1-\lambda)\hat{V}^D(y_i', N'(y_i, N_i))\,|y_i\right].\end{aligned} \tag{21}$$

Upon default, consumption is given by the endowment, net of taxes and of the default cost. Aggregate assets held in country i are again a state variable, as they determine taxes paid by the household. The continuation value reflects that, in the next period, the household re-enters financial markets with zero assets with probability λ.

Finally, in each period, all households with access to financial markets choose whether to borrow from ROW, to borrow from other countries in I, to purchase gross assets, or to default. They choose by comparing the four value functions above defined. The value function associated with this discrete choice problem is given by:

$$\hat{V}(y_i, N_i, n_{i,j}) = \max\left\{\hat{V}^R(y_i, N_i, n_{i,j}), \hat{V}^J(y_i, N_i, n_{i,j}), \hat{V}^S(y_i, N_i, n_{i,j}), \hat{V}^D(y_i, N_i)\right\}. \tag{22}$$

All households in a given country are identical and make the same choices.[45] In particular, all households make the same choice for assets to carry into the next period, as they all have the same initial level of assets. Hence, the law of motion for aggregate assets follows from the policy functions of individual households:

$$N'(y_i, N_i) = n'(y_i, N_i, n_{i,j} = N_i). \tag{23}$$

The price at which individual households in I issue debt to ROW compensates the latter for the risk of default. Given probability of repayment $\pi_{i,j}$, this price is given by:

$$\hat{q}\left(y_i, N_i, n_{i,j}'\right) = \beta_{ROW}\pi_{i,j}, \tag{24}$$

[45]Households are all identical, but due to their negligible size, they do not internalize the effects of their choices on aggregate variables. In particular, each household knows that it cannot influence taxes set by the government. Hence, individual and aggregate assets, n and N, constitute two distinct state variables.

which is analogous to condition (15) in the undistorted world economy.[46]

Governments keep their promises towards domestic households and pay bailout transfers to holders of defaulted bonds. To finance bailout transfers, the government raises taxes from all households in the country.[47] In each period, the government knows with certainty the aggregate amount of resources that it will transfer to households in the following period.[48] To ensure that the government always meets its obligations towards households, it collects tax revenues in advance and pays them back as bailout transfers in the following period.[49] Taxes in each country are equal to the amount of transfers promised by the government $h(y_i, N_i)$ discounted by the risk-free debt price β_{ROW}:

$$\tau(y_i, N_i) = \beta_{ROW} h(y_i, N_i). \tag{25}$$

I define the marginal distributions $\hat{\phi}_C(y, N)$ and $\hat{\phi}_D(y)$ for countries with and without access to financial markets, as the analogous object to ϕ_C and ϕ_D in the undistorted world economy of Section 2.2. I also define the transition function $\hat{\Gamma}$ similarly to Γ in (16).

The market for assets traded among countries in I has to clear. Specifically, the amount of risk-free bundles of assets traded within I must be consistent with the aggregate amount of assets issued, the default probabilities and the extent of the bailout promise.[50]

I define the equilibrium in the world economy with subsidies on international lending as the set of policy functions, value functions, government taxes and transfers, prices, quantities and distributions that is consistent with optimality of all households, the government budget constraint and market clearing.[51] Again, I focus on a stationary allocation where aggregate variables are constant. In particular, the price $\breve{q}$, the price function $\tilde{q}$ and the distributions $\hat{\phi}_C, \hat{\phi}_D$ are all constant over time.

[46] If the household holds gross assets, these are lost in the event of default.

[47] Since all households behave identically, bondholders and taxpayers coincide within each country.

[48] Aggregate bailout transfers are known because households purchase debt of a large number of borrowers with independent default probabilities. Appendix C.5 details how this amount is determined.

[49] This timing assumption allows me to abstract from uncertainty about the commitment of each government to the bailout promise. Alternatively, the government could fund bailout transfers via taxes period-by-period. Aggregate bailouts by the government would be the unaffected. However, the current assumption allows me not to keep track of implicit government liabilities towards households.

[50] Appendix C.6 formally presents the market-clearing condition.

[51] The equilibrium is formally defined in Appendix C.7.

2.4 Calibration and Functional Forms

The model is calibrated at quarterly frequency, to match empirical moments from national accounts of euro area countries.[52] The period utility function is CRRA with relative risk aversion of 2, a standard value in the international macroeconomics literature. The discount factor of *ROW* is set to 0.994, to match a world yearly interest rate of 2.5%.[53] The endowment shock follows an AR(1) process in the logarithm:

$$\log(y_t) = \mu_y + \rho_y \log(y_{t-1}) + \sigma_y \epsilon_{y,t}. \tag{26}$$

I calibrate the process to match cyclical properties of GDP in euro area countries. The default cost $\delta(y)$ takes the same piecewise linear form as in Arellano (2008):

$$\delta(y) = \max(y - \delta E(y), 0). \tag{27}$$

I set the parameters β, λ and δ jointly, to match empirical moments describing euro area countries' external borrowing prior to the EMU. The empirical targets are given by the cross-sectional standard deviation of current account balance-to-GDP ratios, by the average interest rate on government debt and by the average net foreign asset position. I then compare the properties of the stationary allocation of the undistorted world economy with these empirical targets. First, the cross-sectional standard deviation of the current account balance to GDP ratio equals 1.8% in the stationary allocation of the undistorted world economy. In the data, the same standard deviation equaled 1.64% in 1994 and 2% in 1998. Second, in the model, the average yearly interest rate paid by countries on external debt implies a spread of 1.5 percentage points over the risk-free interest rate. The spread over the world risk-free rate of the mean real interest rate paid by euro area countries on government debt equaled 1.85 and 2.1 percentage points in 1994 and 1995, respectively. Finally, in the undistorted world economy, countries' average net external asset position equals -2.5% of yearly GDP. In the euro area, the average net foreign asset position equaled -3.1% of GDP, on average, between 1994 and 1995.

[52] Calibration targets are reported in Table 1. Further details are presented in Appendix C.8.

[53] King and Low (2014) show that world real interest rates have been trending downwards since the 1990s. Their average estimate for the world real interest rate between 1996 and 2011 is 2.52%.

The functional forms and parameters that describe the bailout promise and of the cost of intermediating gross assets have no bearing on the equilibrium allocation of the undistorted world economy. I choose these parameters to match some of the stationary allocation properties of the economy with subsidies. I then ignore these targets when evaluating the quantitative performance of the model.

I set the parameters of the bailout promise to capture two important features of euro area countries' interaction with financial markets after the inception of the EMU. First, I set the extent of the bailout promise ξ to match the ratio between two bilateral external positions of borrowers in the euro area. The ratio is the one between their bilateral positions against other countries in the euro area, and against all countries in the world. This ratio equaled 67.5% for the aggregate of Greece, Italy, Portugal and Spain in 2008. A value of ξ of 0.6 implies that the corresponding ratio of bilateral positions equals 67.95% in the model. Second, I set the lower bound on the repayment probability $\bar{\pi}$ to 2%, implying that only the debt of borrowers with very high default probabilities does not benefit from the bailout promise. This assumption is consistent with those elements of financial regulation that allowed all government debt in the euro area to be treated as risk-free for regulatory purposes. Finally, the function describing the cost of intermediating assets takes the isoelastic form $\chi\left(\breve{b}\right) = \frac{1}{\chi_b}\left(\breve{b}\right)^{\chi_b}$, where the parameter χ_b describes the elasticity of intermediation costs to the amount of gross assets intermediated. I set χ_b equal to 1.8. This elasticity implies that the equilibrium risk-free interest rate within I is very close to the risk-free interest rate in ROW, with a spread of 0.43 percentage points.

2.5 Results

I show in this Section the quantitative effects of the bailout promise on countries' saving behavior and on the distribution of net external assets. I consider four key results, by comparing the stationary-allocation equilibrium of the economy with subsidies to that of the undistorted world economy. First, I show that all countries can borrow at lower cost in the economy with subsidies, issuing debt at a higher price both to other countries in the union and to the rest of the world. Second, I highlight the heterogeneous implications

Table 1: Parameter values

Calibrated Parameter		Value	Target
Discount factor in *ROW*	β^{ROW}	.994	World real interest rate
Relative risk aversion in I	γ	2	Standard
Stochastic endowment process	$[\rho_y, \sigma_y]$	$[.98, .012]$	Estimated
Discount factor in I	β	.97	Average interest rate in I
Readmission probability	λ	.12	Average net external assets
Default costs	δ	.98	Current account, standard deviation
Partial bailout	ξ	.6	Borrowers' bilateral positions
Bailout promise limit	$\bar{\pi}$	.02	Subsidy on risky debt
Intermediation cost elasticity	χ_b	1.8	Low risk-free rate in I

of subsidies for countries' net external saving. The current account balance deteriorates for countries with low income and low external wealth, while it improves for high-income, high-wealth countries, replicating the qualitative results of Section 1. Third, I show that both sides of countries' external balance sheets expand due to the bailout promise, as some households finance gross asset purchases in the economic union by borrowing from the rest of the world. Finally, the heterogeneous-countries model shows that the distribution of countries' external wealth widens due to the bailout promise, consistent with empirical evidence for the euro area.[54]

Debt Prices. In the economy with subsidies, countries in the economic union can borrow at lower cost than can countries in the undistorted economy. Similarly, interest rates on government debt fell for countries in the euro area after the inception of the EMU.[55]

[54]Appendix C.9 discusses the heterogeneous countries' choice over types of assets traded, showing that low-income, low-wealth countries borrow from other members of the union, while high-income, high-wealth countries act as gross savers and intermediate resources raised from the rest of the world.

[55]Interest rates on government debt fell for Greece, Italy, Portugal and Spain from around 10% in 1996 to 4% in 2003. Adjusting for future inflation, the decline was similar, from 7.3% to 1.6%, on average.

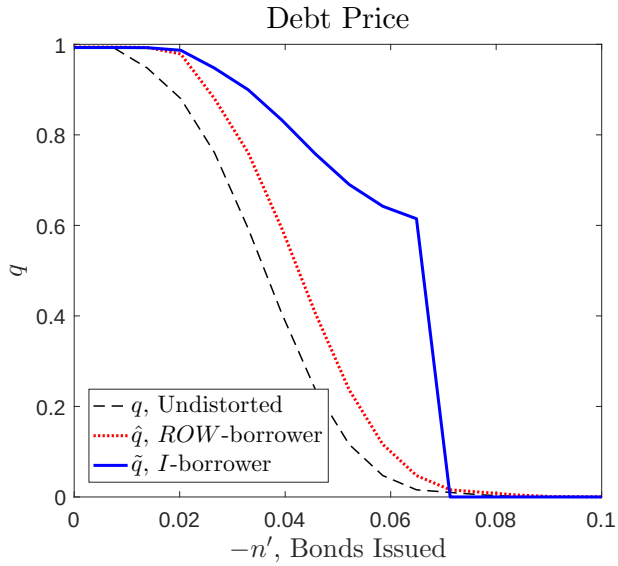

Figure 1: Price of debt issued by borrowers in the undistorted economy and in the economy with subsidies, for borrowers from ROW and from other countries in I. The figure shows the price of debt issued by a household with endowment equal to the long-run mean, $y = \mathbb{E}(y)$, and zero aggregate assets $N = 0$, as a function of bonds issued in units of mean yearly endowment.

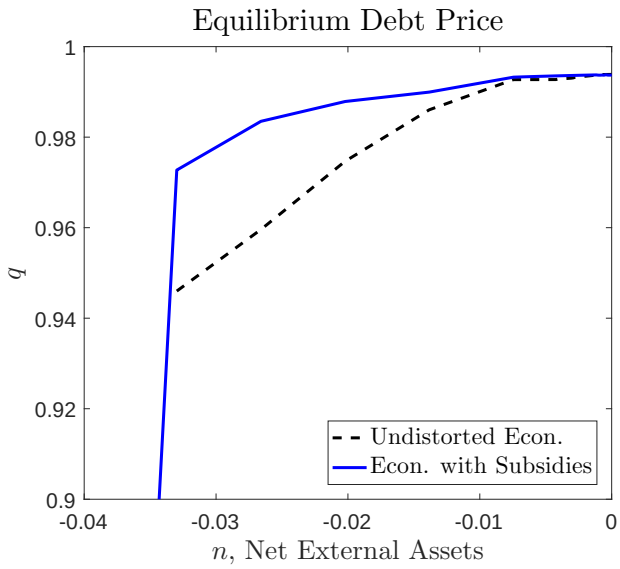

Figure 2: Equilibrium price of debt for borrowers in the undistorted economy and in the economy with subsidies, for a country with endowment equal to the long-run mean, $y = \mathbb{E}(y)$, as a function of net external assets in units of mean yearly endowment.

Figure 1 displays the price at which borrowers issue debt in the undistorted economy and in the economy with subsidies, when borrowing both from the rest of the world and from other countries in the economic union. Three key facts emerge from the figure. First, when their debt is characterized by positive default risk, borrowers who issue debt to other countries in I obtain a higher debt price than borrowers from ROW.[56] Households in I are more willing than those in ROW to purchase risky debt at a high price, because the bailout promise protects them, in part, from default risk. The difference between the two prices is larger, the riskier debt is, as the extent of the subsidy implied by the bailout promise is increasing in default risk. For a country that issues bonds worth 2% of yearly GDP, the implied difference in yearly interest rates is equal to 3.5 percentage points.[57] The difference rises to 30 percentage points if bonds issued rise to just 2.5% of yearly GDP.

Second, borrowers from ROW in the economy with subsidies also obtain a higher price for debt than borrowers in the undistorted economy do. Due to the option to issue risky debt to other countries in I, countries default for higher levels of debt in the economy with subsidies. Given lower default risk, lenders in ROW purchase debt issued by countries in I at a higher price. The advantageous borrowing terms granted by the bailout promise spill over to borrowers who do not directly exploit the promise and borrow from ROW. The difference in yearly interest rates is large, equaling 8 percentage points for countries issuing 1% of yearly GDP worth of bonds across the two economies.

Third, the equilibrium cost of borrowing is also lower in the economy with subsidies, even as countries issue larger amounts of bonds. Figure 2 shows equilibrium debt prices for countries in the undistorted world economy and in the economy with subsidies. The differences in debt prices are smaller than those for a given borrowing choice. The difference in equilibrium yearly interest rates for a country with a net external assets to GDP

[56] Debt issued to countries in I has a higher price than debt issued to ROW if the probability of repayment is sufficiently low. The relevant threshold is given by $1/\left[1+(\beta_{ROW}-\breve{q})/(\xi\breve{q})\right]$, which is close to unity. The price of debt is slightly higher if borrowing from ROW, otherwise. The price of debt traded within I drops to zero when the repayment probability falls below the threshold $\bar{\pi}$.

[57] Unless otherwise specified, I always refer in this Section to variables for a country with endowment equal to the long-run mean of y and zero aggregate assets.

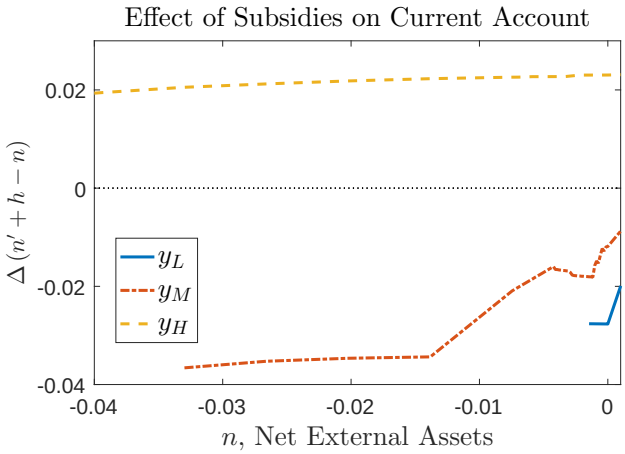

Figure 3: Difference in current account policy functions across the economy with subsidies and the undistorted world economy, as a function of current net external assets in units of mean yearly endowment. y_M indicates an endowment level equal to the long-run mean $\mathbb{E}(y)$. y_L and y_H indicate endowment values 1.5 standard deviations below and above the mean. The current account policy function is given by $n' + h - n$, as the total amount of assets purchased by a country includes risk-free assets h purchased by the government. The difference between policy functions is not defined where a country defaults.

ratio of -1% is equal to 0.84 percentage points, and to 5.7 percentage points for a country with a -2% net external assets to GDP ratio.

