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Financial Intermediation, International Risk Sharing, and Reserve Currencies†

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I model the equilibrium risk sharing between countries with varying financial development. The most financially developed country takes greater risks because its financial intermediaries deal with funding problems better. In good times, the more financially developed country consumes more and runs a trade deficit financed by the higher financial income that it earns as compensation for taking greater risk. During global crises, it suffers heavier losses. Its currency emerges as the reserve currency because it appreciates during crises, thus providing a good hedge. I provide evidence that financial net worth plays a crucial role in understanding this asymmetric risk sharing. (*JEL* E44, F14, F32, G01, G15, G21)

The global financial architecture is characterized by the existence of a key country. This role has been fulfilled by the United States since the Second World War; prior to the First World War it was fulfilled by the United Kingdom. An important characteristic of the key country is the depth of its financial markets and, in particular, of its funding markets. The empirical literature has highlighted stylized facts that characterize the US international position: its external portfolio is characterized by riskier assets than liabilities; it runs a persistent trade deficit; it transfers wealth to the rest of the world (RoW) during global crises; and its currency is the world's reserve currency and earns a safety premium.

Despite extensive debates on the factors underpinning the global financial architecture, there are few formal models that analyze its economic foundations. I provide a theoretical framework based on financial frictions that rationalizes the role of

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the key country in the global financial architecture and jointly explains the stylized facts that characterize the US external position.

The key country has the most developed financial sector and takes on a larger proportion of global fundamental and financial risk because its financial intermediaries are better able to deal with funding problems following negative shocks. In good times it consumes more, relative to other countries, and runs a trade deficit financed by the higher financial income that it earns as compensation for taking greater risk. During global crises, however, capital losses on its external portfolio lead to a wealth transfer to RoW. The key country's currency emerges as the reserve currency because it appreciates during crises, thus representing a global safe asset.

The model not only provides a theoretical framework that jointly makes sense of the empirical stylized facts; its main contribution is to do so by providing the underlying economic foundations through the modeling of financial intermediation and its frictions. The model recognizes the importance of financial intermediation from the key country as both the means of sharing risks globally and a potential source of risk and instability for the global financial architecture.

I summarize the empirical evidence that motivates this paper in four facts:

Fact 1: *The US external balance sheet is characterized by risky assets, mainly denominated in foreign currencies, and safer liabilities, mainly denominated in US dollars.* The top panel in Figure 1 shows the US external balance sheet, as of year-end 2015. US residents' holdings of foreign assets were focused on riskier assets, such as equity securities and equity foreign direct investment (FDI), which together accounted for 60 percent of total US assets. By contrast, foreign residents' holdings of US assets were concentrated in safer assets such as debt, which accounted for 61 percent of total US liabilities.[1] The middle panel in Figure 1 confirms this pattern by plotting the above percentages for the period 1976–2015. The bottom panel in Figure 1 highlights that the majority of US external assets, 61 percent on average, are denominated in foreign currencies. US external liabilities are instead mostly denominated in US dollars, 85 percent on average.[2]

Fact 2: *The United States runs a persistent trade deficit.* The United States has run a trade deficit every year since 1976; in 2015, its trade deficit was 3 percent of GDP.

Fact 3: *During global crises, the United States transfers substantial amounts of wealth to RoW.* The US net foreign asset position deteriorated by \$2.7 trillion in 2008. This corresponds to a transfer of 18 percent of US GDP to RoW over that year.[3]

Fact 4: *The US dollar is the world reserve currency and earns a safety premium.* Institutions around the world, both private and governmental, hold reserves of

[1] Bureau of Economic Analysis (BEA 2017). The percentages are (Equity + Equity FDI)/(Total Assets − Derivatives) and (Debt + Other Investments + Debt FDI)/(Total Liabilities − Derivatives).

[2] Lane and Shambaugh (2010); Bénétrix, Lane, and Shambaugh (2015); average for the period 1990–2012.

[3] BEA (2017). The deterioration is due in part to changes in the US portfolio positions and in part to capital losses. See Gourinchas, Rey, and Truempler (2011).

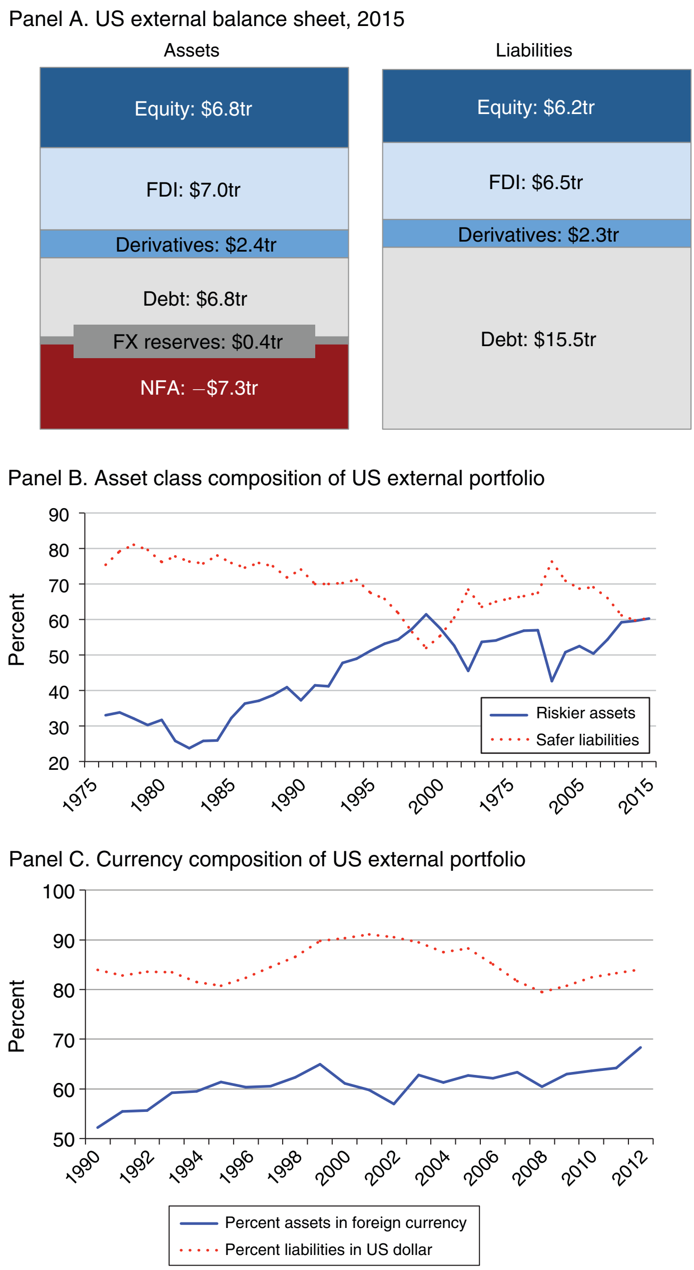

Figure 1. US External Position: Composition and Risk

Notes: Panel A: US external balance sheet at year-end 2015. US external assets: US residents' holdings of assets abroad, by asset class. US external liabilities: RoW residents' holdings of assets in the US, by asset class. Debt assets and liabilities are (debt + other investments). The net foreign assets (NFA) position is reported as a negative number on the asset side. Panel B: annual data (1976–2015) from Bureau of Economic Analysis. The percentages are computed as: (Equity + Equity in FDI)/(Total Assets − Derivatives) for assets and (Debt + Debt in FDI + Other Investments)/(Total Liabilities − Derivatives) for liabilities. Derivatives positions are excluded in order to avoid possible issues associated with the netting of contracts. Panel C: annual data (1990–2012) from Lane and Shambaugh (2010), Bénétrix, Lane, and Shambaugh (2015). Shares of total US external assets denominated in foreign currency and total US liabilities denominated in US dollars.

Source: Bureau of Economic Analysis

US dollars.[4] This demand for US dollar reserves is associated with the US exorbitant privilege, the United States' ability to fund itself more cheaply than other countries.[5] Lustig, Roussanov, and Verdelhan (2014); Maggiori (2012); Verdelhan (2016) provide evidence of a positive and countercyclical safety premium for the US dollar.

To make sense of these facts, I first introduce in Section II a model of financial intermediation in a closed economy. This autarky model highlights the mechanisms that play an important role in the open economy case. In Section III, I introduce a simple open economy model with two countries and a single world endowment. This model highlights the core result of the paper: the asymmetric risk sharing between the key country and RoW, from which Facts 1–3 emerge. I provide empirical evidence not only that RoW financial institutions play an important role in providing leverage to US financial institutions, but also that empirical proxies of RoW financial net worth behave in the data in ways consistent with the model predictions. The model cannot account for Fact 4 because, by design, no exchange rate is present. In Section IV, I extend the previous framework by allowing each country to have an endowment of a differentiated good. In addition to considering how financial frictions affect demand for financial assets, I also consider how they affect demand for goods by introducing trade costs. This not only allows me to analyze the exchange rate, but also generalizes the results from the previous section and highlights paradoxical results on reserve currencies.

In the autarky model in Section II, savings are deposited with financial intermediaries, which in turn invest in risky assets. Since financial intermediaries may choose not to repay their depositors, their funding is potentially credit constrained. When financial intermediaries are well capitalized, the high level of capital acts as a safety buffer against potential investment losses; they can therefore easily raise funding and invest in risky assets. When financial intermediaries are poorly capitalized, concerns over their viability restrict their funding and therefore curtail their ability to invest in risky assets. Financial intermediaries are concerned about two sources of risk: fundamental risk and financial risk. The former stems from variations in output, while the latter results from variations in the aggregate capital of financial intermediaries. In equilibrium, the presence of financing frictions induces intermediaries to discount risky assets more than in a frictionless model.

In the open economy model in Section III, the greater depth of the United States' financial development is represented by the key country's financial intermediaries being better able to raise funding for investment purposes, even when they are poorly capitalized. This, in turn, induces the key country's financial intermediaries to be less concerned about taking leveraged risk: in equilibrium, they take more risk. On the other hand, RoW financial intermediaries accumulate precautionary long positions in safer assets in order to insulate their capital from negative shocks. I show that these predictions are consistent with empirical data on portfolio holdings

[4] Eichengreen (2011) shows that 63 percent of world official reserves were held in US dollars at year-end 2009, a figure close to the average for the period 1965–2009.

[5] The claim of exploitation, or "exorbitant privilege," was directed at the United States by the French Finance Minister, Valéry Giscard d'Estaing. An antecedent was the claim that England exploited its financial power before World War I to attract foreign cheap financing. My model is related to the Kindleberger (1965) hypothesis that the asymmetric external balance sheet of Britain, with respect to its colonies, was due to differences in "demand for liquidity" and did not necessarily represent a form of exploitation.

of RoW financial institutions and the role of US financial institutions, in addition to the US Treasury, in providing safe assets to RoW. The asymmetric US balance sheet (Fact 1) emerges from this asymmetric risk sharing. The US trade deficit (Fact 2) emerges from the higher consumption that it enjoys in good times and in the long run, as compensation for the greater risks that it takes. Similarly, wealth transfers occur in bad times (Fact 3) because of the heavier losses suffered by the key country following negative shocks. Consistent with the model, I show that empirical proxies of RoW financial institutions' net worth are strongly related to the wealth transfers in the data.

The role of the US dollar as a global safe asset is challenging to explain within traditional models. I highlight a "reserve currency paradox," the tension between the wealth transfer from the United States to RoW and the role of the US dollar as a global safe asset. Traditional models predict that a transfer of wealth from the United States to RoW during crises results in a US dollar depreciation, because the wealth transfer increases the relative demand for RoW goods, as long as RoW residents are spending a higher proportion of the wealth that they receive on RoW goods than on US goods. If this were the case, the US dollar would represent a risky asset for RoW residents, since it would pay low in bad states of the world. I show this paradox to be related to a deep issue in international macroeconomics, the "transfer problem," first highlighted by Keynes (1929a, b, c) and Ohlin (1929a, b). In Section IV, I characterize the paradox and show that countervailing forces must be introduced to overcome it. I consider a case in which US relative demand for US goods increases during crises. Following recent debates in the trade literature (Eaton et al. 2016; Amiti and Weinstein 2011), I study a setup in which RoW relative export costs increase whenever RoW financial intermediaries lose capital and decrease the availability of credit to RoW exporters. A less literal interpretation also accommodates frameworks in which United States and RoW exports are differentiated and, in particular, where the demand for US goods is more resilient to global downturns.

I. Related Literature

The model builds on studies of the importance of the financial sector for macroeconomics, in the tradition of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). In particular, it builds on the modeling of financial intermediation of Gertler and Kiyotaki (2010) by studying global solutions in a continuous-time endowment-economy framework. A recent strand of literature has analyzed continuous time closed economies with financial frictions (Brunnermeier and Sannikov 2014; He and Krishnamurthy 2013).

The key assumption of greater financial development of the United States compared to RoW is in the spirit of Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Ríos-Rull (2009).[6] Kindleberger (1965) and Despres, Kindleberger, and Salant (1966) were among the first to argue that the US asymmetric external balance sheet, and previously that of the United Kingdom, could be due to differences in financial development. Caballero, Farhi, and Gourinchas (2008)

[6] I am not suggesting that financial development is the only characteristic. Recent literature, for example, has emphasized country size (Hassan 2013, Martin 2011).

analyze a deterministic model where the United States' greater ability to supply tradable assets rationalizes the emergence of global imbalances, the US trade deficit, and low long-term interest rates. Mendoza, Quadrini, and Ríos-Rull (2009) analyze a production economy with idiosyncratic risk and limited contract enforceability, where the United States' greater ability to enforce contracts leads to a lower US interest rate and an asymmetric US balance sheet. Most recently, Chien and Naknoi (2015) emphasize household finance as a source of global imbalances.

The most closely related work is that of Gourinchas, Govillot, and Rey (2010), who document similar stylized facts and rationalize them by studying the role of the United States as an insurance provider to RoW. They consider a frictionless representative agent framework with complete markets, where agents across countries differ in the coefficient of relative risk aversion. My analysis is in a similar spirit to Gourinchas, Govillot, and Rey (2010) and their view of US international financial adjustment (Gourinchas and Rey 2007b,a); at a broad level, the differences in financial development in this paper can be thought of as providing foundations for differences in preferences. This is particularly important in light of the recent financial crisis that has highlighted the need to further understand the role of banks and frictions in our theoretical models. The framework squarely places the limited risk bearing capacity of financial intermediaries at the core of the global financial architecture and global financial crises.

The two country equilibrium with financial frictions is solved analytically up to a system of ordinary differential equations (ODEs). The time varying international portfolio decisions are characterized globally and show a strong flight to safety during financial crises. The previous literature mostly focused either on comparing steady states or on local approximations of the portfolios.

II. Autarky: The Banking Economy

The output of the economy is determined by a tree with stochastic dividend process

$$\frac{dY(t)}{Y(t)} = \mu\, dt + \sigma\, dz(t), \tag{1}$$

where $z(t)$ is a standard Brownian motion, and μ and σ are constant.

The setup of financial intermediation is a continuous time adaptation of Gertler and Kiyotaki (2010). The economy is populated by a continuum of measure one of households. Each household consists of a continuum of measure one of family members, or agents, of which a fraction $\beta \in (0, 1)$ are savers and a fraction $1 - \beta$ are financiers. All agents, both savers and financiers, have logarithmic utility and identical rate of time preferences. Each financier within a household manages a financial intermediary; these are all, in turn, owned by the household. Savers deposit funds with these financial intermediaries. By assumption, there is perfect consumption insurance within each household because all agents pay out their earnings to be shared equally across the entire household. This assumption, combined with an application of the law of large numbers across households, allows for the construction of the representative agent.

In order to create a meaningful role for financial intermediation, I assume that only financiers, through their financial intermediaries, can hold shares in the output tree.[7] Savers can only deposit funds with financial intermediaries and they receive a predetermined return $r_d(t)$.

The saver's problem, therefore, is to choose how much to consume and how much to deposit with the financial intermediaries:

$$\max_{\{C(u)\}_{u=t}^{\infty}} E_t\left[\int_t^{\infty} e^{-\rho(u-t)} \log(C(u))\, du\right] \tag{2}$$

subject to

$$dD(t) = [r_d(t)D(t) - C(t)]\,dt + \Pi(t)\,dt,$$

where D is the aggregate savers' deposits and Π is the aggregate net transfers from the financiers, described later. Because the economy has a representative agent, I directly write the saver's optimization problem in terms of aggregate quantities. Throughout the paper, uppercase letters denote aggregate quantities, while lowercase letters denote individual agents' quantities. In addition, I use the equilibrium outcome of no default on deposits to directly write the dynamics of the deposit account as being risk free.

Financiers can use their own capital and the deposits that they have raised to invest in the risky asset. The balance sheet of a financial intermediary is $Q(t)s(t) = n(t) + d(t)$, where $s(t)$ is the number of shares of the output tree owned by the financial intermediary, $Q(t)$ is the price of the output tree, and $n(t)$ is the financial intermediary's net worth. The stock price dynamics follow the process $\frac{dQ(t)}{Q(t)} + \frac{Y(t)}{Q(t)}\,dt = \mu_Q(t)\,dt + \sigma_Q(t)\,dz(t)$; the drift and volatility terms need to be solved for in equilibrium.

Financiers face a credit constraint, which requires that the value of the financial intermediary that they manage remains positive. To motivate this constraint, I introduce an incentive compatibility problem. Financiers can walk away from their financial intermediary; if this occurs, the financial intermediary is wound down and its depositors recover the value of the financial intermediary's assets: $s(t)Q(t)$.[8] Savers only deposit funds with financial intermediaries owned by other households. This allows a simple aggregation of the model, while still maintaining a meaningful incentive for financiers to walk away from negative net worth financial intermediaries. It is beyond the scope of this paper to derive debt as the optimal contract and I take the prevalence of debt funding contracts as a primitive of the model.

Since financiers and savers have identical utility functions, there are no incentives for financiers to pay dividends from their financial intermediaries. Instead, financiers would choose to accumulate capital and their financial intermediaries would

[7] The assumption can be motivated by developing micro-foundations where monitoring problems make it inefficient for savers to directly hold assets. I follow Gertler and Kiyotaki (2010) in preventing savers from directly holding assets.

[8] More precisely, savers receive $\min\{s(t)Q(t),\, d(t)\}$, with excess funds, if any, being returned to the financier's household. In equilibrium, however, the financier has no incentive to walk away from the financial intermediary if its deposits can be fully recovered, so the simplified formulation is adopted in the main text.