Current account. The introduction of a bailout promise on risky assets causes the current account of low-income countries to deteriorate, and that of high-income countries to improve. In the euro area, the current account balance of Germany rose by more than 7 percentage points of GDP from 1999 to 2007, reflecting a more general pattern in the group of so-called core countries. Conversely, the current account deteriorated in countries of the so-called periphery: In Spain, the current account balance deteriorated by 7 percentage points of GDP in the same period, between 1999 and 2007.

Figure 3 presents the difference in the policy function for the current account balance of countries in the economic union of the model, between the economy with subsidies on international lending and the undistorted world economy.[58] Two key results emerge from analyzing the difference between the current account policy functions across the two

[58]The policy functions themselves are presented in Appendix C.9.

regimes. First, the bailout promise induces countries with relatively low income to save less. For a country with zero external assets and low endowment, the current account balance is 2.8% of mean endowment lower in the economy with subsidies than in the undistorted world economy. The difference is 1.3% of mean endowment for an economy with endowment equal to its long-run mean, and it grows larger as its net external assets fall. Second, high-income countries save more in the economy with subsidies than in the undistorted world economy. The difference amounts to 2% of mean endowment for a country with high endowment and zero net external assets.

The heterogeneous impact of the bailout promise on countries' current account balance is the outcome of two opposite effects, closely related to the results of Propositions 1 and 3. First, borrowers can issue debt at a higher price in the economy with subsidies, as shown in Figure 1. Households in countries with relatively low endowment take advantage of this fact and they issue more debt. Hence, their current account balance is lower in the economy with subsidies. Second, countries that choose to hold gross assets also choose to increase their net saving. Higher net saving is optimal because it allows countries to frontload the losses they will incur on gross assets.[59] This latter effect of bailout promises on the current account is the dominant one for high-endowment countries, as these countries hold gross assets in equilibrium.

Gross External Positions and Intermediation. In the allocation with subsidies, high-income countries intermediate resources from the rest of the world to other countries in the union. Intermediation of resources and the expansion of external balance sheets have characterized capital flows in the euro area since the inception of the EMU. France increased its bilateral external position against euro area countries from 8% to 32% of GDP between 2001 and 2007.[60] In the same period, its global position fell from 8% of GDP to zero. Asset accumulation against countries in the euro area was thus accompanied

[59] Given that taxes are paid in advance of bailout transfers, households also save via the government. They would be able to offset taxes by borrowing more from ROW, but they do not do so in equilibrium. If the government financed bailouts with contemporaneous taxes, households would respond by saving directly. Appendix B.7 shows the equivalence of these timing assumptions for the model of Section 1.

[60] Figures are drawn from Waysand et al. (2010).

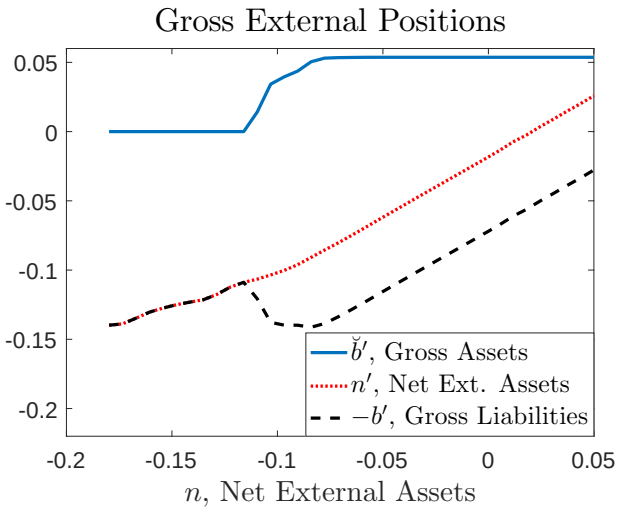

Figure 4: Policy function for external position of a country with high endowment, as a function of net external asset in units of mean yearly endowment. The blue solid line represents the choice for gross assets, the red dotted line net external assets, the black dashed line gross liabilities.

by a fall in the bilateral position against countries outside of it, by 33% of GDP.

Figure 4 shows the policy function for net and gross asset and liability positions of a high-income country, as a function of its current net external assets.[61] In the model, financial counterparties of gross saving countries closely mirror those of core countries in the euro area. A country with high endowment and zero net external assets buys gross assets issued by other countries in I worth more than 5% of mean endowment. At the same time, it reduces its net external assets to -1.8% of mean endowment. Hence, this country funds its gross asset purchases entirely by issuing gross liabilities to the rest of the world. The amount of gross debt issued equals 7% of mean endowment.

Intermediation of gross capital flows emerges because households leverage the benefits of the bailout promise. High-income households buy relatively cheap assets issued by countries in I, and they issue high-price, low-risk debt to ROW. By expanding the gross asset and liability sides of their external balance sheets, households arbitrage differences in prices between truly low-risk liabilities and gross assets, whose default risk is reduced by the presence of the bailout promise.

The incentive to act as gross savers is stronger for countries with higher endowment

[61] As in Figure 3, this country's endowment is 1.5 standard deviations above the mean.

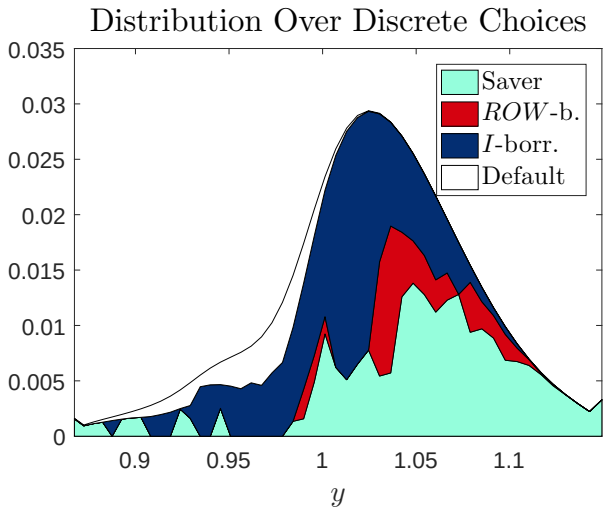

Figure 5: Distribution of countries with access to international financial markets, across endowment realizations and optimal choice of type of assets to trade. The light green area includes countries that purchase gross assets, the red one countries that borrow from ROW, the dark blue region countries that borrow from others in I and the white region countries that default.

realizations. Figure 5 shows the equilibrium distribution of countries with access to international financial markets over levels of income, and across different choices for the type of financial asset they trade. The incentive to default is lower for countries with high endowment realizations.[62] Hence, countries with higher endowment can issue assets that command a higher price, given their amount of borrowing. Thus, a country with a higher endowment level has a stronger incentive to act as gross saver and arbitrage the spread between the price of risk-free assets $\breve{q}$ and that of its own debt. On the other hand, a country with a lower endowment prefers to issue debt to other countries in I and to exploit the subsidy on risky borrowing that the bailout promise implies. The average endowment realization for countries that purchase gross assets is 70% of a standard deviation higher than the average endowment of those that issue gross assets within I. Finally, Figure 5 also shows that the majority of countries with access to international financial markets trade assets with other countries in I. Countries that borrow from within I account for 43% of those with access to international financial markets, while

[62]This result is common to models of endogenous sovereign default that share the quasi-linear default costs of Arellano (2008).

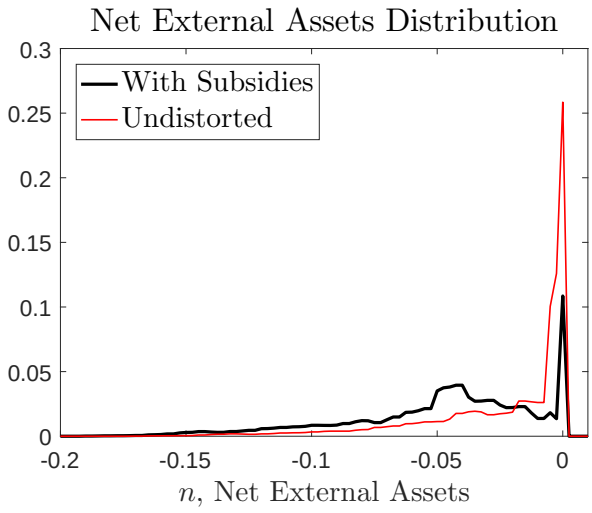

Figure 6: Distribution of countries in the stationary allocation of the undistorted economy and of the economy with subsidies over levels of net external assets. Values on the vertical axis denote masses of countries contained in intervals of net foreign assets equal to 0.25% of mean yearly endowment each.

37% act as gross savers. 11% of countries borrow from ROW, and the remaining 9% default in the stationary allocation of the economy with subsidies.

Net External Assets Distribution. The distribution of countries over levels of net external assets differs between the stationary allocations of the economy with subsidies and the undistorted world economy. Specifically, the distribution in the allocation with subsidies features a larger mass of countries with higher levels of debt and a lower mass with levels of debt close to zero. On the other hand, the two distributions are similar, in that neither features countries with positive values of assets. Figure 6 presents the two distributions, for countries with access to international financial markets.

First, in the equilibrium of the economy with subsidies, a larger fraction of countries owes relatively large debt to its foreign creditors. In the stationary allocation of this economy, 77% of countries have a net external asset position of 2% of mean yearly endowment or lower. In the undistorted economy, only 38% of countries do. This result occurs since the bailout promise induces borrowers to issue more external debt. Low-income countries benefit from low borrowing costs when issuing risky debt in the allocation with subsidies. In the undistorted world economy, countries issue low levels of debt, instead, as borrowing

costs would rise steeply if they issued high-default-risk debt.

Second, in the distribution of both economies, no countries are located at positive values of net external assets. The main reason for this result is that the households in I are less patient than those in ROW, so they prefer to frontload consumption and accumulate negative assets. In the allocation with subsidies, high-income countries have a higher current account balance than in the undistorted economy. However, not even these countries accumulate positive external wealth, given that a fraction of the assets they purchase have a low return because of their default risk.

Finally, the difference between the two distributions can be expressed in terms of their mean and standard deviation. First, the mean asset level equals -4.85% of mean yearly endowment in the stationary allocation of the economy with subsidies, as opposed to -2.5% in the undistorted economy. The low cost of borrowing for high-risk debtors in the economy with subsidies causes the lower average level of net external assets in this economy. A deterioration in the mean level of net external assets was also observed in the euro area, where, with the exception of Germany, most major economies let their net foreign asset position deteriorate after the inception of the EMU. In Spain, net foreign assets went from about -4% of euro area GDP in 2001 to close to -10% in 2007.[63] Also in Italy, net foreign assets deteriorated from -2% to -5% of euro area GDP in the same period. Second, the standard deviation of net foreign assets is also slightly higher in the economy with subsidies—3.8% versus 3.1%. In the undistorted world economy, steeply increasing borrowing costs induce all countries to choose similar levels of debt, characterized by very low default risk. This occurs less in the economy with subsidies, where borrowing costs rise less steeply in debt.

3 Concluding remarks

I find that policy distortions on cross-border asset holdings contribute to three important aspects of the recent European experience of capital flows. In particular, I show in a model of countries in an economic union integrated in international financial markets

[63] Figures are drawn from Lane and Milesi-Ferretti (2007).

that the subsidies on international lending can explain the observations of gross capital flows intermediation, widening current account imbalances, and of a severe debt crisis.

The model introduced in this paper shows that the implications of the subsidy are quantitatively important. In addition, the heterogeneous-country, endogenous sovereign default framework is flexible and can be employed to address a number of related questions. Possible examples include the study of the interaction between distortions on capital flows and aggregate productivity, or between monetary policy in a union of countries and sovereign default risk.[64]

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[64] On capital flows and productivity, see Aoki, Benigno and Kiyotaki (2009), Reis (2013) and Gopinath, Kalemli-Ozcan, Karabarbounis and Villegas-Sanchez (2017).

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A Appendix For Online Publication

A.1 Empirical evidence

In this Appendix, I present the main empirical evidence that motivates this paper. First, I detail facts related to the widening of current account deficit and surplus positions observed in the euro area in the 2000s. Second, I describe evidence on the expansion of gross external asset and liability positions of euro area economies and on the pattern of intermediation of international capital flows. Third, I present specific features of the regulatory and policy frameworks that have contributed to subsidizing cross-border holdings of assets within the euro area. Finally, I present a measure of euro area economies' exposure to trade with European partners. This indicator will be crucial in determining the direction of the effect, in a crisis, of the interaction between financial linkages and trade integration.

Current account imbalances in the euro area. Current account dynamics of economies in the euro area displayed significant imbalances in the years preceding the global financial crisis, an observation widely documented in the literature.[65] Figure 7 displays the sum of current account balances for countries in the two groups of core and periphery members of the monetary union, expressed as ratios to euro area GDP.[66] The gap in current account balances between countries in these two groups widened substantially between the inception of the EMU and the global financial crisis. The current account surplus in core countries approached 3% of euro area GDP in 2007, from a balanced position in 2000. In the periphery, the current account deficit doubled in the same period, rising above 2% of euro area GDP in 2007.

Disaggregated data for individual countries are reported in Figure 8. In the periphery, the current account deficit rose in all countries but Portugal between 2000 and 2008. Prior to the global financial crisis, the current account deficit was above 10% of GDP in Portugal

[65] For a detailed review of the pattern of capital flows in the EMU, see Lane (2013).

[66] As already mentioned, the core includes Austria, Belgium, France, Germany and Netherlands. The periphery includes Greece, Ireland, Italy, Portugal and Spain.

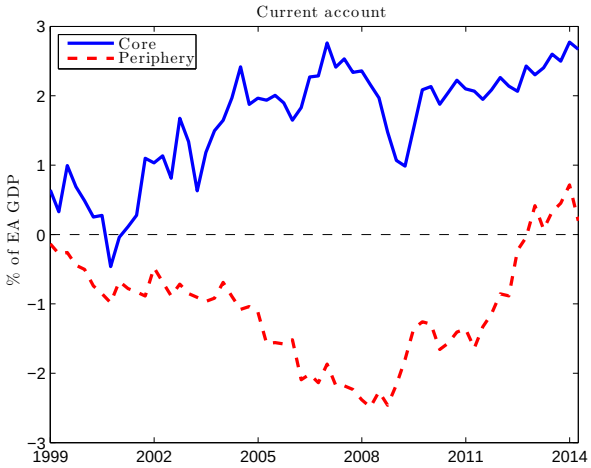

Figure 7: Current account balances of core and periphery countries in the euro area, as fraction of total euro area GDP. Core includes Austria, Belgium, France, Germany and Netherlands. Periphery includes Greece, Ireland, Italy, Portugal and Spain.

and Greece and above 5% in Ireland and Spain. Among core countries, the largest rise in current account surplus was observed in Austria, Germany and the Netherlands. At its peak, in 2007, the German current account surplus amounted to 7% of GDP. A different pattern was observed in France and Belgium, where the surplus diminished in magnitude throughout this period.

Financial linkages and intermediation. Two key facts emerge from the analysis of bilateral international investment positions of euro area economies.[67] First, strong financial linkages tied together economies in the EMU, with large, and growing, cross-border positions among euro area economies. Second, euro area economies traded extensively in financial assets with the rest of the world, with an emerging pattern of intermediation by core countries of capital flows from outside the euro area.

Data on net and gross financial positions of euro area economies reveal the presence of close interdependence among these countries. First, the fraction of total gross external positions of economies in the EMU accounted for by euro area counterparties was equal

[67] All figures reported in this subsection are drawn from the dataset and paper presented by Waysand, Ross and de Guzman (2010).