"grow out" of the credit constraint. To prevent this outcome, I assume that financiers and savers switch roles based on exponential probability functions with intensity λ and $\lambda \frac{1-\beta}{\beta}$, respectively. When a financier switches roles, she pays all her accumulated net worth to her household.

The financier's optimization problem is, therefore, to maximize the value of the financial intermediary that she manages, subject to the credit constraint

$$\max_{\{d(u),s(u)\}_{u=t}^{\infty}} \Lambda_\lambda(t)V(t) = E_t\left[\int_t^\infty \Lambda_\lambda(u)\lambda n(u)\, du\right] \tag{3}$$

subject to

$$dn(t) = s(t)(dQ(t) + Y(t)\,dt) - r_d(t)d(t)\,dt,$$

$$V(t) \geq 0,$$

where $\Lambda_\lambda(t) \equiv e^{-(\rho+\lambda)t}\frac{1}{C(t)}$ is the agents' marginal utility modified for the intensity with which financiers change roles, and $V(t)$ is the value of the financial intermediary. Intuitively, the value of the intermediary is the expected discounted value of its dividends. The first constraint is the evolution of the financial intermediary's net worth, while the second is the credit constraint.[9]

When a saver becomes a financier, she needs capital with which to operate. I assume that this start-up capital is received from the household. In particular, I assume that each new financier is endowed with a fraction $\frac{\delta}{\lambda(1-\beta)}$ of the existing financiers' assets. Therefore, the aggregate net worth of the financial sector evolves according to

$$dN(t) = (r_d(t) - \lambda)N(t)\,dt + S(t)Q(t)[(\mu_Q(t) + \delta - r_d(t))\,dt + \sigma_Q(t)\,dz(t)].$$

Similarly, the sum of net transfers from financiers to households is $\Pi(t) = \lambda N(t) - \delta S(t)\,Q(t)$. The market clearing conditions are $C(t) = Y(t)$ and $S(t) = 1$, where the number of shares in the output tree is normalized to one.

Optimal Consumption and Investment.—Throughout the paper, I scale variables by the value of current output, with a tilde denoting the scaled version of the corresponding variable. I restrict my attention to the class of Markovian equilibria. I suppress the time notation of stochastic processes throughout the rest of the paper, except where necessary for clarity.

Savers choose how much to consume and how much to deposit with financial intermediaries. I conjecture that the saver's value function, denoted U, depends on deposits and the financial sector's net transfers: (D, Π). The marginal saver is atomistic and therefore does not take into account the effect of her saving decision on the financial sector's net transfers.

[9] The credit constraint is written in shorthand notation, but more formally has to hold in all future dates and states of the world.

LEMMA 1 (Saver's Problem): *The optimality conditions for the saver's optimization in equation* (2) *imply that the saver prices risk-free deposits according to*

$$-r_d\,dt = E_t\left[\frac{d\Lambda}{\Lambda}\right], \quad where \quad \Lambda \equiv e^{-\rho t}\frac{1}{C}. \tag{4}$$

This and all other proofs are reported in online Appendix A.1. The saver's Euler equation is unaffected by frictions and has the standard intuition of the optimal trade-off between consumption and savings, given the interest rate.

Since each financier is atomistic and, therefore, does not affect expected returns in equilibrium, the value of a financial intermediary is scale invariant: an intermediary with ten times more net worth has a value that is ten times higher. Consequently, I conjecture that the financier's value function is linear in the individual financial intermediary's net worth: $V(\tilde{N}, n) = \Omega(\tilde{N})\,n$. I also conjecture that the marginal value of net worth, Ω, only depends on the aggregate financial sector net worth, scaled by output. Aggregate net worth affects the incentives for financiers to walk away from their financial intermediaries; consequently, it intuitively also determines the tightness of the credit constraint and, in turn, expected returns to financial capital.

LEMMA 2 (Financier's Problem): *The optimality conditions for the financier's optimization in equation* (3) *imply that the financier prices risk-free deposits and shares in the tree according to*

$$0 = \lambda\Lambda Q(1-\Omega)\,dt + \Lambda\Omega Y dt + E_t\left[d(\Lambda\Omega Q)\right], \tag{5}$$

$$0 = \lambda\Lambda D_a(1-\Omega)\,dt + E_t\left[d(\Lambda\Omega D_a)\right], \tag{6}$$

where D_a is the deposit asset with dynamics $\frac{dD_a}{D_a} = r_d dt$.

The financier is concerned about two risks: consumption risk and financial risk. The financier dislikes assets with low returns when aggregate consumption is low and when her financial intermediary has low net worth. The former, which is consistent with standard consumption-based asset pricing models, is captured by the term Λ. The latter, which would result in a tightening of the credit constraint, is captured by the multiplicative term Ω. If financial risk and consumption risk are positively correlated, as they are in equilibrium, financiers discount the risky asset more than an investor with equal consumption but logarithmic utility, hereafter referred to as the log investor.

The Ω term can be interpreted as the "q price" of installed financial capital. Capital outside the financial sector is worth its purchase value of 1, since the consumption good is the numeraire. However, installed capital inside the financial sector is worth more than 1 because financial intermediaries earn, from the perspective of a log investor, abnormal risk-adjusted returns. Intuitively, the term $\lambda(1-\Omega)$ in the above Euler equations accounts for the probability λdt with which a financier switches role in the next dt units of time and the fact that, upon switching, capital is only worth 1 rather than Ω.

Equilibrium.—Assume that there are no frictions, so that financiers always have to repay all deposits. In this case, the equilibrium is equivalent to that of a standard Lucas endowment economy (Lucas 1978) with a logarithmic-utility representative agent (*The Lucas Economy*), see online Appendix A.1.

Intuitively, the distribution of wealth between deposits and financial capital does not affect the equilibrium; this is because financiers can either issue equity or always raise sufficient deposits to achieve the desired investment in the risky asset. It follows that the marginal value of net worth, Ω, is constant at 1. Consequently, the pricing equations in equations (5)–(6) simplify to the classic Lucas equations.

The equilibrium of the economy with frictions is affected by the wealth distribution, that is, the amount of capital inside the financial sector. When financial intermediaries have low capital, financiers are concerned about losing further capital; consequently, financial intermediation becomes disrupted and wealth cannot readily be invested in the risky asset. By contrast, when financial intermediaries are better capitalized there is a buffer against investment losses, leading to an investment allocation closer to the one in the Lucas Economy.

PROPOSITION 1: *The financier's and saver's optimization problems can be written in terms of a single state variable: the aggregate financial sector net worth scaled by output $\tilde{N}$. Furthermore, the state variable is a strong Markov process with dynamics*

$$(7) \qquad \begin{aligned} \frac{d\tilde{N}}{\tilde{N}} &= \left[\rho - \lambda + \phi(\mu_Q - r_d + \delta - \sigma\sigma_Q)\right] dt + (\phi\sigma_Q - \sigma)\, dz \\ &\equiv \mu_{\tilde{N}} dt + \sigma_{\tilde{N}} dz, \end{aligned}$$

where $\phi \equiv \frac{Q}{N}$ is the financial sector leverage. The equilibrium is characterized by a system of two coupled second-order ODEs for the price-dividend ratio, $\tilde{Q}(\tilde{N})$, and the marginal value of net worth, $\Omega(\tilde{N})$:[10]

$$(8) \qquad 0 = \mu_Q - r_d - \sigma\sigma_Q + \sigma_\Omega\sigma_Q,$$

$$(9) \qquad 0 = \lambda\frac{1-\Omega}{\Omega} + \mu_\Omega - \sigma\sigma_\Omega,$$

where $\frac{d\Omega}{\Omega} = \mu_\Omega dt + \sigma_\Omega dz$.

A quantitative analysis is beyond the scope of this paper; the equilibria described in this and the following sections are numerical examples rather than calibrations. I focus here only on the dynamics of the closed economy that play a crucial role in the open economy. The full dynamics, the stochastic steady state, and the stationary distribution are discussed in online Appendix A.1.

[10] Both here and in subsequent propositions, the ODEs are expressed implicitly, since the drifts and volatilities are themselves only functions of $\tilde{N}$ and the level and first two derivatives of the functions Ω and $\tilde{Q}$. The explicit form of the ODEs is provided in online Appendix A.1.

In equilibrium, financiers are concerned about both fundamental and financial risk. This concern lowers the demand for risky assets and induces a precautionary demand for safe assets. The effects of intermediary net worth on the equilibrium are nonlinear: a negative output shock not only results in financiers losing capital, their concern about further potential losses also induces them to further decrease investments in the risky asset, as a precautionary measure. As all financiers have similar balance sheets, the initial small i.i.d. fundamental shock is amplified by systemic risk. Each individual financier trying to sell depresses the stock price, inducing further capital losses and triggering an attempt to sell even more shares. The model therefore endogenously generates a flight-to-safety effect. These static and dynamic effects play a crucial role in the open economy in the next section.

III. Open Banking Economy: Single World Tree

To understand the role of the United States in the global financial architecture, I introduce a simple model with two countries, Home and Foreign, which are symmetric other than the extent to which their respective financial systems are developed. This stylized model isolates the role of the asymmetry in the countries' financial sectors and describes the main result of this paper: the asymmetric risk sharing between the United States and RoW. The empirical *Facts* 1–3 emerge from the implementation of this risk sharing.

The United States, which acts as the key country in the global financial architecture, is characterized by the greater extent of its financial development and, in particular, the greater depth of its funding markets. This asymmetry is in the spirit of Kindleberger (1965), Caballero, Farhi, and Gourinchas (2008), and Mendoza, Quadrini, and Ríos-Rull (2009), who were among the first to emphasize differences in financial development as a key driver of global imbalances.

One can think of a general form of the credit constraint, in which financiers have different abilities to divert assets or to walk away from their obligations. The less financiers are able to divert assets or to walk away from their obligations, the greater financial development is. This is meant to capture both the legal framework that is essential for the emergence of financial markets, and the broader institutional and regulatory design that affects the cost and efficiency of transactions in financial markets. For simplicity, I assume that Home financiers are unconstrained, while Foreign financiers face the constraint described in the previous section. A frictionless Home country with logarithmic preferences is most convenient for tractability and allows to capture the key economics of the paper, but as a drawback inherits some of the common failures of consumption based models, such as excess volatility of consumption.

The global output of the sole good is generated by the process in equation (1); each country is endowed with half of the total output. Almost the entire setup of each of the two economies is identical to the autarky case, so I only describe the differences. I describe the model for the Foreign country, only specifying the corresponding Home country equations where necessary. Foreign variables are denoted by the superscript $*$.

Savers can only deposit funds with their domestic financial intermediaries; consequently, they solve a problem identical to equation (2). This restriction emphasizes the fact that private savings primarily enter the global financial system through domestic financial institutions. In addition to raising deposits domestically and investing in the risky asset, financiers can also lend and borrow in an international market for interbank loans. These instantaneous interbank loans are promises to pay one unit of the consumption good. Both interbank loans and deposits are risk free in equilibrium, so I directly use this outcome to write their dynamics. The balance sheet of an individual financier is $Qs^* = n^* + d^* + b^*$, where b^* is the amount that the financier has borrowed in the interbank market.

In a technical simplification[11] from the autarky case, the exiting financiers have the option to reinvest their net worth with the incoming financiers. Since financiers maximize the value to their households of the intermediaries that they manage, they choose to reinvest the net worth whenever $\Omega^* > 1$ and to pay it out whenever $\Omega^* = 1$, where Ω^*, by analogy with the previous section, is the Foreign financier's marginal value of net worth. The representative financier problem is, therefore, equivalent to one for an intermediary not paying any net worth out to the household until a stopping time $t' \equiv \inf\{t : \Omega^*(\tilde{N}^*(t)) = 1\}$. After that point is reached, exiting financiers pay their net worth to their households.[12] The representative financier's optimization problem is

$$(10) \qquad \max_{\{d^*(u), b^*(u), s^*(u)\}_{u=t}^{\infty}} \Lambda^*(t)\, V^*(t) = E_t\Big[\int_{t'}^{\infty} \Lambda^*(u)\, e^{-\lambda(u-t')}\, \lambda n^*(u)\, du\Big]$$

subject to

$$dn^* = s^*(dQ + Ydt) - r_d^* d^* dt - r_b b^* dt,$$

$$V^* \geq 0.$$

The Home financier's problem is symmetric, but without the last constraint. By analogy with the previous section, I assume that the start-up capital provided by households to new financiers is a function of the stochastic steady state[13] holdings of the risky asset in each country: $\overline{S}$ and $\overline{S}^*$, respectively. Consequently, new Home financiers receive $\delta\overline{S}Q$ and new Foreign financiers receive $\delta\overline{S}^*Q$. The aggregate net worth dynamics follow:

$$dN^* = r_d^* N^* dt + Q\big\{S^*[(\mu_Q - r_d^*)dt + \sigma_Q dz] + \delta\overline{S}^* dt\big\} + B^*(r_d^* - r_b)dt.$$

[11] This assumption allows for the simplification of the equilibrium risk sharing between Home and Foreign without altering the basic economic implications of the model. In particular, it allows the equilibrium to be expressed as a function of a single state variable. See online Appendix A.1 for details.

[12] For this to be an equilibrium, the state where $\Omega^* = 1$ needs to be absorbing. As with the autarky case, this is guaranteed by the restriction $\delta = \lambda - \rho$, which is imposed in both this section and the next. See online Appendices A.1 and A.2 for details.

[13] The assumption is meant to capture the fact that the household uses both the current value of assets and the long-run financial size of its country to judge how much start-up capital its new financiers need in order to operate. The specific functional form has been chosen to simplify the boundary analysis, and does not substantially affect the equilibrium.

An extra outflow of $\lambda N^* dt$ is detracted from the dynamics for all times after t'. The net transfers from financiers to their households are equal to $\Pi^* = -\delta \bar{S}^* Q$, with the extra inflow of $\lambda N^* dt$ added for all times after t'.

The Foreign trade balance is the difference between the Foreign share of world output and Foreign consumption. Net foreign assets (NFA) for the Foreign country are the difference between the wealth owned in Home by Foreign residents and the wealth owned in Foreign by Home residents. Finally, the change in NFA is the current account (CA). Home definitions are symmetric. Thus, I have

$$NX^* \equiv \frac{Y}{2} - C^*; \quad NFA^* \equiv \left(S^* - \frac{1}{2}\right) Q - B^*. \tag{11}$$

The market clearing conditions are: $C + C^* = Y$; $S + S^* = 1$; $B = -B^*$; $N^* = S^* Q - D^* - B^*$.

Optimal Consumption and Investment.—The Home country has no frictions; consequently, the Home marginal value of net worth is equal to one and the Home financiers' value function takes the form $V = n$. Foreign financiers instead value financial capital above one; as with the autarky case, their value function is $V^* = \Omega^*(\tilde{N}^*) n^*$. Since the Home and Foreign dynamic programming problems of both savers and financiers are extensions of those in the autarky case, they are reported in online Appendix A.1. I include below only the corresponding Euler equations.

LEMMA 3: *The optimality conditions for Home savers and financiers imply that they price assets according to*

$$0 = \Lambda Y dt + E_t\left[d(\Lambda Q)\right], \tag{12}$$

$$0 = E_t\left[d(\Lambda D_a)\right], \tag{13}$$

$$0 = E_t\left[d(\Lambda B_a)\right]. \tag{14}$$

The optimality conditions for Foreign savers and financiers imply that they price assets according to

$$0 = \Lambda^* \Omega^* Y dt + E_t\left[d(\Lambda^* \Omega^* Q)\right], \tag{15}$$

$$0 = E_t\left[d(\Lambda^* D_a)\right] = E_t\left[d(\Lambda^* \Omega^* D_a)\right], \tag{16}$$

$$0 = E_t\left[d(\Lambda^* B_a)\right] = E_t\left[d(\Lambda^* \Omega^* B_a)\right], \tag{17}$$

where D_a is the deposit asset and B_a is the interbank asset.

Equations (12)–(14) show that the frictionless Home country only cares about consumption risk: the Home representative agent prices assets as though it had logarithmic preferences. By contrast, equations (15)–(17) show that the constrained Foreign country also cares about financial risk, in addition to consumption risk. The Foreign representative agent discounts the stock more than an agent with logarithmic preferences if, as is the case in equilibrium, it has low returns when financial intermediaries have low capital. An immediate consequence of both deposits and interbank loans being risk free is that, to prevent arbitrage, their rates of return are equal: $r_b = r_d = r_d^*$.

Equilibrium.—Consider a Lucas open endowment economy (Lucas 1982) with two symmetric countries, a single good generated by equation (1), and a representative agent with logarithmic preferences in each country, both of whom can trade claims to the tree and a risk-free bond (*Open Lucas Economy*). If there are no frictions in the Foreign financial system, then the equilibrium of my model is equivalent to that of the Open Lucas Economy (see online Appendix A.1). Intuitively, the two countries are symmetric and the Foreign country is not affected by frictions, so that agents only care about consumption risk. Consequently, the international risk sharing and pricing equations reduce to the classic Lucas analysis. The equilibrium features of this economy are well known: symmetric equity portfolios, with each country owning half of the shares; no trading in the risk-free interbank market; equal Home and Foreign consumption state-by-state; and zero NFA, CA, and NX. These results are a far cry from the stylized facts of the global financial system in Facts 1–3.

The equilibrium of the open economy with frictions is affected by the wealth distribution, that is, the amount of capital inside the RoW financial sector.

PROPOSITION 2: *The financier's and saver's optimization problems in the Home and Foreign countries can be written in terms of a single state variable: the aggregate Foreign financial sector net worth scaled by output* $\tilde{N}^*$. *Furthermore, the state variable is a strong Markov process with dynamics given by*

$$\begin{aligned}\frac{d\tilde{N}^*}{\tilde{N}^*} &= \left[\left(r_d - \lambda \mathbf{1}_{\{t>t'\}} - \mu + \sigma^2\right) + \phi^*\left(\mu_Q - r_d - \sigma\sigma_Q\right) + \delta\,\frac{\bar{S}^*Q}{N^*}\right]dt \\ &\quad + \left(\phi^*\sigma_Q - \sigma\right)dz \\ &\equiv \mu_{\tilde{N}^*}\,dt + \sigma_{\tilde{N}^*}\,dz,\end{aligned}$$

where $\phi^* \equiv \frac{S^*Q}{N^*}$. *The equilibrium is characterized by a system of two coupled second-order ODEs for the price-dividend ratio,* $\tilde{Q}(\tilde{N}^*)$, *and the marginal value of Foreign net worth,* $\Omega^*(\tilde{N}^*)$*:*

$$0 = \mu_Q - r_d - \sigma_C\sigma_Q, \tag{18}$$

$$0 = \mu_{\Omega^*} - \sigma_{C^*}\sigma_{\Omega^*}, \tag{19}$$

where $\frac{dC}{C} = \mu_C dt + \sigma_C dz$ *and* $\frac{dC^*}{C^*} = \mu_C^* dt + \sigma_C^* dz$.