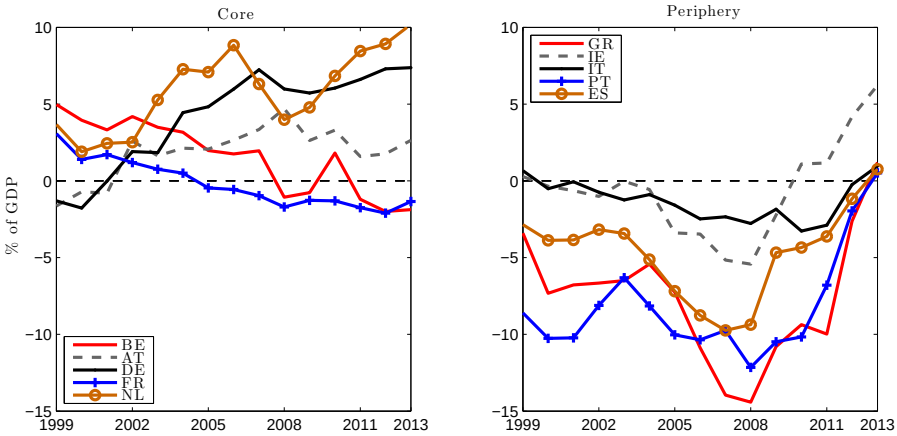

Figure 8: Current account balances of selected countries in the euro area, as a fraction of individual GDP. The left-hand panel represents so-called core countries, while the periphery is displayed in the right-hand panel.

to approximately half of their total gross positions. Second, economies in the euro area core represented major financial partners for peripheral countries. Gross liabilities of peripheral countries held by Germany, France and the Netherlands in 2008 ranged from 40% of GDP for Italy to 69% of GDP for Portugal.[68] Gross liabilities held by the three major core countries were even higher for Ireland, amounting to 268% of Irish GDP.[69] Finally, the bilateral positions of peripheral countries against euro area partners could largely explain their global international investment positions. The fraction of the global international investment position of peripheral countries represented by their bilateral position against euro area partners ranged between 61% for Portugal to 80% for Greece, in 2008, highlighting how the majority of these countries' trade in financial assets took place within the EMU.[70]

[68] In addition, substantial amounts of liabilities corresponding to counterparties in the United Kingdom and Luxembourg are likely to partly reflect claimants ultimately based in the euro area core. Waysand, Ross, de Guzman (2010) discuss the merits of alternative residence reporting principles.

[69] The pattern observed in Ireland, however, is substantially different from that of Italy, Spain, Portugal and Greece. Ireland, in fact, held a substantial amount of gross assets outside the euro area, amounting to approximately 400% of GDP just for the United Kingdom and the United States.

[70] Again, the pattern is different in the case of Ireland. Given substantial holdings of gross assets outside the euro area, its global international investment position amounted to -56% of GDP, while its

Trade in financial assets by euro area economies with the rest of the world was characterized by two main features. First, the evolution of gross financial positions of core euro area economies can be interpreted as describing intermediation of international capital flows by these countries. The bilateral international investment position of core economies with respect to the rest of the euro area rose between 2002 and 2007. This increase ranged between 30 percentage points of GDP for Belgium to 12 percentage points for France. At the same time, the global international investment position of some of these countries was deteriorating, signaling that they were funding gross saving in the euro area by borrowing from the rest of the world, rather than by increasing their net savings.[71] In Germany, the global international investment position was also growing at the time, but by less than the bilateral one with the euro area, so that the bilateral investment position with respect to the rest of the world was deteriorating.

Second, the magnitude of gross external positions of the euro area with the rest of the world was large by international standards, highlighting its financial openness and close integration with world financial markets. While the external net foreign asset position of the euro area was small compared to that of the United States or Japan, the sum of its gross external assets and liabilities amounted to 350% of GDP in 2008, compared with less than 250% of GDP for the United States and 175% for Japan. Given the presence of large gross capital flows between the euro area and the rest of the world, it is important to consider the implications of financial trade by euro-area countries with economies located outside of it, in order to conduct a comprehensive analysis of their pattern of external positions since the inception of the monetary union.

Distortions on asset holdings in the European Monetary Union. Several aspects of policy and regulation in the EMU are likely to have contributed to the pattern of intermediation of capital flows observed in the euro area. I will briefly discuss some

bilateral position against the rest of the euro area amounted to -123% of GDP.

[71] In France, Belgium and Austria, the global international investment position deteriorated by 14, 10 and 7 percentage points of GDP, respectively, between 2002 and 2008. In the Netherlands, on the other hand, a substantial improvement in the global international investment position was matched by a smaller one in the bilateral one with euro area partners.

aspects of banking regulation and collateral eligibility rules in transactions with the European Central Bank which subsidized holdings of euro-denominated assets, for institutions based within the monetary union. In addition, I will review ex-post policy actions in the context of the sovereign debt crisis that, similarly to a bailout, reduced losses suffered by holders of peripheral countries' debt.

First, financial regulation in place in the EMU has provided incentives for banks in the euro area to hold large amounts of euro-denominated sovereign debt. In the European Union, the Capital Requirements Directive allowed financial institutions to assign a "zero-risk weight" to government debt of member states denominated and funded in their own currency.[72] According to Nouy (2012), the zero-risk weight mandated by the Capital Requirements Directive, implied that regulators largely regarded local currency debt as risk-free. In addition, the author expressed a concern that these aspects of regulation actively encouraged banks to accumulate sovereign debt.[73]

Second, the ability to use sovereign debt issued by euro area governments as collateral in transactions with the European Central Bank has provided an additional incentive to financial institutions based in the monetary union in holding these assets. Buiter and Sibert (2005) point out that operational practices on collateral eligibility at the ECB have subsidized European banks' holdings of risky, short-maturity government debt. In particular, according to these authors, the eligibility as collateral of debt issued by all euro area governments has contributed to the compression of borrowing costs observed among euro area governments.

Third, actions taken by policy institutions in the euro area during the sovereign debt crisis, in the form of explicit bailouts or non-standard monetary policy, have helped reduce the adverse effects of the crisis on financial institutions with large exposures to peripheral governments. To the extent that banks in the euro area expected similar measures to be taken in the event of a crisis, such expectations induced them to exert

[72]Regulation (EU) No 575/2013, Part Three, Title II, Chapter 2, Section 2, Article 114.4 contains the most recent version of relevant legislation.

[73]Ms. Nouy was then General Secretary of the Prudential Supervisory Authority at the Banque de France. She is currently Chair of the Supervisory Board of the Single Supervisory Mechanism at the European Central Bank.

less caution regarding the occurrence of future crises, as they expected, to some degree, to be bailed out in such circumstances.[74] A concrete bailout example is reported by Acharya and Steffen (2013), who discuss the case of the Franco-Belgian banking group Dexia. The size of Dexia's sovereign bond portfolio amounted to "almost three times of its book equity," and it was largely composed of Italian and Greek government debt. In the second half of 2011, as sovereign bond prices fell and this bank found it harder to access sources of funding, Dexia was rescued by the governments of Belgium, France and Luxembourg. In addition, the Outright Monetary Transactions (OMT) programme launched by the ECB in 2012, with the aim of "safeguarding an appropriate monetary policy transmission and the singleness of the monetary policy," was successful in reducing yields on government debt of peripheral countries, thereby increasing the market value of such assets on financial institutions' balance sheets (Altavilla, Giannone and Lenza, 2014).

In the model presented in this paper, I introduce a bailout promise to represent institutional distortions giving preferential treatment to residents of an economic union when purchasing risky assets issued by union partners. This modeling choice allows me to characterize, in a simple way, a wide range of subsidies and distortions leading residents of an economic union to perceive returns on union-issued assets to be higher, or safer, than outside residents perceived them to be.[75]

Trade integration and specialization. In 2005, trade with partners in the European Union accounted for approximately two thirds of total trade by EU economies.[76] Given theri geographical proximity, similarity in tastes and explicit trade liberalization, it is not surprising that European economies largely trade with each other, highlighting the high degree of goods-market integration characterizing the Union.

[74] Acharya and Steffen (2013) document European banks' behavior of betting on the survival of the euro area, "choosing to hold peripheral sovereign bonds and financing their investments in short-term wholesale markets."

[75] Clearly, this assumption does not allow for a separate analysis of the individual channels suggested in the literature. Such analysis is left for future research.

[76] Source: Eurostat, International trade data.

Economies in the European Union, however, differ significantly in terms of relative specialization in those industries whose output is more extensively traded internationally. Manufacturing accounted for 23% of Gross Value Added (GVA) in Germany in 2005, but represented only 10% and 16% of GVA in Greece and Spain, respectively.[77] Peripheral economies, on the other hand, are relatively specialized in industries characterized by a lower degree of tradability of output. In the same year, construction accounted for only 4% of GVA in Germany, while rising to 6% and 12% in Greece and Spain.[78]

In order to document the asymmetric pattern of specialization of European economies, accounting for heterogeneity in tradability of output produced by different industrial sectors, I construct a country-level measure of average tradability of output.[79] I define tradability of individual industrial sectors as the ratio, for each sector, of total exports and imports attributed to that sector in a sample of advanced economies, to total Gross Value Added (GVA) of that sector. Formally, tradability of sector s is defined as

$$\mathrm{TDTY}_s = \frac{\sum_{i \in I} \mathrm{EXP}_{s,i} + \mathrm{IMP}_{s,i}}{\sum_{i \in I} \mathrm{GVA}_{s,i}},$$

where $\mathrm{EXP}_{s,i}$ and $\mathrm{IMP}_{s,i}$ represent total exports and imports attributed to sector s in country i. I represents the set of all countries in my sample. Hence, $\sum_{i \in I} \mathrm{GVA}_{s,i}$ represents total GVA of sector s in the entire sample.

At the country level, average tradability of output is given by the average of tradability in all industrial sectors, weighted by the shares of GVA represented by each sector in the economy of each country.[80] Formally, this is given by

$$\overline{\mathrm{TDTY}}_i = \sum_{s \in S} \mathrm{TDTY}_s \frac{\mathrm{GVA}_{s,i}}{\overline{\mathrm{GVA}}_i},$$

where S represents the set of all sectors that compose the economy, and $\overline{\mathrm{GVA}}_i = \sum_{s \in S} \mathrm{GVA}_{s,i}$ represents total GVA in economy i.

[77] In the System of National Accounts, GVA "is defined as the value of output less the value of intermediate consumption and is a measure of the contribution to GDP made by an individual producer, industry or sector."

[78] Data are drawn from the OECD Structural Analysis (STAN) database.

[79] A complete description of the data used to construct this measure is presented in the paragraph below.

[80] This measure is analogous to that of tradedness in Betts and Kehoe (2001).

Figure 9 presents values of average tradability of output for EU economies. Consistently with the observation that tradable sectors such as manufacturing are underrepresented in these economies, Greece, Spain and Portugal feature low average tradability of output. On the other hand, average tradability is high in Germany, especially in comparison to other very advanced economies. This variable, in fact, is closer in Germany to the level encountered in recent accession countries, such as Hungary and Slovenia, than in the United Kingdom or France. Low values for average tradability of output observed in Southern European economies are due to the relative specialization in these countries is sectors characterized by lower sectoral tradability. Detailed evidence on EU economies' sectoral specialization is presented in the paragraph below.

In Section 1.4, I study how specialization in industries characterized by lower tradability determines an amplification of the adverse effects of a debt crisis, when debt is owed to partners in an economic union. The ability of a country to generate trade surpluses through exports is in fact hampered by weak economic conditions in union partner economies if industrial specialization determines a high degree of exposure to export demand from these countries.

Description of data on trade integration and specialization The data used to construct the measures of tradability of output presented in this appendix are drawn from the STructural ANalysis (STAN) and Trade in Value Added (TiVA) databases released by OECD and WTO (OECD 2011 and OECD/WTO, 2015).

I consider data for the year 2005, as that is the last year for which data from both datasets are available for a sufficiently wide sample of countries. The sample consists of all 34 OECD countries with the exclusion of Turkey and Chile, for which STAN data are not fully available. This sample does not include all EU economies: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta and Romania are EU-28 members but not OECD members, hence they are excluded from this sample.

Industrial sectors in my sample correspond to groupings of 2-digits industries from the ISIC Rev.3 Classification. Specifically, these are: Agriculture, hunting, forestry and fishing (01-05), Mining and quarrying (10 - 14), Food products, beverages and tobacco

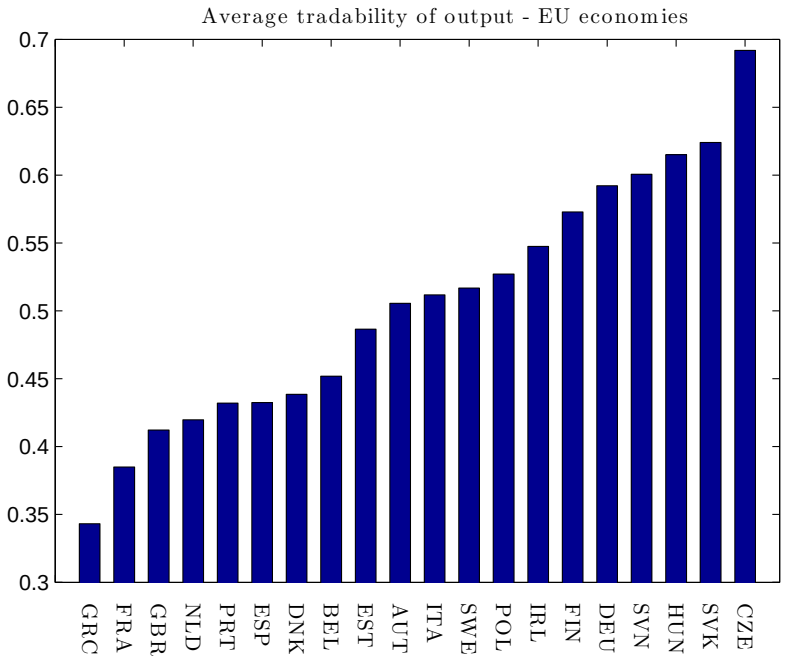

Figure 9: Average tradability of output in the European Union. This measure is computed as the weighted average of sector-level tradability of output, with weights given in each country by the shares of total GVA corresponding to each sector. Data source: OECD STAN and TiVA databases, year 2005.

(15 - 16), Textiles, textile products, leather and footwear (17 - 19), Wood, paper, paper products, printing and publishing (20 - 22), Chemicals and non-metallic mineral products (23 - 26), Basic metals and fabricated metal products (27 - 28), Machinery and equipment, not elsewhere classified (29), Electrical and optical equipment (30 - 33), Transport equipment (34 - 35), Manufacturing not elsewhere classified; recycling (36 - 37), Electricity, gas and water supply (40 - 41), Construction (45), Wholesale and retail trade; Hotels and restaurants (50 - 55), Transport and storage, post and telecommunication (60 - 64), Financial intermediation (65 - 67), Business services (70 - 74), Other services (75 - 95).

In order to clarify the results described in section A.1, I present in Figure 10 data for tradability of output disaggregated at the industrial sector level. Intuitively, services are characterized by low tradability of output, while subsectors of manufacturing, mining and agriculture are characterized by higher than average tradability.

Figure 11 decribes the industrial specialization of the EU economies in the sample,

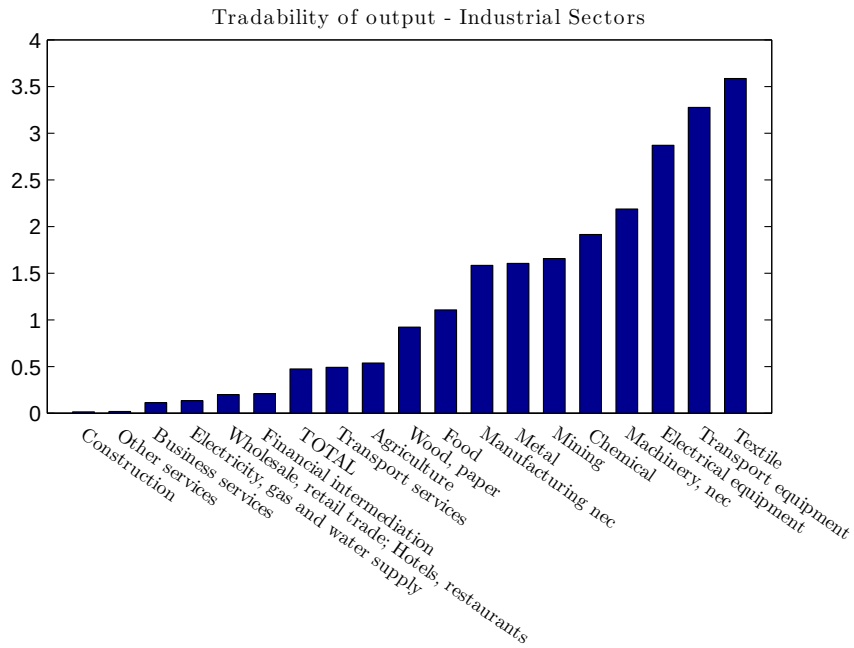

Figure 10: Tradability of output at the industrial sector level. This measure is given by the ratio of total exports and imports attributed to a sector in all countries in the sample, to total GVA of that sector. Data source: OECD STAN and TiVA databases, year 2005.

displaying the shares of GVA attributed to groups of industrial sectors ordered according to their tradability. Manufacturing is divided into two groups, with high tradability manufacturing including Textile, Transport equipment, Electrical equipment, Machinery and Chemical products and low tradability manufacturing including Metallic products, Manufacturing not elsewhere classifed, Food and Wood and paper products. Transport services are treated separately from other services due to their higher tradability. Consistently with the evidence presented on tradability of individual sectors, countries displaying higher average tradability are typically characterized by a larger share of the manufacturing sector.