Online Appendix Proposition A.1 derives the equilibrium allocation. In the interest of space, I focus here on the resulting intuitive risk-sharing condition:

$$\frac{C^*}{C} = \frac{\Omega^*}{\xi}, \tag{20}$$

where ξ is a scaling constant that depends on the initial conditions and is akin to the relative weight of the Home country in a complete-market central-planner problem. The risk sharing is asymmetric: an increase in the marginal value of Foreign net worth is associated with a relative increase in Foreign consumption over Home consumption. As Ω^* is countercyclical in equilibrium, this provides the foundations of the risk sharing that underpins the global financial architecture.

Figures 2–3 show the equilibrium of the Open Banking Economy. Since Home financial intermediaries are always able to achieve their desired investments in the risky asset by funding themselves in the deposit or interbank markets, they are less concerned than Foreign financial intermediaries about losses of capital. Consequently, the optimal risk sharing is for Home financial intermediaries to increase their investments in the risky asset by leveraging themselves in the international interbank market. Foreign financial intermediaries do exactly the opposite: they accumulate precautionary long positions in risk-free interbank deposits and reduce their investments in the risky asset. The portfolio implementation of the risk sharing condition therefore generates the asymmetric NFA portfolio of Home or, in actuality, of the United States which is predominantly short safe debt-securities and long riskier assets (equity and FDI) (Fact 1).

The equilibrium portfolio can be interpreted in the language of comparative advantage, as applied to trade in assets (Helpman and Razin 1978; Svensson 1988). In autarky, Home's comparative advantage in financial markets results in higher Foreign than Home prices for "down state" Arrow securities. Once the two economies open for trade, Foreign buys "down state" from and sells "up state" Arrow securities to Home in order to achieve a safer portfolio overall.

Evidence on Financial Intermediaries' International Portfolios.—The core premise of the model is that financial intermediation is important in understanding global imbalances. One of the core results of the model, derived above, is that RoW financial intermediaries provide leverage to the US economy, thus inducing an asymmetric risk sharing. Figure 4 and Table 1 provide supportive evidence for these modeling elements.

Panel A of Figure 4 focuses on three kinds of US debt-like securities bought by RoW: government debt, debt issued by US financial institutions, and debt-like instruments (deposits and loans) that are foreign liabilities of US banks. As is well known, foreigners hold substantial amounts of US government debt, \$6 trillion in 2015. In addition, foreigners have substantial holdings of debt securities issued by US financial institutions and other debt-like claims on US banks, \$2.5 trillion and \$4 trillion in 2015, respectively. This foreign demand for US safe assets provides substantial leverage to the US economy and its financial system: Figure 4, panel B shows that foreigners are financing (hold) 48 percent of all US Treasury debt and 47 percent of all debt issued by US financial institutions. Similarly, safe assets (debt securities) issued by the US government and financial institutions account for the lion's share of all US debt securities bought by foreigners, 82 percent in 2015 (Figure 4, panel C). This evidence supports the quantitative importance of US financial intermediaries, in addition to the US government, in providing safe assets to RoW.

Table 1 focuses, instead, on the importance of RoW financial institutions as buyers of US debt. Panel A focuses on US debt held by foreign countries' financial

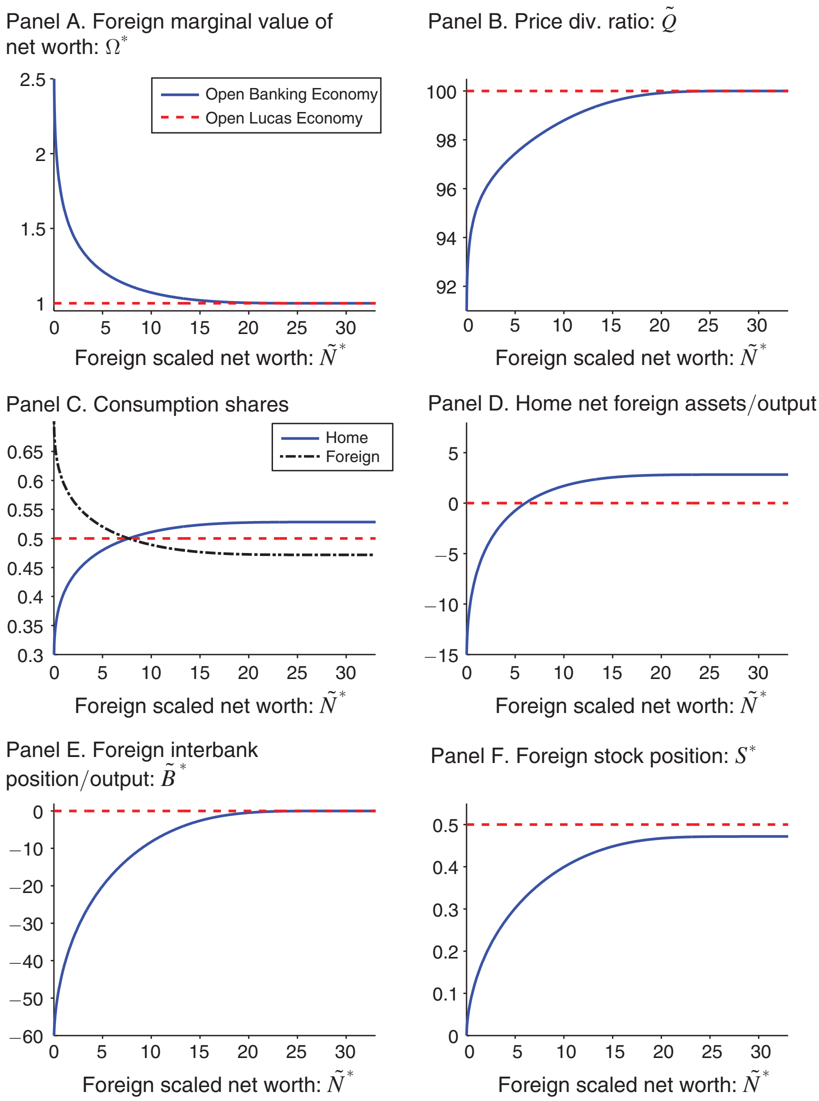

Figure 2. Open Economy Equilibrium, Single Tree: Allocations

Notes: Numerical solution for the equilibrium in Section III. Parameter values: $\rho = 0.01$, $\delta = 0.004$, $\lambda = 0.014$, $\mu = 0.01$, $\sigma = 0.05$. The starting scaled net worth is $\tilde{N}^*(0) = 5.2$, which results in $\xi = 1.12$. Note that the graphs plot the solution for the state space of the Open Banking Economy, the range of the state variable $\tilde{N}^*$. The Open Lucas Economy solution is plotted over the same state space for comparison purposes, but the state space of the Open Lucas Economy extends beyond the one of the Open Banking Economy. The state space of the Open Banking Economy is $\left(0, \frac{1}{\rho(1+\xi)}\right]$; in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is $\frac{1}{\rho(1+\xi)}$.

sectors as a percentage of each country's total holding of US debt. For 54 countries in the IMF Coordinated Portfolio Investment Survey, the financial sector accounted for 66 percent of US debt holdings on average for the period 2013–2015. This percentage increases to 86 percent when countries are weighted by the market value of their total US debt holdings. Panel B of Table 1 highlights the role of foreign financial institutions in some of the countries with the largest US debt holdings.

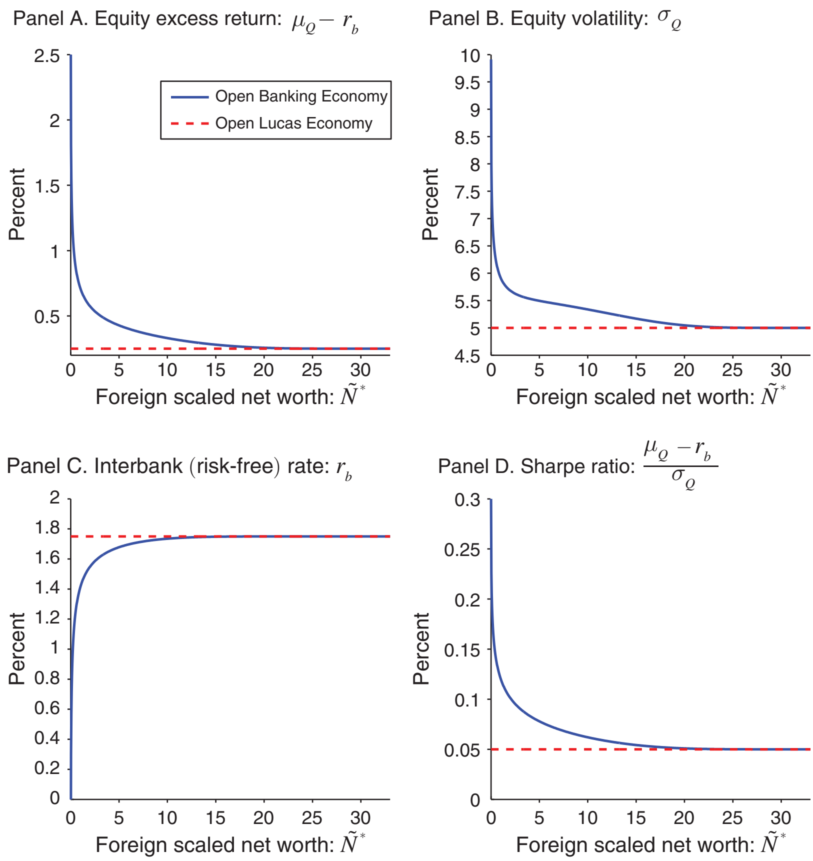

Figure 3. Open Economy Equilibrium, Single Tree: Asset Prices

Notes: Numerical solution for the equilibrium in Section III. Parameter values: $\rho = 0.01$, $\delta = 0.004$, $\lambda = 0.014$, $\mu = 0.01$, $\sigma = 0.05$. The starting scaled net worth is $\tilde{N}^*(0) = 5.2$, which results in $\xi = 1.12$. Note that the graphs plot the solution for the state space of the Open Banking Economy, the range of the state variable $\tilde{N}^*$. The Open Lucas Economy solution is plotted over the same state space for comparison purposes, but the state space of the Open Lucas Economy extends beyond the one of the Open Banking Economy. The state space of the Open Banking Economy is $\left(0, \frac{1}{\rho(1+\xi)}\right]$; in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is $\frac{1}{\rho(1+\xi)}$.

For example, Japan, the largest holder of US debt, reports that its financial sector accounts for 96 percent of all Japanese holdings of US debt.

It has to be recognized that data on international portfolio holdings suffer from important drawbacks (Bernanke et al. 2011; Shin 2012; Zucman 2013). Similarly, the available aggregate data do not allow positions at the intermediary level between RoW and US financial intermediaries to be fully traced.[14] This prevents a direct analysis of the net effect of international transactions on leverage at the intermediary

[14] This matter is further complicated by the presence of several different types of intermediaries (investment houses, banks, hedge funds, pension funds), as well as interoffice transfers among global financial intermediaries. I acknowledge and discuss all these well-known shortcomings of existing data in the online Appendix. Furthermore, for many foreign countries there is a blurry line between governments and bank actors, because of both direct control and implied bailouts.

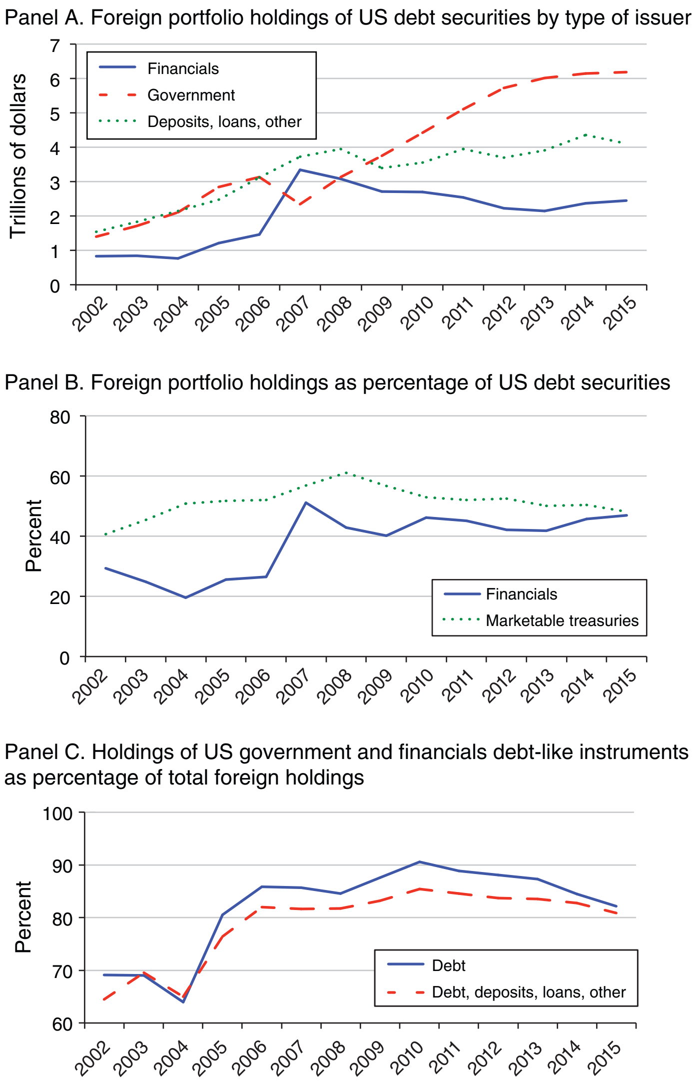

Figure 4. Foreign Holdings of US External Debt

Notes: Panel A: RoW portfolio holdings of: debt securities issued by the US government, debt securities issued by US financial institutions, and other debt-like instruments (deposit and loans) that are liabilities of US financial institutions. All data are from TIC: annual June 2002 to June 2015. Panel B: RoW portfolio holdings of US debt securities issued by the government and financial institutions, as a fraction of the total outstanding stock of debt issued by that sector. Data on holdings are from TIC, data on stock of securities are from Flow of Funds and Bureau of Public Debt. Panel C: RoW holdings of debt securities issued by the US government and US financial institutions as a percentage of total foreign holdings of US debt securities. Data on holdings by type of security are from TIC, data on total foreign holdings are from Bureau of Economic Analysis. See online Appendix A.3.A for full details on data sources and methodology.

Table 1—Share of US Foreign Debt Held by Foreign Financial Institutions

	Equally weighted by country	Weighted by country's total US debt holdings
Panel A. Average aggregate share		
Average share from financials (percent of total foreign holdings)	65.83	85.85
	Share from financials (percent)	Total debt holdings (US$ billion)
Panel B. Top five countries by total US debt held		
Japan	95.97	852.4
United Kingdom	98.10	457.1
Germany	79.70	168.7
France	92.12	153.2
Netherlands	94.45	114.4

Notes: Individual country shares are constructed by dividing US debt held by the foreign country's financial sector by total US debt held by that foreign country. Panel A: Individual country shares are averaged (in the first column, by using equal weights, and in the second column, by weighting each country by its total holdings of US debt) to create an average share across countries for each survey (biannual from June 2013 to June 2015). This cross-country average is then averaged over the five waves of the survey. Panel B: Countries shown are the five largest holders of US debt in the Coordinated Portfolio Investment Survey (CPIS), as measured by average debt holdings for all sectors over the period June 2013 to June 2015. Their respective average holdings are reported in the second column. The first column reports the average (2013–2015) fraction of US debt held by each country's financial sector as a share of total US debt holdings by that country. Data are from CPIS published by the International Monetary Fund. Online Appendix A.3.B provides further details.

level. However, the analysis in Figure 4 and Table 1 paints a broad picture that is consistent with both the importance of financial institutions in global capital flows and the substantial foreign demand for US debt (both government and financial). Online Appendices A.3.A and A.3.B further discuss the above empirical patterns and provide details on data sources and empirical methodology.

In the model, the asymmetric Home and Foreign external portfolios combine to generate a wealth transfer from Home to Foreign in response to negative shocks (Fact 3). The wealth transfer supports the risk-sharing allocation by financing the relatively higher Foreign consumption in bad states of the world. This is evident in Figure 2, where the value of the Home NFA portfolio falls in response to negative shocks, and Home and Foreign consumption shares and trade balances move in opposite directions.

Negative shocks cause capital losses in Foreign financial intermediaries and a fall in the stock market. As in the autarky case, a vicious cycle sets in due to the systemic risk generated by the fact that all financial intermediaries hold the same risky asset. As Foreign financial intermediaries try to sell the risky asset, they further depress its price and, in turn, tighten their own credit constraints. Their increased concern for their net worth generates a flight-to-safety toward the safe asset (interbank deposit) provided by Home intermediaries. In turn, Home financiers are willing to use the funds that the Foreign financiers are providing to buy the stock that Foreign financiers are trying to sell. However, Home financiers require extra compensation for taking on this additional leveraged risk; this is achieved through a combination of an increase in the expected stock excess returns and a decrease in the interbank rate.