B Additional Material and Proofs for Section 1.

This Appendix provides additional details on the properties of the model economy introduced in Section 1. In addition, it provides the proofs of the propositions in Section

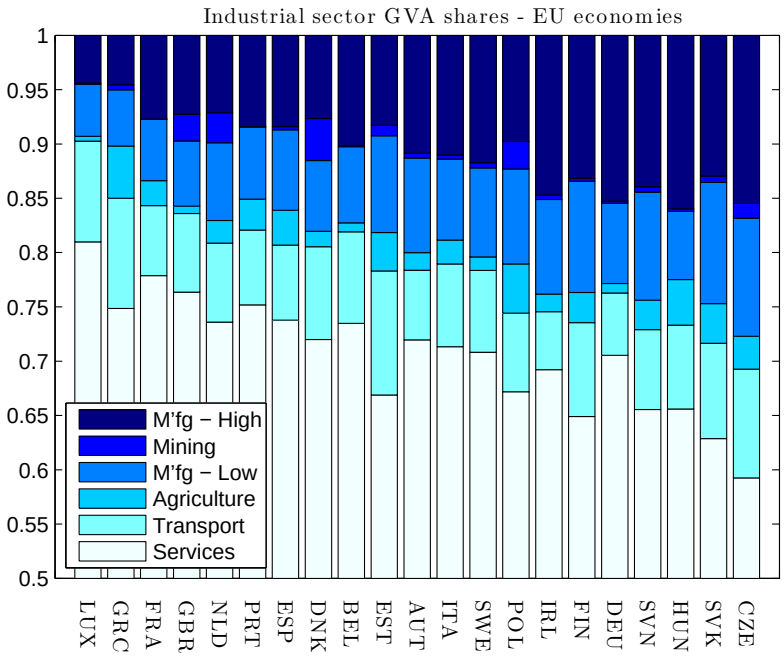

Figure 11: Shares of GVA attributed to broad industrial sectors, ordered by tradability of output. EU economies. Data source: OECD STAN and TiVA databases, year 2005.

1.3.

B.1 Undistorted World Economy, Maximization and Equilibrium

B.1.1 Maximization Problems in the Undistorted World Economy

Formally, the maximization problem of the representative household in H introduced in Section 1.1 is given by:

$$\begin{aligned} \max_{c_{H,1},c_{H,2,N},c_{H,2,K},b_H} \quad & u\left(c_{H,1}\right) + \beta\left[\pi u\left(c_{H,2,N}\right) + (1-\pi)\, u\left(c_{H,2,K}\right)\right] \\ \text{s.t.} \quad & c_{H,1} = y_{H,1} + q_H b_H \\ & c_{H,2,N} = y_{H,2} - \min\left\{b_H, \hat{\zeta}\right\} \\ & c_{H,2,K} = y_{H,2} - \min\left\{b_H, 0\right\}. \end{aligned} \tag{28}$$

The maximization problem of the representative household in F is defined as follows:

$$\begin{aligned} \max_{c_{F,1},c_{F,2},b_F} \; & u\left(c_{F,1}\right) + \beta u\left(c_{F,2}\right) \\ \text{s.t. } & c_{F,1} = y_{F,1} + q b_F \\ & c_{F,2} = y_{F,2} - b_F \end{aligned} \tag{29}$$

Note that I abstract here from trade in risky assets between F and H, and I only consider trade in risk-free assets between F and ROW at price q. In equilibrium, it is not optimal for F to buy assets issued by H given its risk-aversion and that prices are determined by the risk-neutral ROW.

B.1.2 Definition of Equilibrium the Undistorted World Economy

Definition 1. *An equilibrium allocation in the undistorted world economy is a vector of quantities b_H, b_F, $c_{H,1}$, $c_{H,2,N}$, $c_{H,2,K}$, $c_{F,1}$, $c_{F,2}$ and prices q and q_H that are consistent with*

- *Optimality for the representative household in H, as represented by the solution to the problem in* (28)
- *Optimality for the representative household in F, as represented by the solution to the problem in* (29)
- *Optimality for the representative household in ROW, implying the asset prices*

$$q = \beta \text{ and } q_H = \beta\pi. \tag{30}$$

B.1.3 Equilibrium Quantities in the Undistorted World Economy

In the Undistorted World Economy, the Euler conditions in H and F, (4) and (5), can be solved for the amount of assets issued by the two countries and for their consumption:

$$\begin{aligned} b_{H,U} &= \frac{y_{H,2} - y_{H,1}}{1+\beta\pi}, \; c_{H,1,U} = c_{H,2,N,U} = \frac{y_{H,1} + \beta\pi y_{H,2}}{1+\beta\pi}, \; c_{H,2,K,U} = y_{H,2}, \\ b_{F,U} &= \frac{y_{F,2} - y_{F,1}}{1+\beta}, \; c_{F,1,U} = c_{F,2,U} = \frac{y_{F,1} + \beta y_{F,2}}{1+\beta} \end{aligned} \tag{31}$$

where the subscript U indicates that the values correspond to the equilibrium of the undistorted allocation.

The equilibrium values of the current account balance of the two countries are given by:[81]

$$CA_{H,U} = \frac{\beta\pi}{1+\beta\pi}\left(y_{H,1} - y_{H,2}\right); \quad CA_{F,U} = \frac{\beta}{1+\beta}\left(y_{F,1} - y_{F,2}\right) \tag{32}$$

where the subscript U indicates that the quantities are the ones associated with the equilibrium of the undistorted world economy. In addition, the current account of the union formed by H and F is given by:[82]

$$CA_{HF} = -q_H b_H - q b_F = \beta\left[\pi\frac{y_{H,1} - y_{H,2}}{1+\beta\pi} + \frac{y_{F,1} - y_{F,2}}{1+\beta}\right]. \tag{33}$$

B.2 Economy with Subsidies, Maximization and Equilibrium

B.2.1 Maximization Problem in F in the Economy with Subsidies

Formally, the problem of the representative household in F in the economy with subsidy on risky assets of Section 1.3 is the following:

$$\begin{aligned} \max_{\substack{c_{F,1}, c_{F,2,N}, c_{F,2,K}, \\ b_{F,ROW}, b_{H,F}}} & u\left(c_{F,1}\right) + \beta\left[\pi u\left(c_{F,2,N}\right) + (1-\pi)\, u\left(c_{F,2,K}\right)\right] \\ \text{s.t. } & c_{F,1} = y_{F,1} + q b_{F,ROW} - q_H b_{H,F} \\ & c_{F,2,N} = y_{F,2} - b_{F,ROW} + b_{H,F} \\ & c_{F,2,K} = y_{F,2} - b_{F,ROW} + b_{H,F} - \tau. \end{aligned} \tag{34}$$

Finally, the net amount of debt issued by F is defined as $b_F \equiv b_{F,ROW} - b_{H,F}$.

B.2.2 Equilibrium Definition in the Economy with Subsidies

The equilibrium allocation in the world economy with subsidies on risky assets is formally defined as follows.

[81] I define the trade balance of the two countries in the initial period as $TB_i = y_{i,1} - c_{i,1}$. Due to the absence of initial assets, the trade balance is also equal to the current account balance, CA_i.

[82] The current account balance of the union formed by H and F is formally defined as $CA_{HF} = y_{H,1} + y_{F,1} - (c_{H,1} + c_{F,1})$

Definition 2. *An equilibrium allocation in the undistorted world economy is a vector of quantities* b_H, $b_{H,F}$, $b_{F,ROW}$, $c_{H,1}$, $c_{H,2,N}$, $c_{H,2,K}$, $c_{F,1}$, $c_{F,2,N}$, $c_{F,2,K}$, τ *and prices* q *and* q_H *that are consistent with*

- *Optimality for the representative household in* H*, as represented by the solution to the problem in* (28)
- *Optimality for the representative household in* F*, as represented by the solution to the problem in* (34)*, implying the relationship between asset prices:*

$$q = q_H \tag{35}$$

- *Optimality for the representative household in ROW, implying the asset price:*

$$q = \beta \tag{36}$$

- *Bailout transfers are financed via taxation by the government in* F*:*

$$\tau = b_{H,F} \tag{37}$$

- *The market for assets issued by* H *clears within the union of* H *and* F*:*

$$b_H = b_{H,F} \tag{38}$$

B.3 Proofs and Results of Section Section 1.3

B.3.1 Proof of Proposition 1 and Quantities under CRRA

The proof follows from the first-order condition in (9). Making use of the fact that $u'' < 0$ it is possible to note that $c_{H,1} > c_{H,2,N}$ in the allocation with subsidies, while $c_{H,1} = c_{H,2,N}$ in the undistorted allocation. I will consider two possible cases. First, suppose that H issues a higher amount of debt issued in the allocation with subsidies, $b_{H,D} \geq b_{H,U}$, thus enjoying higher consumption in the initial period than in the terminal-period crisis state. Note that the current account balance can be expressed as $CA_H = -q_H b_H$. In addition, note the price of debt issued by H is higher in the allocation with subsidies:

$q_{H,D} = \beta > \beta\pi = q_{H,U}$. Hence, the current account balance of H will be lower in the allocation with subsidies than in the undistorted one.

Second, suppose that H issues a lower amount of debt in the allocation with subsidies, $b_{H,D} < b_{H,U}$. It must then be the case that terminal-period consumption in normal times is higher in the allocation with subsidies than in the undistorted one: $c_{H,2,N,D} > c_{H,2,N,U}$. Then, (9) implies that initial-period consumption is also higher in the allocation with subsidies, $c_{H,1,D} > c_{H,1,U}$, given that $c_{H,1,D} > c_{H,2,N,D}$ and $c_{H,1,U} = c_{H,2,N,U}$, as established in (31). Hence, given that initial-period consumption is equal to the initial-period endowment minus the current account balance, $c_{H,1} = y_{H,1} - CA_H$, and that endowment realizations are the same across the two allocations, it has to be the case that the current account balance of H is lower in the allocation with subsidies. As H runs a current account deficit, the current account balance is higher in absolute value. □

Finally, it is possible to obtain explicit solutions for the amount of debt issued by H and for the current account in this country by assuming that $u(\cdot)$ takes the CRRA form. These are given by

$$b_{H,D} = \frac{y_{H,2} - \pi^{1/\gamma} y_{H,1}}{1 + \beta\pi^{1/\gamma}} \text{ and } CA_{H,D} = \beta\pi \frac{\pi^{-\frac{1}{\gamma}} y_{H,2} - y_{H,1}}{\pi^{1-\frac{1}{\gamma}} + \beta\pi}. \tag{39}$$

B.3.2 Proof of Proposition 2

To establish the desired result, first note that the amount of tax τ that the F-government charges domestic households in the crisis state is equal to b_H. This is due to the fact that all debt held by households in F is defaulted upon in the crisis state, and the government has to fully compensate asset holders. In order to satisfy the government budget constraint, tax receipts must equal transfers, $\tau = b_H$. The first-order conditions in (9) can then be rewritten in terms of gross borrowing and gross asset purchases as

$$u'(y_{F,1} + \beta(b_{F,ROW} - b_H)) = \pi u'(y_{F,2} - b_{F,ROW} + b_H) + (1-\pi) u'(y_{F,2} - b_{F,ROW}) \tag{40}$$

The first-order conditions in (40) can be used to prove the result on the effects of the bailout promise on the bilateral position of F against ROW.

The proof relies on evaluating the first-order condition associated with the choice of $b_{F,ROW}$in this problem, (40), at the value $b_{F,ROW,U}$ that is optimal in the undistorted

allocation but at the value of of gross assets $b_{H,D}$ that is issued by H and purchased by F in the allocation with subsidies. I show below that the first-order condition takes a positive value if evaluated at these quantities:

$$\begin{aligned} u'\left(y_{F,1}+\beta\left(b_{F,ROW,U}-b_{H,D}\right)\right)-\pi u'\left(y_{F,2}-b_{F,ROW,U}+b_{H,D}\right) \\ -\left(1-\pi\right)u'\left(y_{F,2}-b_{F,ROW}\right)>0. \end{aligned} \tag{41}$$

The inequality follows from $b_H > 0$ and $u'' < 0$. The positive sign of the inequality establishes the fact that it is optimal for F to let its bilateral position against ROW be lower in the allocation with subsidies than it is in the undistorted allocation. □

The algebraic derivations behind the result in (41), are as follows. The first-order condition in (5) can be expressed as

$$u'\left(y_{F,1}+\beta b_{F,ROW,U}\right)-\pi u'\left(y_{F,2}-b_{F,ROW,U}\right)-\left(1-\pi\right)u'\left(y_{F,2}-b_{F,ROW}\right)=0.$$

by imposing the equilibrium result that $q_H = \beta\pi$. By subtracting this from (40), it is possible to obtain:

$$\begin{aligned} &u'\left(y_{F,1}+\beta\left(b_{F,ROW,U}-b_{H,D}\right)\right)-\pi u'\left(y_{F,2}-b_{F,ROW,U}+b_{H,D}\right)-\left(1-\pi\right)u'\left(y_{F,2}-b_{F,ROW}\right)= \\ &\left[u'\left(y_{F,1}+\beta\left(b_{F,ROW,U}-b_{H,D}\right)\right)-u'\left(y_{F,1}+\beta b_{F,ROW,U}\right)\right]- \\ &\qquad\qquad \pi\left[u'\left(y_{F,2}-b_{F,ROW,U}+b_{H,D}\right)-u'\left(y_{F,2}-b_{F,ROW,U}\right)\right]. \end{aligned} \tag{42}$$

$b_{H,D} > 0$ and $u'' < 0$ imply that the first term in square parenthesis is positive, and the second is negative. Hence, the whole expression is positive, as stated in (41).

B.3.3 Proof of Proposition 3

First, note that by making use of the definition of b_F the first-order condition (40) can be rewritten in terms of net borrowing and gross asset purchases as

$$u'\left(y_{F,1}+\beta b_F\right)=\pi u'\left(y_{F,2}-b_F\right)+\left(1-\pi\right)u'\left(y_{F,2}-b_F-b_{H,F}\right). \tag{43}$$

The argument of the proof relies on the fact that the first-order condition for b_F in (43) takes a negative value when evaluated at the value of net borrowing that is optimal in

the undistorted allocation, $b_{F,U}$ but at the value of of gross assets $b_{H,D}$ that is purchased by F in the allocation with subsidies. By subtracting from (43) the first-order condition in (5), we obtain

$$\begin{aligned} u'\left(y_{F,1}+\beta b_{F,U}\right) - \pi u'\left(y_{F,2}-b_{F,U}\right) - (1-\pi)\, u'\left(y_{F,2}-b_{F,U}-b_{H,D}\right) = \\ (1-\pi)\left[u'\left(y_{F,2}-b_{F,U}\right) - u'\left(y_{F,2}-b_{F,U}-b_{H,D}\right)\right] \leq 0 \end{aligned} \tag{44}$$

where the inequality follows again from $b_H > 0$ and $u'' < 0$. The inequality in (44) establishes the optimality for F to choose a lower value for net debt b_F to issue in the initial period. Hence, F chooses to run a higher current account surplus in the allocation with bailout promise than it does in the undistorted allocation. □

B.4 Current Account of the Union of H and F

Subsidies on risky assets have an ambiguous effect on the current account balance of the union of H and F. The sign of this effect crucially depends on the endowment profile in H, on the probability of default, and on the degree of risk-aversion in F. In general, the current account of the union is higher in the economy with subsidies on risky assets if the position of F vis-a-vis *ROW* deteriorates upon introduction of the bailout promise by an amount that is smaller than borrowing by H in the undistorted allocation.

The conditions on endowment and parameter values under which the aggregate current account of the union improves or deteriorates are summarized in the following proposition and are further discussed below, along with the proof of the proposition.

Proposition 5. *The current account balance of the union of H and F is lower in the allocation with a bailout promise than in the undistorted allocation if the probability of a crisis is sufficiently high (π is sufficiently low). The current account is higher in the allocation with bailout promise if the probability of a crisis is sufficiently low (π is sufficiently high), households in F are sufficiently risk-averse and if the endowment profile in H is sufficiently skewed towards the terminal period.*

This appendix discusses the conditions on parameter values according to which the aggregate current account of the union rises or falls as a consequence of the introduction of

subsidies on risky assets. First, I discuss intuitively the results on the aggregate current account established by Proposition 5. Second, I analyze properties of the solution to the F-household problem in a neighborhood of the two limits where the probability of repayment π tends to zero or to unity. In these limits, it is possible to obtain an analytical solution to the first-order condition in (40), while this is in general not possible for other values of π.