The above mechanism induces the Home country to take on more global risk as its NFA deteriorate. The Home country earns, on average, an expected compensation for the extra risk that it takes. This stream of income helps finance higher

Home consumption, and the Home country runs a deeper trade deficit (Fact 2).[15] The external adjustment of the United States happens through both the traditional trade-balance channel and expected valuation effects on its NFA. Consistent with the empirical evidence of Gourinchas and Rey (2007 a, b), there are expected valuation effects on the NFA portfolio; these are generated in my model by time-varying risk premia. In the data, the US NFA position is actually negative, but the United States still runs a trade deficit. The model helps rationalize this seemingly puzzling outcome: despite being a net debtor, the United States earns positive financial income on average since its assets, while fewer, are riskier than its liabilities. This income helps finance the US trade deficit. The dynamic portfolio rebalancing of Home and Foreign is consistent with the empirical evidence in Curcuru, Dvorak, and Warnock (2010), who find that RoW switches from equities to US safe assets precisely at times when the future performance of these safe assets is poor compared to equities, which helps finance the US trade deficit.[16]

The model offers the view that some of the observed patterns in the data, including global imbalances, are the outcome of equilibrium risk sharing. However, it stresses the substantial risks involved: Home benefits, on average, from positive financial income on its external portfolio only because it takes greater risks. In the model, global imbalances are a symptom of asymmetric frictions that move the equilibrium away from the first best (the Open Lucas Economy). Even in the long run, once Foreign intermediaries have accumulated enough capital to self-insure and risk-sharing is symmetric, the model predicts the persistence of a Home trade deficit financed by the higher wealth accumulated by Home via past asymmetric risk taking. This long-run outcome is driven by the fact that the countries face different constraints. The framework could be extended by introducing constraints on both countries, along the lines of the work by Alvarez and Jermann (2000, 2001), to study alternative long-run outcomes in which Foreign intermediaries fail to grow out of the constraints.

Evidence on RoW Financial Intermediaries' Net Worth and US International Investment Position.—The model provides a way to interpret the data by emphasizing the importance of credit constraints and RoW financial sector's net worth. To provide evidence on the role of RoW financial net worth, I build an empirical proxy of $\tilde{N}^*$ by dividing the market value of firms included in the Datastream Financial Equity World ex-US index by the World ex-US GDP provided by the World Bank. The behavior of the empirical proxy supports the model predictions: financial net worth is pro-cyclical ($\sigma_{\tilde{N}^*} > 0$ in the data) and collapses when adverse shocks (1998 LTC crisis, 2001 dot-com crash, 2008 financial crisis) hit the world economy (see Figure A.6 and Table A.9 in the online Appendix). Online Appendix A.3.C provides full details, as well as robustness checks, on the measure construction.

[15] In contrast to the Rueff (1972) interpretation of the US deficit as being "without tears," I emphasize that the US deficit is in fact financed by the "tears" of wealth transfers during crises.

[16] Curcuru, Dvorak, and Warnock (2010) interpret the evidence in terms of bad timing of the purchase of US safe assets from RoW investors. I interpret the empirical evidence in terms of time-varying risk compensation.

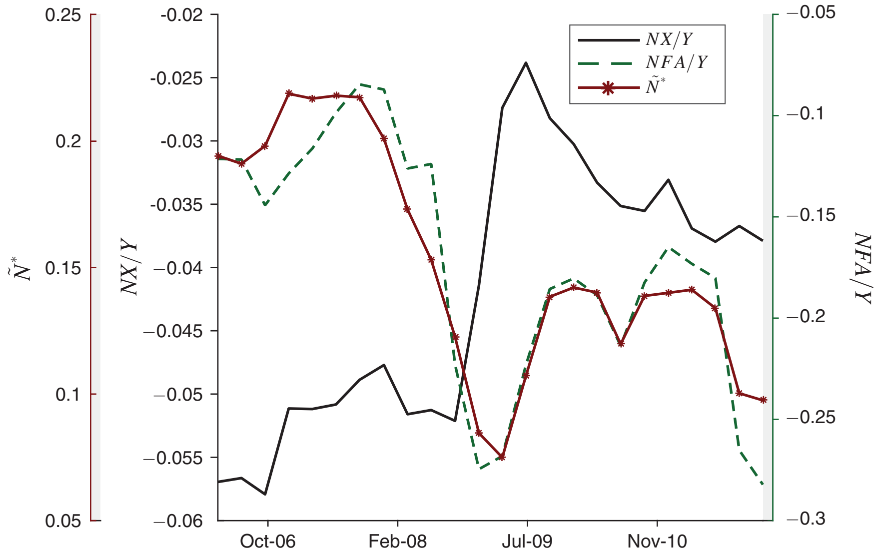

Figure 5. US Net Foreign Assets and Net Exports, and RoW Financial Net Worth: Global Financial Crisis

Notes: The figure shows net exports of good and services as a share of GDP for the United States $\left(\frac{NX_t}{Y_t}\right)$, net foreign assets as a share of GDP for the United States $\left(\frac{NFA_t}{Y_t}\right)$, and RoW financial net worth $\tilde{N}_t^*$. All series units are expressed as fractions (e.g., $\frac{NX_t}{Y_t} = -0.03$ means that net exports for that year are -3 percent of US GDP). The outer left axis corresponds to $\tilde{N}^*$, the inner left axis to NX/Y, and the right axis to NFA/Y. The data are quarterly from 2006:I to 2011:IV. The measure $\tilde{N}^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-US index by world GDP ex-US provided by the World Bank. Online Appendix A.3.C provides further details on measure construction and robustness checks. Net exports of goods and services, net foreign assets, and GDP for the United States are from the Bureau of Economic Analysis.

Figure 5 focuses on the global financial crisis and plots the proxy of RoW financial net worth and the US NFA and net exports. As the global financial crisis unfolds in 2008, RoW financial firms' net worth crashes, going from 22 percent to 7 percent of RoW GDP, a 68 percent fall. At the same time, the United States suffers heavy losses in its NFA portfolio, which worsens from -9 percent to -27 percent of US GDP; this corresponds to a wealth transfer to RoW of 18 percent of US GDP ($2.7 trillion in absolute value). US net exports move in the opposite direction, showing an increase (a lower trade deficit) from -5.2 percent to -2.4 percent of US GDP. These patterns are consistent with the dynamic predictions of my model, discussed above.

More generally, RoW financial net worth and US NFA are strongly positively associated in the data for the period 1976–2015, as predicted by the model. Figure 6 illustrates the relationship by plotting the US change in NFA minus net exports (NX) as a fraction of US GDP versus the contemporaneous changes in the empirical proxy for RoW financial net worth. The solid line is the fitted linear relationship obtained by the corresponding regression:

$$\frac{\Delta NFA_t - NX_t}{GDP_t} = \alpha + \beta \Delta \ln \tilde{N}_t^* + u_t, \tag{21}$$

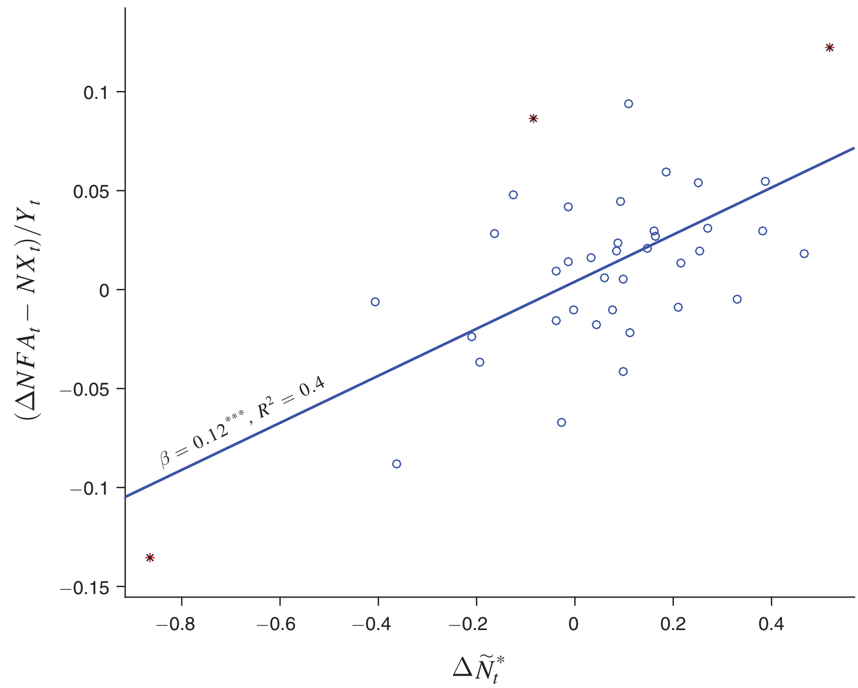

Figure 6. US NFA and RoW Financial Net Worth: $\Delta \tilde{N}_t^*$ versus $(\Delta NFA_t - NX_t)/Y_t$

Notes: Scatterplot corresponds to the benchmark regression in Table 2 column 1. The vertical axis plots the annual change in the net foreign asset position of the United States minus net exports, expressed as a share of US GDP: $\frac{NFA_t - NX_t}{Y_t}$. The horizontal axis plots the logarithmic change in RoW financial net worth as a fraction of RoW GDP, $\Delta \tilde{N}^*$. The measure $\tilde{N}^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-US index by world GDP ex-US provided by the World Bank. Online Appendix A.3.C provides further details on measure construction and robustness checks. Net exports of goods and services, and net foreign assets of the United States are from the Bureau of Economic Analysis. The sample period is 1976–2015, annual data; the years of the global financial crisis, 2007–2009, are plotted with a star maker. The regression line and coefficient reported here are those estimated in the benchmark regression in Table 2 column 1.

the estimated parameter values of which are reported in the first column of Table 2. The data resemble the model predictions in a number of interesting ways. On average, a 10 percent loss of RoW financial net worth is associated with a 1.2 percent deterioration of the US external position (net of any movements in net exports) as a fraction of US GDP. The linear relationship under-predicts US external losses for large losses of RoW net worth (financial crises). For example, the linear relationship predicts a US external loss of 11 percent in 2008, versus the actual 14 percent. This is consistent with the nonlinearities in the model, which induce bigger Home external losses for bigger losses of RoW net worth (Figure 2, panel D).[17] Similarly, column 3 of Table 2 shows that the relationship becomes stronger during the period of global imbalances 2001–2015, which is consistent with the increase in asymmetric global risk sharing over this more recent period.