B.4.1 Subsidies and the Current Account of H and F

In the equilibrium of the undistorted world economy, the aggregate current account of the union $CA_{HF,U}$ is given by the sum of the bilateral current account with ROW of both member countries.[83] In the allocation with subsidies, the current account of the union $CA_{HF,D}$ solely depends on the gross amount of assets traded by F with ROW, as H does not trade with ROW and capital flows between H and F net out to zero.[84] Hence, if F finances a sufficient amount of gross asset purchases with net saving, the current account of the union improves as a consequence of the bailout promise introduction. Formally, this condition can be expressed as:

$$CA_{HF,D} > CA_{HF,U} \leftrightarrow b_{F,ROW,D} - b_{F,U} > \pi b_{H,U}. \tag{45}$$

Intuitively, while the bilateral position of F against ROW worsens in the allocation with subsidies, the aggregate current account of the union improves since H ceases to borrow from ROW and it borrows from F, instead.

First, the current account of the union deteriorates due to the bailout promise in the limit where the probability of repayment π tends to zero. When the repayment probability is very low, H borrows a high amount of resources in the allocation with subsidies. Hence, F issues a large amount of assets to ROW to finance its lending to H.[85] Conversely, borrowing by H equals zero in the undistorted allocation, in the limit where the repayment probability tends to zero. Hence, by comparing the deterioration

[83] Formally, $CA_{HF,U} = -\beta\pi b_{H,U} - \beta b_{F,U}$.

[84] Following the definition of CA_{HF} in (33), $CA_{HF,D} = -\beta b_{F,ROW,D}$.

[85] Note that the bilateral position of F against ROW always deteriorates in the allocation with subsidies, as established by Proposition 41.

of the bilateral position of F against ROW with borrowing by H in the undistorted allocation, we conclude that the current account of the union deteriorates due to the bailout promise, when the repayment probability is sufficiently close to zero. Appendix B.4.2 presents this result formally.

Second, the current account of the union improves due to the bailout promise when the repayment probability tends to unity, if the endowment profile of H is sufficiently skewed towards the future and if the representative household in F is sufficiently risk averse. The bailout promise does not amount to a subsidy when $\pi = 1$, as debt issued by H is repaid with certainty. Hence, the current account of the union is not affected by the bailout promise in the limit itself.[86] The current account of the union is higher in the presence of the bailout promise when π is close to one if, as π falls, the amount of debt issued by F to ROW in the allocation with subsidies falls by more than the amount borrowed by H in the undistorted allocation does. Formally, the union as a whole borrows less from ROW if the derivative with respect to π of the bilateral position of F vis-a-vis ROW in the allocation with subsidies is smaller than the derivative of borrowing by H in the undistorted allocation:[87]

$$\left.\frac{d\, b_{F,ROW,D}}{d\, \pi}\right|_{\pi=1} > \left.\frac{d\ (\pi b_{H,U})}{d\, \pi}\right|_{\pi=1} \tag{46}$$

A highly skewed endowment profile in H and a high degree of risk-aversion in F both cause the current account of the union to be higher in the allocation with subsidies on risky assets. If its endowment profile is substantially skewed towards the future, H borrows a large amount of resources from ROW in the undistorted allocation. Hence, slightly higher saving by F in the allocation with bailout promise is sufficient to ensure that the current account of the union is higher in this allocation. Because of precautionary saving, strong risk-aversion of F-households ensures that the current account of this country rises sufficiently to imply that the aggregate current account of the union rises as well.

[86] More generally, the bailout promise does not intrinsically affect the nature of the allocation, given the risk-free property of debt issued by H. Consumption in the two periods of both countries is also identical across the undistorted allocation and the one with bailout promise.

[87] Appendix B.4.3 provide derivations for the result in (46)

B.4.2 Current account of the union in the limit for $\pi = 0$

The current account of the union deteriorates due to the bailout promise in the limit where the probability of repayment π equals zero.

I show in this appendix that the inequality in (45) is never satisfied in this limit. First, the term $\pi b_{H,U}$ equals zero when $\pi = 0$. I then need to show that the bilateral position of F vis-a-vis ROW deteriorates in the allocation with bailout promise, i.e. $b_{F,ROW,D} - b_{F,U} > 0$. This result is established by Proposition 2. Hence, the current account of the union deteriorates due to subsidies on risky assets in the limit where $\pi = 0$. $\square$

It can be shown in addition that the deterioration of the bilateral position of F vis-a-vis ROW is equal to a fraction of the amount of assets issued by H in the allocation with the bailout promise:

$$b_{F,ROW,D} - b_{F,U} = \frac{\beta}{1+\beta} b_{H,D} \tag{47}$$

The deterioration of the bilateral position of F in (47) is also equal to the deterioration of the aggregate current account of the union, given the inability to borrow by H in the undistorted allocation.

B.4.3 Current account of the union in the limit for $\pi = 1$

I discuss here the conditions on risk aversion of households in F and on the endowment profile in H under which the current account of the union improves due to the bailout promise, when the probability of repayment is close to unity.

Derivation of (46) The current account of the union is higher in the allocation with subsidies if, according to (45):

$$b_{F,ROW,D} - b_{F,U} < \pi b_{H,U}. \tag{48}$$

In the limit where $\pi = 1$, in the allocation with bailout promise, F funds the entirety of its purchase of debt issued by H with funds borrowed from ROW. Hence, the difference

in the amount of debt issued by F across the two allocations is given exactly by the amount of debt issued by H and purchased by F:[88]

$$b_{F,ROW,D} - b_{F,U} = b_{H,D}. \tag{49}$$

Hence, the aggregate current account of the union is unaffected by the bailout promise in the limit. In addition, the amount of debt issued by H is identical across the two allocations, as the price of debt q_H is given by β in both cases. Hence, given $b_{F,ROW,D} - b_{F,U} = b_{H,U}$, the current account of the union is identical across the two allocations.

I assess the current account of the union when π is close but not equal to unity by evaluating debt issued by the two countries as a local approximation around the allocation where $\pi = 1$. Consider the policy functions for gross assets issued by F to ROW in the allocation with subsidies and for assets issued by H in the undistorted allocation, $b_{F,ROW,D}(\pi)$ and $b_{H,U}(\pi)$, respectively, as a function of the parameter π governing the probability of repayment by H.

In a neighborhood of $\pi = 1$, the policy functions $b_{F,ROW,D}(\pi)$ and $b_{H,U}(\pi)$ can be approximated by a first-order Taylor expansion:

$$\begin{aligned} b_{F,ROW,D}(\pi) &\cong b_{F,ROW,D}|_{\pi=1} + (\pi - 1) \left.\frac{d\, b_{F,ROW,D}}{d\,\pi}\right|_{\pi=1} \\ \pi b_{H,U}(\pi) &\cong b_{H,U}|_{\pi=1} + (\pi - 1) \left.\frac{d\,(\pi b_{H,U})}{d\,\pi}\right|_{\pi=1} \end{aligned} \tag{50}$$

noting that the amount of assets issued by F in the undistorted allocation $b_{F,U}$ is not affected by π. We have established in (49) that $b_{F,ROW,D} - b_{F,U} = b_{H,U}$ when $\pi = 1$. Hence, locally, $CA_{HF,D} > CA_{HF,D}$ follows from

$$(\pi - 1) \left.\frac{d\, b_{F,ROW,D}}{d\,\pi}\right|_{\pi=1} < (\pi - 1) \left.\frac{d\,(\pi b_{H,U})}{d\,\pi}\right|_{\pi=1} \tag{51}$$

or, given that $\pi < 1$

$$\left.\frac{d\, b_{F,ROW,D}}{d\,\pi}\right|_{\pi=1} > \left.\frac{d\,\ (\pi b_{H,U})}{d\,\pi}\right|_{\pi=1} \tag{52}$$

which is the condition in (46).

[88] The result obtains when evaluating (40) for $\pi = 1$.

Derivation of parameter conditions for (46) I analyze here under what conditions on parameters (46) is satisfied. Two additional assumptions are helpful to analyze such conditions. First, I assume that utility takes the CRRA form in both countries. Second, I assume that the two countries are symmetric in the terminal period, in the sense that the terminal-period endowment in H equals the average endowment in F: $y_{H,2} = \bar{y}_F \equiv \frac{y_{F,1}+\beta y_{F,2}}{1+\beta}$. Finally, I define the relative difference between terminal and initial period endowments in H as $\epsilon \equiv \frac{\bar{y}_F - y_{H,1}}{\bar{y}_F} \in (0,1)$. Given these additional assumptions, it can be shown that (46) is summarized by the following condition on parameter values

$$\epsilon\,(1-\gamma) + (1+\beta)\left[\left(\frac{1+\beta-\epsilon}{1+\beta}\right)^{-\gamma} - 2\right] > 0. \tag{53}$$

The expression in (53) implies a function $\epsilon\,(\gamma)$, defined as the threshold value of ϵ above which the inequality is satisfied and the current account of the union is higher in the allocation with subsidies. The function is decreasing in γ, implying that for the current account of the union to improve, the required degree of skewness of the H-income path is falling in the degree of risk aversion in F. The remainder of this appendix presents derivations needed to obtain the implied by (53).

I obtain the derivative of the policy function $\frac{d\,b_{F,ROW,D}}{d\,\pi}$ by making use of the implicit function theorem on the first-order condition (40). Define the function G:

$$G = u'\left(y_{F,1} + \beta\left(b_{F,ROW} - b_H\right)\right) - \pi u'\left(y_{F,2} - b_{F,ROW} + b_H\right) - (1-\pi)\,u'\left(y_{F,2} - b_{F,ROW}\right)$$

which equals zero when evaluated at the solution to the problem of F. Hence, I can obtain

$$\frac{db_{F,ROW}}{d\pi} = -\frac{\partial G/\partial \pi}{\partial G/\partial b_{F,ROW}}.$$

The two partial derivatives are given by:

$$\partial G/\partial b_{F,ROW} = \beta u''\left(c_{F,1}\right) + \pi u''\left(c_{F,2,N}\right) + (1-\pi)\,u''\left(c_{F,2,K}\right) \underbrace{=}_{\text{if } \pi=1} (1+\beta)\,u''\left(\bar{y}_F\right)$$

where the last equality follows from the fact that $c_{F,1} = c_{F,2,N} = \bar{y}_F$ when $\pi = 1$,

$$\partial G/\partial \pi = -\beta u''\left(c_{F,1}\right)\frac{db_{H,D}}{d\pi} - \pi u''\left(c_{F,2,N}\right)\frac{db_{H,D}}{d\pi} - u'\left(c_{F,2,N}\right) + u'\left(c_{F,2,K}\right)$$

which, at $\pi = 1$, noting that $c_{F,2,K} = y_{F,2} - b_{F,ROW} = \bar{y}_F - b_{H,D}$, can be rewritten as

$$\partial G/\partial \pi = -u''(\bar{y}_F)(1+\beta)\frac{db_{H,D}}{d\pi} - u'(\bar{y}_F) + u'(\bar{y}_F - b_{H,D}).$$

Hence, we can write

$$\begin{aligned}\frac{db_{F,ROW}}{d\pi} &= -\left[\frac{-u''(\bar{y}_F)(1+\beta)\frac{db_{H,D}}{d\pi}}{u''(\bar{y}_F)(1+\beta)} + \frac{1}{1+\beta}\left(\frac{u'(\bar{y}_F - b_{H,D}) - u'(\bar{y}_F)}{u''(\bar{y}_F)}\right)\right] = \\ &= -\left[\frac{db_{H,D}}{d\pi} + \frac{1}{1+\beta}\left(\frac{u'(\bar{y}_F - b_{H,D}) - u'(\bar{y}_F)}{u''(\bar{y}_F)}\right)\right].\end{aligned} \tag{54}$$

The expression above can be simplified by making use of the two additional assumptions. The assumptions of CRRA utility and of symmetry across the two countries imply the following expression for $b_{H,D}$:

$$b_{H,D} = \frac{y_{H,2} - \pi^{1/\gamma} y_{H,1}}{1+\beta\pi^{1/\gamma}} = \bar{y}_F \frac{1 - \pi^{1/\gamma}(1-\epsilon)}{1+\beta\pi^{1/\gamma}}$$

which implies

$$\frac{db_{H,D}}{d\pi} = \bar{y}_F \frac{-(1-\epsilon)\frac{1}{\gamma}\pi^{\frac{1}{\gamma}-1}\left(1+\beta\pi^{1/\gamma}\right) - \frac{\beta}{\gamma}\left(1 - \pi^{\frac{1}{\gamma}}(1-\epsilon)\right)}{\left(1+\beta\pi^{1/\gamma}\right)^2} \underbrace{=}_{\text{if } \pi=1} \frac{\bar{y}_F}{\gamma}\frac{\epsilon - 1 - \beta}{(1+\beta)^2} < 0.$$

In addition, thanks to the assumption of CRRA utility, the final term in (54) can be written as

$$\frac{u'(\bar{y}_F - b_{H,D}) - u'(\bar{y}_F)}{u''(\bar{y}_F)} = -\frac{\bar{y}_F}{\gamma}\left[\left(\frac{\bar{y}_F - b_{H,D}}{\bar{y}_F}\right)^{-\gamma} - 1\right]$$

The assumption of symmetry across the two countries allows us to write

$$\frac{\bar{y}_F - b_{H,D}}{\bar{y}_F} = 1 - \frac{1 - \pi^{1/\gamma}(1-\epsilon)}{1+\beta\pi^{1/\gamma}} \underbrace{=}_{\text{if } \pi=1} \frac{1+\beta-\epsilon}{1+\beta}.$$

We can finally rewrite the expression in (54) as

$$\frac{db_{F,ROW}}{d\pi} = \frac{\bar{y}_F}{\gamma}\frac{\epsilon - 1 - \beta}{(1+\beta)^2} + \frac{\bar{y}_F}{\gamma}\frac{1}{1+\beta}\left(\left(\frac{1+\beta-\epsilon}{1+\beta}\right)^{-\gamma} - 1\right). \tag{55}$$

The expression above must be compared with $\frac{d\left(\pi b_{H,U}\right)}{d\pi}$. Given the assumption of symmetry:

$$\pi b_{H,U} = \pi\frac{y_{H,2} - y_{H,1}}{1+\beta\pi} = \epsilon\bar{y}_F\frac{\pi}{1+\beta\pi}$$

and

$$\frac{d\pi b_{H,U}}{d\pi} = \epsilon \bar{y}_F \frac{1}{(1+\beta\pi)^2} \underbrace{=}_{\text{if } \pi=1} \epsilon \bar{y}_F \frac{1}{(1+\beta)^2}.$$

Finally, the inequality in (46) can be expressed as

$$\frac{1}{\gamma}\left[\epsilon - (1+\beta) + (1+\beta)\left(\frac{1+\beta-\epsilon}{1+\beta}\right)^{-\gamma} - (1+\beta)\right] > \epsilon$$

or

$$\epsilon\,(1-\gamma) + (1+\beta)\left[\left(\frac{1+\beta-\epsilon}{1+\beta}\right)^{-\gamma} - 2\right] > 0.$$

which is the expression in (53).

By making use of the implicit function theorem on the function

$$\epsilon\,(1-\gamma) + (1+\beta)\left[\left(\frac{1+\beta-\epsilon}{1+\beta}\right)^{-\gamma} - 2\right] = 0$$

it can be shown that $\frac{d\epsilon}{d\gamma} < 0$.

B.5 Analytical Derivations in the Two-Good Model of Section 1.4

Consumption in each country is given in each period by a combination of consumption of the two goods , given by the CES aggregator

$$c_{i,t} = \left[a^{\frac{1}{\theta}} c_{A,i,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} c_{B,i,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

where c_A and c_B denote consumption of each of the two goods, and θ represents the elasticity of substitution across the two goods. In each period t, each country may receive endowments of both goods which are given by $y_{A,i,t}$ and by $y_{B,i,t}$, respectively. Good A is the numeraire of the economy, and all assets are denominated in units of this good. The relative price of good B is given by p_B. The price index of the aggregator c is given by $p = \left[a + (1-a)p_B^{1-\theta}\right]^{\frac{1}{1-\theta}}$.

In the union, the price p_B is given in equilibrium by:

$$p_{B,t} = \left(\frac{1-a}{a}\right)^{\frac{1}{\theta}} \left(\frac{c_{A,F,t} + c_{A,H,t}}{y_{B,F,t} + y_{B,H,t}}\right)^{\frac{1}{\theta}}. \tag{56}$$

This result follows from intratemporal optimization in both countries and from the requirement that good B is only traded within the union. This is strictly true only in the interval of relative prices where gains from trade are outweighed by transport costs. Defining $p_{B,ROW}$ as the relative price of B that holds in ROW, this interval is given by $p_B \in \left(p_{B,ROW}\left(1-\nu\right), p_{B,ROW}\frac{1}{(1-\nu)}\right)$. If the price implied by (56) were to lie below $p_{B,ROW}\left(1-\nu\right)$, it would be more profitable for sellers to pay transport costs and ship good B to ROW. Symmetrically, if the price were higher than $p_{B,ROW}\frac{1}{(1-\nu)}$, it would be cheaper to import good B from ROW.

The difference across the two allocations in terms of the amount of good A available in the crisis is given by the difference in the amount of assets issued by F to ROW, $\Delta b_{F,ROW} = b_{F,ROW,U} - b_{F,ROW,D}$. Proposition 2 establishes this difference to be positive in the one-good economy. In the economy with two goods, the result holds as long as differences in the intertemporal profile of prices across allocations do not induce higher external savings by F in the allocation with subsidies. The result holds, for example, in an economy where $u\left(\cdot\right)$ takes logarithmic form and where F receives endowments of good A, only.

The bailout promise induces F to borrow resources to finance purchases of gross assets issued by H. The higher is the amount borrowed by F, the lower is the relative price of good B in the crisis state, in the allocation with subsidies. The ratio of this relative price across the two allocations is given by $\frac{p_{B,D}}{p_{B,U}} = \left(1 - \frac{\Delta b_{F,ROW}}{y_{A,H}+y_{A,F}}\right)$ where $\Delta b_{F,ROW}$ denotes the difference in the amount borrowed by F from ROW across the two allocations.

A fall in p_B is detrimental for H if the fall in the value of the good-B endowment outweighs the reduction in the price of the consumption basket. This is the case when the country is a net exporter of good B, and its endowment of this good is higher than the amount consumed in the undistorted allocation. This is true locally, for sufficiently small changes in p_B. More generally, the difference in prices across the two allocations may be large enough for H to become a net buyer of good B in the allocation with subsidies. In this case, crisis consumption by H in the allocation with subsidies is lower than in the undistorted allocation if $\Delta p_B y_{H,B,2} < \Delta p \frac{y_{H,A,2}+p_{B,U}y_{H,B,2}}{p_U}$ where Δp_B and Δp denote $p_{B,D} - p_{B,U}$ and $p_D - p_U$, respectively.

The value of consumption by H in the event of a crisis is given by the value of its endowment of goods. Aggregate external wealth of the union only matters for consumption in H if it affects the value of the endowment of goods in this country, through fluctuations in relative prices. Hence, subsidies have no effects on H crisis consumption in a one-good economy.

B.6 Additional Details on the Welfare Effects of Subsidies

B.6.1 Welfare of H

The two different sets of welfare effects of the bailout promise on H can be seen clearly by taking a second-order approximation of welfare of the representative household in H. Welfare in H V_H is given by the solution to (28):

$$V_H = u\left(y_{H,1} + q_H b_H\right) + \beta\pi u\left(y_{H,2} - b_H\right) + \beta\left(1-\pi\right) u\left(y_{H,2}\right) \tag{57}$$

Explicit solutions for b_H in the undistorted allocation and in the allocation with subsidies are given in (31) and (39), respectively. However, it will be convenient to conduct a second-order expansion of (57) around an allocation where the income path in H is flat, $y_{H,1} = y_{H,2}$ and where no debt is issued, $b_H = 0$, for a given price of debt q_H. Defining average income in H as $\bar{y}_H = \frac{y_{H,1}+\beta y_{H,2}}{1+\beta}$ and the deviation from the average in the first period as $\Delta_{y_H} = y_{H,1} - \bar{y}_H \leq 0$, welfare can be expressed as

$$\begin{aligned} V_H \cong\ & u\left(\bar{y}_H\right)\left(1+\beta\right) + u'\left(\bar{y}_H\right) \underbrace{\left(q_H - \beta\pi\right) b_H}_{\text{Mean consumption}} + \\ & \frac{u''\left(\bar{y}_H\right)}{2}\left(\underbrace{(1+\beta)\Delta_{y_H}^2/\beta}_{\text{Income volatility}} + \underbrace{2\left(q_H+\pi\right) b_H \Delta_{y_H}}_{\text{Insurance}} + \underbrace{\left(q_H^2 + \beta\pi\right) b_H^2}_{\text{Frontloading}}\right) \end{aligned} \tag{58}$$

The expression above highlights three main effects of the bailout promise on welfare in H. These three effects are due to the implications of debt issuance on average consumption, on insurance against income fluctuation, and on frontloading of consumption. First, the term denoted as "Mean consumption" highlights how the bailout promise leads to higher average consumption in H. In the undistorted allocation, the price q_H equals

$\beta\pi$, while it is given by $q_H = \beta$ in the allocation with subsidies. Hence, this term equals zero in the undistorted allocation, while it is positive for any $b_H > 0$ in the allocation with subsidies, leading to a first-order welfare gain from the promise. Intuitively, H benefits from the ability implied by the presence of subsidies to issue debt at a high price, above the one that would be accepted by a risk-neutral investor. I denote as overborrowing the fact that H issues debt in order to exploit the difference $q_H - \beta\pi$ between the market price of debt and the one that would solely be given by the default probability and the rate of intertemporal preference of lenders.

Second, the impact of debt on the intertemporal volatility of consumption is given by the combination of the two terms denoted as "Insurance" and "Front-loading". The total effect of the bailout promise on consumption volatility depends on the relative importance of these two effects: Volatility increases due to the subsidy if overborrowing leads to excessive frontloading of consumption and it decreases if debt allows for better insurance against income fluctuations.[89] In turn, higher or lower volatility of consumption contribute positively or negatively to welfare, respectively, given the desire of households for a smoother path of consumption as implied by the negative second derivative of the utility function.

Households in H can always achieve lower volatility of consumption in an economy with subsidies on risky assets than they can in the undistorted allocation. In the undistorted economy, households issue debt with the sole purpose of minimizing consumption volatility. However, volatility is higher in this allocation than it can be in the economy with subsidies. This is due to the high cost of transferring resources to the initial period in the undistorted economy. As a consequence, consumption in the initial period and in the terminal-period, normal-times state are substantially lower than in the terminal-period, crisis state. The difference in consumption across states can be lower in the economy with subsidies, due to the lower cost of transferring resources across states. The minimum consumption volatility would be achieved in this economy by setting $b_H = b^* \equiv -\Delta_{y_H}/\beta$,

[89] The term denoted as "Income volatility" only depends on the exogenous path for income and it is unaffected by the amount of debt issued or by the price of debt.

implying in turn $c_{H,1} = c_{H,2,N} = \bar{y}_H$.[90] Consumption in these states is still lower than it is in the terminal-period, crisis state, but the difference is smaller than it is in the undistorted economy, so that overall volatility can be lower in the economy with subsidies.

In the undistorted allocation, $q_H = \beta\pi$ and the amount of debt issued can be expressed as $b_H = -\frac{\Delta_{y_H}}{\beta}\frac{1+\beta}{1+\beta\pi}$. Hence, the second order term simplifies to

$$\frac{u''(\bar{y}_H)}{2}\frac{1+\beta}{\beta}\frac{1-\pi}{1+\beta\pi}\Delta_{y_H}^2 \tag{59}$$

This solution achieves the minimum volatility of consumption given parameter values and $q_H = \beta\pi$.

In the allocation with bailout promises, the lowest volatility of consumption is achieved by setting $b_H = b^*$ to minimize the term multiplying $u''(\bar{y}_H)$. The first-order condition associated with this minimization problem is given by

$$(q_H + \pi)\Delta_{y_H} + \left(q_H^2 + \beta\pi\right) b^*.$$

Noting that in this allocation, $q_H = \beta$, the solution is given by

$$b^* = -\frac{\Delta_{y_H}}{\beta} \rightarrow c_{H,1} = c_{H,2,N} = \bar{y}_H$$

Then, the second order term simplifies in this case to

$$\frac{u''(\bar{y}_H)}{2}\frac{1-\pi}{\beta}\Delta_{y_H}^2.$$

We note that, for $\pi \in (0,1)$, the minimum volatility of consumption that can be achieved in the allocation with subsidies on risky assets is lower than the one achieved in the undistorted allocation.

Finally, I compute the variance of consumption in the allocation with subsidies when H chooses b_H to maximize welfare. For ease of comparison with the two solutions above, I will consider the solution for b_H that maximizes the second-order approximation to welfare (58) rather than the full solution as given by (39) for CRRA utility. The first-order condition associated with this problem is given by:

$$u'(\bar{y}_H)(q_H - \beta\pi) + u''(\bar{y}_H)\left[(q_H + \pi)\Delta_{y_H} + \left({q_H}^2 + \beta\pi\right) b_H\right] = 0$$

[90] This solution arises by choosing b_H to minimize the sum of the three terms multiplying $\frac{u''(\bar{y}_H)}{2}$ in (58).

By imposing $q_H = \beta$ and $\gamma = -\frac{u''(\bar{y}_H)\bar{y}_H}{u'(\bar{y}_H)}$, the solution is given by

$$b_H = -\frac{\Delta_{y_H}}{\beta} + \frac{1-\pi}{\gamma(\beta+\pi)}\bar{y}_H \tag{60}$$

where the first term corresponds to the amount of debt issued to minimize fluctuations in consumption and the second term emerges due to the presence of the overborrowing motive. The expression above already clarifies that for a high degree of risk aversion γ the latter term is negligible and the household issues debt in order to reduce consumption volatility. The opposite is true for a low value of γ, and the overborrowing motive dominates the desire for insurance. By imposing this solution in the second-order welfare term, we find that this is given by

$$\frac{u''(\bar{y}_H)}{2}\left[\frac{1-\pi}{\beta}\Delta_{y_H}^2 + \frac{\beta(1-\pi)^2}{\gamma^2(\beta+\pi)}\bar{y}_H^2\right].$$

Hence, the condition for volatility of consumption to be higher in the allocation with subsidies then in the undistorted allocation is given by comparing the above term with (59):

$$\left(\frac{\Delta_{y_H}}{\bar{y}_H}\right)^2 < \frac{\beta(1+\beta\pi)}{\gamma^2(\beta+\pi)}. \tag{61}$$

For a high degree of curvature of the utility function, households place a high negative weight on consumption volatility.[91] Hence, their choices in the economy with subsidies result in a lower volatility of consumption than in the undistorted allocation. For a lower degree of curvature, the first-order effect of debt issuance on average consumption dominates. Hence, consumption in the allocation with bailout promises features higher mean as well as higher variance than in the undistorted economy.

It is clear that welfare in H must be weakly higher in the allocation with subsidies, since it is always possible for the representative household to issue in the economy with bailout promise the same amount of debt it issues in the undistorted economy. This choice would give rise to identical consumption across allocations in the terminal period, and to higher consumption in the initial period.

[91] Formally, this is the case if $|u''(c)/u'(c)|$ is relatively high.

B.6.2 Welfare of F

Welfare V_F of the representative household in F is given by the solution to (34), or:[92]

$$\begin{aligned} V_F =& u\left(\bar{y}_F - \beta b_H + \beta b_{F,ROW}\right) + \\ & \beta\pi u\left(\bar{y}_F + b_H - b_{F,ROW}\right) + \beta\left(1-\pi\right) u\left(\bar{y}_F - b_{F,ROW}\right) \end{aligned} \tag{62}$$

In the undistorted allocation, welfare is simply given by the constant utility of consumption, evaluated in the two periods:

$$V_{F,U} = u\left(\bar{y}_F\right)\left(1+\beta\right) \tag{63}$$

To evaluate welfare of F in the allocation with subsidies, it is again convenient to study a second-order approximation to (62), around an allocation where $b_H = b_{F,ROW} = 0$. In this approximation, it can be shown that welfare in F depends on the amount of debt issued by H as follows:[93]

$$\begin{aligned} V_{F,D} \cong & u\left(\bar{y}_F\right)\left(1+\beta\right) + u'\left(\bar{y}_F\right) \underbrace{\beta\left(\pi-1\right) b_H}_{\text{Mean consumption}} + \\ & \frac{u''\left(\bar{y}_F\right)}{2}\left(\underbrace{\frac{\beta^2}{1+\beta}\left(1-\pi\right)^2}_{\text{Mean cons., 2}^{\text{nd}}\text{ order}} + \underbrace{\beta\pi\left(1-\pi\right)}_{\text{Default risk}}\right) {b_H}^2 \end{aligned} \tag{64}$$

The term denoted as "Mean consumption" captures the loss in average consumption in F due to the presence of the bailout promise. The term labeled as "Mean consumption, second order" captures the second-order welfare effects of the lower mean of consumption. Finally, the term labeled as "Default risk" captures the adverse welfare consequences of higher consumption volatility, due to the exposure to risk of default by H. Note that this term would be minimized if the probability of repayment π were either zero or unity. In both cases, there would be no risk, as F would either suffer from a certain loss, or it would

[92] We can ignore fluctuations in income and assume without loss of generality that $y_{F,1} = y_{F,2} = \bar{y}_F$ due to the ability of F to issue risk-free securities at price β.

[93] This expression emerges after imposing that the amount of debt issued by F to ROW is the one that maximizes the second-order approximation to welfare. This choice for debt is exactly correct if utility takes quadratic form, but it ignores the effect of risk on precautionary savings.

enjoy certainty of a full repayment. In addition, this term would also be absent if F were able to purchase on international financial markets insurance against the realization of the crisis state.[94]

B.6.3 Aggregate Welfare

By combining (58) and (64) and subtracting welfare in the undistorted allocation, a second order approximation of the change in aggregate welfare induced by the bailout promise is given by:

$$\begin{aligned} V_D - V_U &= (V_{H,D} - V_{H,U}) + (V_{F,D} - V_{F,U}) \\ &\cong \beta (1-\pi) \left[u'(\bar{y}_H) - u'(\bar{y}_F)\right] b_{H,D} \\ &+ \frac{u''(\bar{y}_H)}{2} \left(2\Delta_{y_H} \left[(\beta+\pi) b_{H,D} - \pi (1+\beta) b_{H,U}\right] + \right. \\ &\left. \beta (\beta+\pi) {b_{H,D}}^2 - \beta\pi (1+\beta\pi) {b_{H,U}}^2\right) \\ &+ \frac{u''(\bar{y}_F)}{2} \left(\frac{\beta^2}{1+\beta} (1-\pi)^2 + \beta\pi (1-\pi)\right) {b_{H,D}}^2 \end{aligned} \tag{65}$$

First-order welfare gains arise if the difference in marginal utilities $u'(\bar{y}_H) - u'(\bar{y}_F)$ is positive. If average endowments are equal across countries, $\bar{y}_H = \bar{y}_F$, aggregate welfare only rises if the second-order welfare gain in H is larger in absolute value than the second-order welfare loss in F. Figure 12 graphically presents the conditions on the curvature of the utility function $u(\cdot)$, on the probability of repayment π and on the volatility of the endowment path in H under which aggregate welfare is identical across the undistorted allocation and the one with subsidies, after imposing equilibrium values for $b_{H,U}$ and $b_{H,D}$.

B.7 Two-period model with a continuum of borrowers

Consider an economy that is identical to the one of Section 1.1 but where the small open economy H is replaced by a continuum of countries $\{H_i\}_i$. In each country H_i,

[94] More formally, consumption volatility due to default risk would be absent if F were able to purchase in the initial period assets delivering a payoff in the terminal period crisis state, at price $\beta(1-\pi)$. This price would be compatible with optimality of risk-neutral investors in *ROW*. Similarly, there would be no volatility if F purchased a portfolio of assets issued by a continuum of countries with identical repayment probability, but independent realizations of the crisis state.

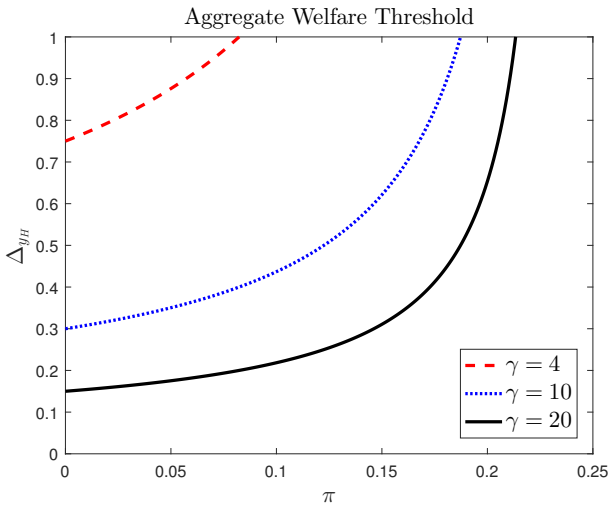

Figure 12: The three lines represent the threshold for repayment probability π and income volatility in H Δ_{y_H} such that aggregate welfare in the allocation with subsidies on purchases of risky assets is identical to that in the undistorted allocation. The parameter γ denotes the constant coefficient of relative risk aversion in the utility function $u(\cdot)$. Welfare is higher in the allocation with subsidies for parameter values north-west of the threshold. Intuitively, higher volatility of income in H increases this country's need for insurance, making the introduction of the bailout promise more beneficial. The threshold shifts south-eastwards as the elasticity of intertemporal substitution falls, or γ rises. For higher values of γ, H engages in overborrowing to a smaller extent, as the desire for a smooth path of consumption dominates. The less pervasive is overborrowing, the larger is subset of the parameter space where the introduction of the bailout promise is beneficial.

the crisis state occurs with probability $1-\pi$, but the realizations are independent across countries. The problem of each individual H_i is identical to the problem introduced in 1.1. The equlibrium allocation of the Undistorted World Economy is also identical. The optimization problem in F is isntead slightly different in the Economy with Subsidies on Risky Assets, and it is presented below.

The initial-period budget constraint is again given by (6):

$$c_{F,1} + q_H b_{H,F} = y_{F,1} + q b_{F,ROW} \tag{66}$$

In the terminal period, there is no uncertainty. A fraction the amount of tax charged by the government is given by τ with certainty. The terminal-period budget constraint is as follows:

$$c_{F,2} = y_{F,2} - b_{F,ROW} + b_{H,F} - \tau. \tag{67}$$

The first-order conditions associated with this problem are extremely similar to the ones in Section 1.3 and are omitted for brevity. In equilibrium, $q_H = q = \beta$ holds, and $c_{F,1} = c_{F,2}$. In addition, in equilibrium, a fraction $1-\pi$ of the countries in H defaults with certainty. Hence, taxation is given by $\tau = (1-\pi)\, b_H$. The net amount of assets issued by the representative household is given by $b_F = \frac{1}{1+\beta}\left(y_{F,2} - y_{F,1} - (1-\pi)\, b_H\right)$. We can derive the current account balance of country F:

$$y_{F,1} - c_{F,1} = \frac{\beta}{1+\beta}\left[y_{F,1} - y_{F,2} + (1-\pi)\, b_H\right] \tag{68}$$

It is possible to formulate an additional version of this simple model, where taxation is paid by the representative household in the initial period. Receipts from taxation are stored by the government in the form of assets issued by ROW and rebate to households in the form of bailout transfers in the terminal period. This version of the model where taxation is paid in advance is closely related to the formulation adopted in the infinite-horizon version of Section XXX. In this version of the model, the two budget constraints are

$$c_{F,1} + q_H b_{H,F} = y_{F,1} + q b_{F,ROW} - \tilde{\tau} \tag{69}$$

and

$$c_{F,2} = y_{F,2} - b_{F,ROW} + b_{H,F}. \tag{70}$$

The equilibrium of this model is substantially identical to the previous formulation here introduced. The amount of taxes charged by the government is given by $\tilde{\tau} = \beta (1 - \pi) b_H$, the amount of assets purchased by the representative household in F is given by $b_F = \frac{1}{1+\beta} (y_{F,2} - y_{F,1} + \beta (1 - \pi) b_H)$, and consumption in the two periods is as in the previous formulation. In particular, the current account balance is given by (68).

C Additional Materials for Section 2

C.1 Equilibrium Definition in the Infinite-Horizon Undistorted World Economy

The equilibrium in the infinite-horizon undistorted world economy is defined below.

Definition 3. *A recursive equilibrium in the undistorted world economy is a set of value functions V^C, V^D, V^D, policy functions for assets n' and for default D, a debt price function q that satisfy the following conditions:*

- *The value functions V^C, V^D, V^D and the policy functions n', D solve the households' optimization problems in* (12) - (13), (14)
- *The price of assets traded with ROW is consistent with default probabilities and with optimality for ROW residents,* (15)
- *The distributions ϕ_C, ϕ_D evolve according to the transition function Γ, which follows from the law of motion of the process for y, the aggregate policy functions n' and D and the probability of redemption of excluded countries λ.*

C.2 Optimality conditions of household problem in (19)

Consider the problem of a household that purchases gross assets, as described by (19). I consider here for completeness the possibility that the household buys the individual

risky assets that compose the risk-free bundle. The extended problem is as follows:

$$\begin{aligned}
\hat{V}^S\left(y_i, N_i, n_{i,j}\right) = & \max_{n'_{i,j}, \breve{b}'_{i,j}, \left\{\tilde{b}'_{i,j,k}\right\}_k, b'_{i,j}} u\left(c^S_{i,j}\right) + \beta \mathbb{E}\left[\hat{V}\left(y'_i, N'_i, n'_{i,j}\right)|y_i\right] \\
\text{s.t. } & c^S_{i,j} = y_i + n_{i,j} - \tau\left(y_i, N_i\right) + \hat{q}\left(y_i, N_i, n'_{i,j}\right) b'_{i,j} + \\
& - \breve{q}\breve{b}'_{i,j} - \int_I \tilde{q}_k \tilde{b}'_{i,j,k} dk - \chi\left(\breve{b}'_{i,j} + \int_I \tilde{b}'_{i,j,k}\left[\pi_k + \left(1-\pi_k\right)\xi\right] dk\right) \\
& \breve{b}'_{i,j} \geq 0 \\
& n'_{i,j} = \breve{b}'_{i,j} + \int_I \tilde{b}'_{i,j,k}\left[\pi_k + \left(1-\pi_k\right)\xi\right] dk - b'_{i,j} \\
& N'_i = N'\left(y_i, N_i\right)
\end{aligned} \tag{71}$$

where $\tilde{b}'_{i,j,k}$ denotes the position of household j resident in country i against borrowers in country k. The price associated with this asset is given by $\tilde{q}_k$, and the repayment probability is π_k.

The first-order conditions associated with this problem are as follows:

$$\begin{aligned}
n'_{i,j} &: u'\left(c^S_{i,j}\right)\left(\frac{\partial \hat{q}}{\partial n'_{i,j}} b'_{i,j}\right) + \beta \frac{\partial \mathbb{E}\left[\hat{V}\right]}{\partial n'_{i,j}} - \lambda = 0 \\
b'_{i,j} &: u'\left(c^S_{i,j}\right)\hat{q} - \lambda = 0 \\
\breve{b}'_{i,j} &: u'\left(c^S_{i,j}\right)\left(\breve{q} - \chi_b\right) + \lambda = 0 \\
\tilde{b}'_{i,j,k} &: u'\left(c^S_{i,j}\right)\left[\tilde{q}_k - \chi_b\left(\pi_k + \left(1-\pi_k\right)\xi\right)\right] + \lambda\left[\pi_k + \left(1-\pi_k\right)\right]\xi = 0
\end{aligned} \tag{72}$$

where λ denotes the lagrange multiplier associated with the law of motion of $n'_{i,j}$ and where χ_b denotes the derivative of the intermediation cost χ with respect to the total gross asset position.

First, by combining the first-order conditions for gross liabilities $b'_{i,j}$ and for the risk-free bundle $\breve{b}'_{i,j}$, it is possible to note that the arbitrage gains given by the difference between the prices of gross assets and gross liabilities have to equal the marginal cost of intermediating of capital flows: $\hat{q} - \breve{q} = \chi_b$.

Second, by combining the first-order conditions for individual gross asset positions and the one with respect to the risk-free bundle of assets, we obtain the condition in (20).

$$\tilde{q}\left(y_s, N_s, n'_{s,z}\right) = \breve{q}\,\mathbb{E}\left[1 - \left(1-\xi\right)\hat{D}\left(y'_s, N'\left(y_s, N_s\right), n'_{s,z}\right)|y_s\right] \tag{73}$$

The expression in (20) holds if the borrower's probability of repayment is above $\bar{\pi}$.

Finally, the conditions above clarify that households are indifferent between holding different portfolios of gross bilateral asset positions, as long as prices are consistent with the above conditions and the aggregate position given by the sum $\breve{b}'_{i,j} + \int_I \tilde{b}'_{i,j,k} \left[\pi_k + (1-\pi_k)\,\xi\right] dk$ is the same across portfolios. It is then possible to focus on the allocation where all countries only purchase a risk-free bundle of gross assets, and prices of individual bonds are given by (20). In equilibrium, the risk free bundle of assets is given by the market portfolio of debt traded among countries in I. The shares of each borrower in this bundle thus correspond to the share of each individual borrower in the gross asset position of each country. In (75) and (25), these shares and the total gross asset position determine the amount of tax that is set in each country.

C.3 Policy Functions for Assets Traded

The solution to the problem in 17 for $n'_{i,j}$ defines the policy function for assets traded $n'_R(y, N, n)$ conditional on borrowing from ROW.

As above, the solution to the problem is 18 for $n'_{i,j}$ defines the policy function for assets traded $n'_J(y, N, n)$ conditional on borrowing from countries in I

The policy function for net foreign assets carried into the next period that is associated with the problem in (19) is denoted by $n'_S(y, N, n)$. In addition, that problem above defines the policy function for gross asset purchases from other countries in I, $\breve{b}'(y, N, n)$.

C.4 Discrete Choice by Households over Interaction with International Financial Markets

The problem in (22) defines the indicator policy functions $\hat{R}(y_i, N_i, n_{i,j})$, $\hat{J}(y_i, N_i, n_{i,j})$, $\hat{S}(y_i, N_i, n_{i,j})$, $\hat{D}(y_i, N_i, n_{i,j})$ which take the value of unity in the regions of the state space where households choose to borrow from ROW, from other countries in I, to purchase gross assets, and to default, respectively. I also define the policy function for assets carried into the next period by all households, as the combination of the discrete and of

the continuous choice problems:

$$n'(y,N,n) = \begin{cases} n'_R(y,N,n) & \text{if } \hat{R}(y,N,n) \\ n'_J(y,N,n) & \text{if } \hat{J}(y,N,n) \\ n'_S(y,N,n) & \text{if } \hat{S}(y,N,n) \\ \text{undefined} & \text{if } \hat{D}(y,N,n) \end{cases} \tag{74}$$

The probability of repayment by a household in a given country is given by $\pi_{i,j} = \mathbb{E}\left[1 - \hat{D}(y_i, N_i, n_{i,j}) | y_i\right]$

I define aggregate policy functions for the discrete choice in each country over the type of interaction with international financial markets $R(y,N)$, $J(y,N)$, $S(y,N)$ and $D(y,N)$ which take the value of unity in the regions of the state space where countries choose to borrow from ROW, from other countries in I, to purchase gross assets, and to default, respectively.[95] In addition, I define the aggregate policy function for gross assets purchased from other countries in I $\breve{b}'(y,N)$.

C.5 Government Budget Constraint

The total amount of resources that the government promises to transfer to households in the next period due to the bailout promise is given by:

$$h(y_i, N_i) = \int_I \xi\, \tilde{b}'_{i,k}(y_i, N_i)\, \mathbb{E}\left[\hat{D}(y'_k, N'(y_k, N_k)) | y_k\right] dk \tag{75}$$

where $\tilde{b}'_{i,k}$ denotes the policy function for the aggregate gross asset position of country i vis-a-vis a generic country k.

C.6 Asset Market Clearing

Formally, market clearing in the market for assets within I is given by the condition:

$$\int_I \breve{b}'_i S_i di = \int_I -N'_i \left[\pi_i + (1-\pi_i)\xi\right] J_i di \tag{76}$$

[95] These policy functions follow from households' discrete choice in (22) and the fact that households in each country are all identical. Appendix C.4 defines the individual households' policy functions.

where π_i denotes for brevity the probability of repayment by country i.[96] The right-hand side of this expression represents the amount of resources obtained with certainty in the following period if purchasing the entirety of the bonds issued within I, after adjusting for default risk and for the bailout promise ξ. For market clearing, this amount has to equal the aggregate amount of resources paid to holders of the risk-free bundle of risky assets, given by the left-hand side of this expression.

C.7 Equilibrium in the world economy with subsidies on international lending

I can now formally define the equilibrium in the world economy with subsidies on international lending.

Definition 4. *A recursive equilibrium in the world economy with bailout promises on international lending is a set of individual policy functions $n'_R, n'_J, n'_S, \breve{b}'$, value functions $\hat{V}, \hat{V}_R, \hat{V}_J, \hat{V}_S, \hat{V}_D$, indicator policy functions $\hat{R}, \hat{J}, \hat{S}, \hat{D}$, aggregate policy functions $N', \breve{b}', R, J, S, D$, government policy τ, h, price functions $\hat{q}, \tilde{q}$, price $\breve{q}$, distributions $\hat{\phi}, \hat{\phi}_D$ and transition function $\hat{\Gamma}$:*

- *The value functions $\hat{V}, \hat{V}_R, \hat{V}_J, \hat{V}_S, \hat{V}_D$ and the policy functions $n'_R, n'_J, n'_S, \breve{b}'$ solve the households' optimization problems in* (17) - (21)
- *The value function $\hat{V}$ solves the discrete choice problem in* (22) *and the policy functions $\hat{R}, \hat{J}, \hat{S}, \hat{D}$ are consistent with the definition in* (74)
- *The aggregate policy functions $N', \breve{b}', R, J, S, D$ are consistent with the definition in* (23)
- *The price of assets traded with ROW is consistent with default probabilities and with optimality for ROW-households,* (24)

[96] Formally, $\pi_i = \mathbb{E}\left[1 - D\left(y'_i, N'\left(y_i, N_i\right)\right)|y_i\right]$ Similarly, S_i and J_i denote $S\left(y_i, N_i\right)$ and $J\left(y_i, N_i\right)$.

- *Bailout transfers h compensate households for default risk when lending to countries in I consistently with the bailout promise, according to* (75) *and lump-sum taxes are set to satisfy the government budget constraint* (25).

- *The price of assets issued within I is consistent with optimality of lenders, given the probability of default and the extent of the bailout promise, according to* (20).

- *The market for assets traded among countries in I clears,* (76)

- *The distributions $\hat{\phi}_C, \hat{\phi}_D$ evolve according to the transition function $\hat{\Gamma}$, which follows from the law of motion of the process for y, the aggregate policy functions N' and D and the probability of redemption of excluded countries λ.*

C.8 Calibration

I present in this appendix further details about the calibration strategy introduced in Section 2.4.

The parameters of the endowment process (26) are set to replicate properties of GDP of euro area countries. I consider quarterly data for real GDP of euro area-12 countries (EA-12), with the exclusion of Luxembourg and Ireland.[97] I obtain a cyclical component of GDP by subtracting an exponential trend that I estimate separately for each country. Given the cyclical component of GDP, I obtain the parameters ρ_y and σ_y by estimating the model (26) on the pooled data for all countries. I set ρ_y and σ_y in (26) to equal the obtained point estimates, and I set μ_y to normalize the unconditional mean of y_t to unity. The process is discretized with the procedure of Tauchen (1986) over a grid of 50 points. Point estimates are reported in Table 1.

I obtain from the OECD Balance of Payments dataset data for the current account balance of euro area countries. The cross-sectional standard deviation of the current account balance to GDP ratio for euro area countries prior to the introduction of the

[97] Data are extracted from Eurostat, seasonally and calendar adjusted. The full set of euro area-12 countries is given by Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain. Luxembourg is excluded because of its small size and due to its high reliance on the financial sector, while Ireland is omitted due to the large data revision of 2015.

EMU is one of the calibration targets of the model. I compare against this calibration target the cross-sectional standard deviation for countries in the stationary allocation of the undistorted world economy. I consider yearly data for 1994 and 1995 as the pre-EMU reference point. The use of yearly data allows me to disregard concerns about heterogeneous seasonal patterns across countries driving the dispersion of the current account balance. The sample considered is given by the EA-12 group of countries with the exclusion of Luxembourg, Belgium and Portugal. For the last two countries, data are not available from this dataset in those years. I compute the average current account balance-to-GDP ratio by weighting individual countries by their share of total GDP. I then compute the standard deviation by making use of the same GDP weights. The cross-sectional standard deviation of the current account balance to GDP ratio can also be computed for countries in the stationary allocation of the undistorted world economy. To do so, I define the policy function for the current account balance of countries with access to international financial markets as $ca\left(y,n\right)=n'\left(y,n\right)-n$. I then evaluate the policy function over the state space, and compute the mean and standard deviation of the current account making use of the distribution $\phi_C\left(y,n\right)$:

$$\bar{ca}=\frac{\int_{-\infty}^{\infty}\int_{0}^{\infty}ca\left(y,n\right)\phi_C\left(y,n\right)dy\,dn}{\int_{-\infty}^{\infty}\int_{0}^{\infty}\phi_C\left(y,n\right)dy\,dn}$$

$$s.d.\left(ca\right)=\left[\frac{\int_{-\infty}^{\infty}\int_{0}^{\infty}\left(ca\left(y,n\right)-\bar{ca}\right)^2\phi_C\left(y,n\right)dy\,dn}{\int_{-\infty}^{\infty}\int_{0}^{\infty}\phi_C\left(y,n\right)dy\,dn}\right]^{\frac{1}{2}}.$$

I compare the average interest rate paid by countries in the stationary allocation of the undistorted world economy with the one paid by countries in the euro area prior to the EMU. I define the policy function for the equilibrium price of debt issued by countries with access to international financial markets as $q_{eq}\left(y,n\right)=q\left(y,n'\left(y,n\right)\right)$. I then compute the average yearly interest rate as

$$\bar{r}_y=\frac{\int_{-\infty}^{\infty}\int_{0}^{\infty}q_{eq}^{-4}\left(y,n\right)\phi_C\left(y,n\right)dy\,dn}{\int_{-\infty}^{\infty}\int_{0}^{\infty}\phi_C\left(y,n\right)dy\,dn}$$

and the spread over the risk free rate as $\Delta\bar{r}_y=\bar{r}_y-\beta_{ROW}^{-4}$. I obtain data for the nominal interest rate paid by countries in the euro area from Eurostat. I measure government

borrowing costs with data from the yearly series on EMU convergence criterion bond yields. This series reports yields on countries' government bonds that have comparable characteristics across issuers. The residual maturity of the bonds considered is of approximately ten years. The sample I consider is of EA-12 countries with the exclusion of Luxembourg. I obtain a measure of real interest rates by subtracting future inflation in each country from the nominal interest rates above described. Future inflation is given by the next-year value of the CPI inflation, as reported by the OECD. I compute the average real interest for 1994 and 1995 by weighting individual countries by their share in total GDP. As discussed in Section 2.4 the average spread paid by countries in the model is slightly lower than the one above described for euro area countries. The data however, describe yields over bond with ten-year maturity, while debt is rolled-over at quarterly frequency in the model. Hence, at least part of the higher spread observed in the data is likely to reflect the presence of a premium charged on risky debt with long maturity.

The average net external asset position of countries in the stationary allocation is defined as the average value of the state variable n over the distribution ϕ_C:

$$\bar{n} = \frac{\int_{-\infty}^{\infty} \int_{0}^{\infty} n\phi_C\left(y, n\right) dy\, dn}{4 \int_{-\infty}^{\infty} \int_{0}^{\infty} \phi_C\left(y, n\right) dy\, dn}.$$

The average is divided by four to compare net external assets, which are a stock variable, with yearly GDP, a flow, given that the mean quarterly endowment is normalized to unity. In the data, I compute the mean net foreign asset position of euro area countries referring to the data in Lane and Milesi-Ferretti (2007). Specifically, I compute the average ratio of net foreign assets to GDP as the sum of net foreign assets for EA-12 countries excluding Luxembourg, divided by the sum of GDP for the same countries. This ratio equals 3.3% for 1994 and 2.95% for 1995.

The ratio of bilateral positions of euro area borrowers is computed by making use of data reported in Waysand et al. (2010), Table 1. The total Net International Investment Position of Greece, Italy, Portugal and Spain is reported as equal to -2,169 USD billions in 2008.[98] The bilateral Net International Investment Position of the same countries against

[98] I exclude Ireland from this empirical target due to its atypical bilateral position against countries outside the EU, which is positive and very large.

partners in the euro area equalled in the same year -1,463 USD billions. Hence, the ratio between the two positions is equal to 67.5%. I compute in the stationary allocation of the model economy with subsidies the ratio between the aggregate amount of debt issued by borrowers within I and total debt issued by borrowers from I or ROW. Formally, this ratio is given by

$$\frac{\int_i N_i' J_i \; d_i}{\int_i N_i' \left(J_i + R_i\right) \; d_i}$$

and it is equal to 66.5%.

From the optimization problem of countries holding gross assets, it is possible to obtain a condition relating the amount of gross assets purchased with the difference in debt prices of gross assets and gross liabilities. Given the functional form for intermediation costs, defined in Section 2.4, the condition is as follows:

$$\breve{b} = (\hat{q} - \breve{q})^{\frac{1}{\chi_b - 1}}$$

The condition clarifies that the higher the gain from arbitrage, the higher is the amount of gross assets purchased by intermediaries. The gain from arbitrage is given by the difference between the price at which gross liabilities are issued and the one at which gross assets are bought.

C.9 Additional Results

Heterogeneous Types of Assets Traded. The optimal choice over the type of asset traded by countries in I in the allocation with subsidies is illustrated in Figures 16 and 5. Figure 16 displays the type of asset that is traded by countries, depending on their endowment realization and holdings of net external assets.

The main result highlighted by Figure 16 is that countries with higher levels of assets and endowment hold gross assets issued by other countries in I, which have lower endowment realizations and lower holdings of assets. The optimal choice of countries, given their endowment realization, is generally to act as gross savers if holding a relatively high level of assets, to borrow from ROW if poorer and to borrow from I for even lower levels of asset holdings. Finally, countries default if they have a sufficiently low endowment realization and sufficiently high debt.

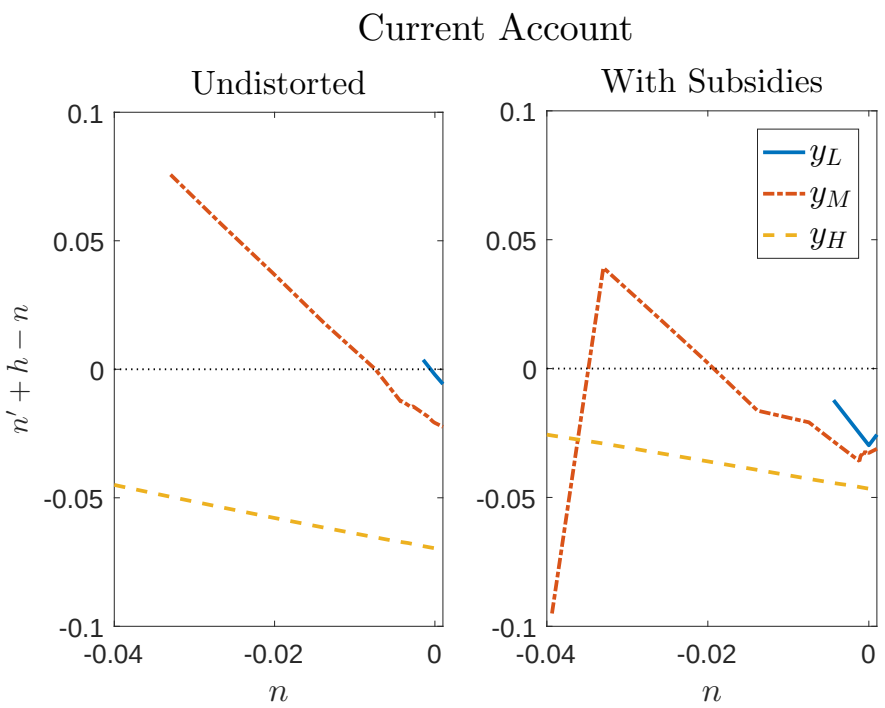

Figure 13: Current account policy function, for countries with endowment equal to the long-run mean and 1.5 standard deviations above and below it.

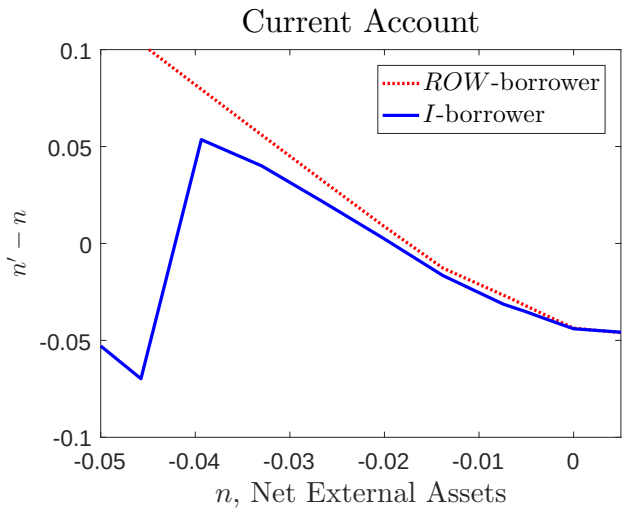

Figure 14: Policy function for current account of country with endowment equal to the long-run mean and zero aggregate assets, conditional on different discrete choices for type of assets to issue. The blue solid line is the policy function if borrowing from other countries in I. The red, dotted line is the policy if borrowing from ROW. Borrowers from I exploit the higher debt price when issuing high debt by posting a higher current account deficit.

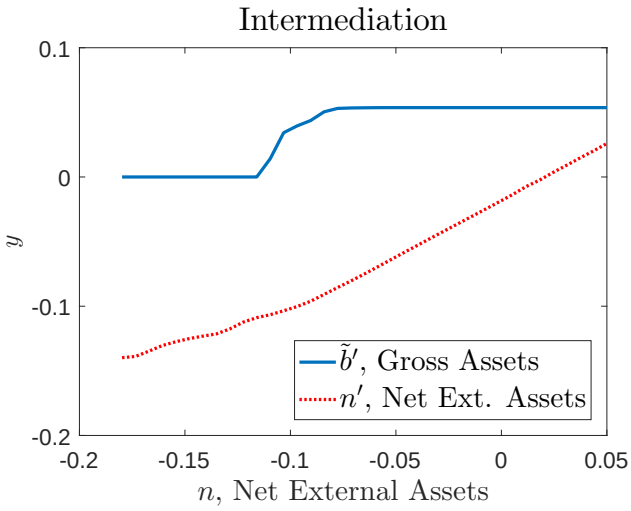

Figure 15: Policy function for net and gross asset position of a country with high endowment, as a function of aggregate net external asset. The red, dotted line represents the choice for net external assets, the blue solid line the choice for gross assets. The lower the choice for net external assets, the lower is the price of debt issued, and the lower is the amount intermediated.

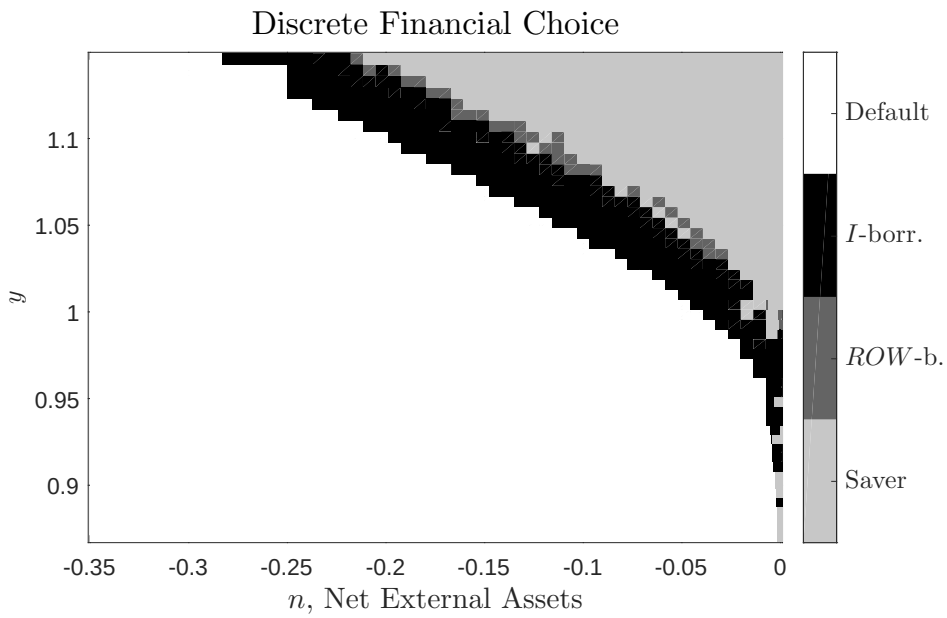

Figure 16: Policy function for discrete choice over the type of asset to trade in international financial markets, as a function of countries' endowment realization and holdings of net external assets. The white area denotes the region where it is optimal to default. The black area is the region where it is optimal to issue debt to other countries in I, the dark grey area where it is optimal to issue debt to ROW and the light grey are where it is optimal to purchase gross assets.

The key driver behind a country's choice over the type of assets to trade in international financial markets is the incentive to issue debt characterized by a high or low default probability. First, countries with large negative net asset positions have a desire to refinance such debt by issuing a large amount of assets. Since high levels of borrowing are associated with high default probabilities, it is beneficial for these countries to issue debt to other countries in I, benefiting from the high price they offer for risky debt. Second, countries with smaller net external liabilities prefer to borrow from ROW. Since they issue assets characterized by a low default probability, they exploit the higher price for risk-free assets that ROW is willing to offer. Finally, countries with positive or smaller negative asset positions tend to act as gross savers. These countries issue gross liabilities at a price close to the world risk-free price, β_{ROW}. Hence, they arbitrage the spread between the price of the risk-free securities they issue and the price of the risk-free bundle of assets $\breve{q}$ that prevails in I. Households in these countries exploit this arbitrage opportunity by issuing gross liabilities to ROW and purchasing assets issued by other countries in I, thus reaping the benefits of the bailout promise offered by their governments.

C.10 Infinite-horizon model, solution method

The solution of this model is obtained by a numerical algorithm which I describe in this Appendix. The algorithm shares some properties with those commonly adopted to solve heterogeneous agents models, e.g. Fornaro (2016) in the international macro literature, and models of endogenous sovereign default, e.g. Arellano (2008).

Solution for the equilibrium of the undistorted world economy in Section 2.2 is relatively simple. The risk-free real interest rate is determined in ROW. I need to solve for the policy functions for asset accumulation and default, $n'(y_i, n_i)$ and $D(y_i, n_i)$, for the debt price function $q(y_i, n_i')$, and for the endogenous distributions over the endowment and net external assets in (16). The algorithm to obtain policy functions and debt price functions is standard, as described in Arellano (2008). I then employ the non-stochastic simulation algorithm put forward by Young (2010), to solve for the distributions.

The algorithm to solve for the equilibrium of the economy with subsidies in Section 2.3 is computationally more demanding, but conceptually quite simple. The key variables that characterize the equilibrium of this model are the price of assets traded within I, $\breve{q}$ and the taxes τ set by governments to finance bailout transfers. To solve the model, I initialize the algorithm by formulating initial guesses for τ and $\breve{q}$. I then proceed to solve households' problem, including their the discrete choice problem in (22), until convergence of the debt price functions $\hat{q}$ and $\tilde{q}$. The solution method is closely related to the one employed for the undistorted world economy, but for the higher dimensionality, the richer discrete choice problem, and savers' choice over both gross assets and gross liabilities. I initialize the solution of the households' problem making use of the undistorted world economy as a guess for policy and value functions. Having solved the households' problem given initial guesses, I update guesses for aggregate policy functions, for the law of motion of aggregate variables and, crucially, for the distribution of countries, again making use of the non-stochastic simulation algorithm. I then check for the amounts of assets purchased by savers and issued by borrowers within I, I update the guess for $\breve{q}$, and I solve the households' problem until clearing of this market. Then, I check for the amount of bailout transfers paid by governments in I, and I update the function τ accordingly, solving again the households' problem until both the market for asset clears and the guesses for taxes are consistent with the government budget constraints.

A difficulty in the solution for the equilibrium of the economy with subsidies lies in the fact that the dimensionality of the household problem increases because of the need to consider aggregate assets N. To maintain tractability, I discretize the endogenous states n and N over a grid of 150 points. The grid is unevenly spaced, and it is finer in the region of the state space that is visited more frequently. I then proceed to obtain a smoother solution by solving households' value function with interpolation, after computing finer sovereign debt price functions by interpolating the default policy functions and using the solution over the discretized space as an initial guess.