[17] Introducing a quadratic term $\left(\Delta \ln \tilde{N}_t^*\right)^2$ in the regression in equation (21) confirms this nonlinear association in the data, but in the interest of simplicity I maintain the linear specification in the text above.

Table 2—US NFA and RoW Financial Net Worth

	Full sample (1976–2015)	Ex-crisis (2007–2009)	Global imbalances (2000–2015)
α	0.0040	0.0034	0.0154
	(0.0062)	(0.0064)	(0.0119)
β	0.1189	0.0850	0.1805
	(0.0266)	(0.0285)	(0.0151)
R^2	0.4031	0.5794	0.6347

Notes: Dependent variable is the annual change in the net foreign asset position of the United States minus net exports of goods and services, expressed as a share of US GDP: $\frac{NFA_t - NX_t}{GDP_t}$. Regressors are a constant, and the logarithmic change in RoW financial net worth as a fraction of RoW GDP, $\Delta \tilde{N}^*$. The measure $\tilde{N}^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-US index by world GDP ex-US provided by the World Bank. Online Appendix A.3.C provides further details on measure construction. Net exports of good and services, and net foreign assets of the United States are from the Bureau of Economic Analysis. All regressions use annual data; the regression in column 2 also includes three dummies for the financial crisis years: 2007, 2008, and 2009. Standard errors are in parentheses and built with Newey-West with one lag.

While this evidence is supportive of the model, it has to be recognized that it does not identify the mechanism as causal. However, recent evidence (Adrian, Etula, and Muir 2014; Muir 2017; He, Kelly, and Manela 2017), has shown that measures of financial net worth have ex ante explanatory power for risk premia in a variety of asset classes (equities, bonds, currencies), in contrast to the well-known failure of consumption measures. This mounting evidence further supports the view of this paper that global asymmetric risk sharing, which relies on these risk premia, is linked ex ante to imperfections in financial intermediation.

This section has shown how a simple asymmetry in the global financial system can explain the first three stylized facts (Facts 1–3) about the role of the United States in the global financial architecture and provide meaningful foundations for its economic analysis. In the next section, an interesting extension of the framework introduces differentiated goods in order to highlight the role of the US dollar as a reserve currency (Fact 4), the related currency denomination of assets and liabilities, and introduces the reserve currency paradox.

IV. Open Banking Economy: Two Trees

The open economy model described above does not incorporate exchange rates. The previous literature on global imbalances is also largely silent on currency movements and the role of the dollar, often referring to the safety of US debt in dollar terms, rather than in terms of the local currency of the holder of the asset.[18]

[18] My view extends the "Global Saving Glut" hypothesis of Bernanke (2005) by emphasizing the role of the exchange rate in making US short-term liabilities safe. After all, not even the safest US assets (such as treasuries and short-term liabilities of the banking system) would be safe for foreigners if the dollar were to systematically depreciate during crises.

In this paper, I offer a view of the international role of the US dollar as a reserve currency based on risk. This contrasts with previous models of the key currency that focused on its role as a vehicle currency, that is, a medium of exchange in international transactions (Krugman 1980; Matsuyama, Kiyotaki, and Matsui 1993). In this view, US short-term debt denominated in dollars is safe for foreigners because the US dollar appreciates in times of global crisis. A dramatic example of this behavior is the 24 percent appreciation of the US dollar index (DXY) between August and November 2008 as the Lehman bankruptcy unfolded. This state contingent behavior of the exchange rate offered a high payoff to foreign holders of US debt precisely when capital (i.e., having extra resources) was most valuable.

Based on this risk-view of the reserve currency, I show that traditional macroeconomic models predict that relative wealth transfers in times of crisis result in a US dollar depreciation, which is inconsistent with the role of the US dollar as a global safe asset. I call this tension between the wealth transfer from the United States to RoW during crises and the role of the US dollar as a global safe asset the "reserve currency paradox." In this section, I first set up the general model, then characterize the nature of the paradox, and finally discuss possible resolutions of these seemingly contradictory forces.

In setting up the general model, I maintain the assumption from the previous section that the Home financial system is more developed than the Foreign one. In addition to applying this asymmetry to trade in assets, I also allow financial frictions to affect international trade in goods by introducing trade costs. There are two differentiated goods, one produced by Home and the other by Foreign. The output of the two goods is given by processes

$$\frac{dY(t)}{Y(t)} = \mu\, dt + \sigma\, d\vec{z}(t); \qquad \frac{dY^*(t)}{Y^*(t)} = \mu\, dt + \sigma^*\, d\vec{z}(t), \tag{22}$$

where $\sigma = [\sigma_z \quad 0]$, $\sigma^* = [0 \quad \sigma_z^*]$, and $\vec{z}$ is a vector of two independent standard Brownian motions. In both countries, agents have logarithmic preferences over a basket of the two goods, with the Home and Foreign baskets given by, respectively,

$$C = C_H^{\alpha} C_F^{1-\alpha}; \qquad C^* = C_H^{*1-\alpha} C_F^{*\alpha}, \tag{23}$$

where $\alpha \in \left[\frac{1}{2}, 1\right)$ potentially allows for bias in each country's preferences toward its domestic good.[19]

To model trade costs I assume, for simplicity, iceberg transport costs: if one unit of a good is shipped internationally, only $\frac{1}{\tau}$ units reach the destination, where $\tau \geq 1$ (Samuelson 1954; Dumas 1992; Obstfeld and Rogoff 2001b; Coeurdacier 2009). In keeping with the simplification that the Home country is unconstrained, I assume that there are no transport costs for Home exports. I focus here on deriving the main result, the reserve currency paradox, and later discuss the foundations of trade costs in the context of possible resolutions of the paradox.

[19] I set a basket of the two goods, consisting of $\theta \in (0, 1)$ units of the Home good and $1 - \theta$ units of the Foreign good, as the numeraire. All prices are expressed in this common unit.

Standard static optimization of the consumption baskets gives the Home and Foreign demand for the two goods

$$(24) \qquad C_H = \alpha\left(\frac{p}{P}\right)^{-1}C; \qquad C_F = (1-\alpha)\left(\frac{p^*\tau}{P}\right)^{-1}C;$$

$$(25) \qquad C_H^* = (1-\alpha)\left(\frac{p}{P^*}\right)^{-1}C^*; \qquad C_F^* = \alpha\left(\frac{p^*}{P^*}\right)^{-1}C^*,$$

where p and p^* are the prices of the Home and Foreign good, respectively, and P and P^* are the prices of one unit of the Home and Foreign consumption baskets, respectively.

The terms of trade (ToT) are defined as the ratio of Foreign to Home goods prices, such that an increase in ToT represents a deterioration in the Home ToT. The real exchange rate ($\mathcal{E}$) is expressed as the Home price of Foreign currency and is given by the ratio of Foreign to Home price indices (a fall in $\mathcal{E}$ is a Home currency appreciation). Thus, I have: $ToT \equiv \frac{p^*}{p}$ and $\mathcal{E} \equiv \frac{P^*}{P}$. I denote the exchange rate dynamics by $\frac{d\mathcal{E}}{\mathcal{E}} = \mu_{\mathcal{E}}dt + \sigma_{\mathcal{E}}d\vec{z}$.

Savers can only make deposits with domestic financial institutions. Deposits are instantaneous promises to pay one unit of the domestic consumption basket. Deposits are risk free for domestic agents because there is no default in equilibrium and deposits pay the consumption basket. The saver's problem is, therefore, identical to those in the previous sections and is reported in online Appendix A.1.

Financiers in each country can raise domestic deposits, invest in either of the two stocks, and borrow or lend in an international interbank market. Interbank loans can be denominated in either Home or Foreign currency and are instantaneous promises to pay one unit of either the Home or Foreign consumption basket, respectively. The Foreign financier's balance sheet is $s_H^*\frac{Q}{\mathcal{E}} + s_F^*Q^* = n^* + d^* + b_H^* + b_F^*$, where s_H^* and s_F^* are the Foreign equity holdings of Home and Foreign stocks, Q and Q^* are the prices of the Home and Foreign stocks, both expressed in local currencies, and b_H^* and b_F^* are the amounts borrowed in the interbank market in Home and Foreign currency, both expressed in Foreign currency.

The Foreign financier's optimization problem is

$$(26) \qquad \max_{\{d^*(u),b_H^*(u),b_F^*(u),s_H^*(u),s_F^*(u)\}_{u=t}^{\infty}} \Lambda^*(t)V^*(t) = E_t\left[\int_{t'}^{\infty}\Lambda^*(u)\,e^{-\lambda(u-t')}\lambda n^*(u)\;du\right]$$

subject to

$$dn^* = s_H^*\left(d\left(\frac{Q}{\mathcal{E}}\right) + \frac{pY}{P^*}dt\right) + s_F^*\left(dQ^* + \frac{p^*Y^*}{P^*}dt\right)$$

$$- r_d^*d^*dt - \left(r_b dt - \frac{d\mathcal{E}}{\mathcal{E}} + \sigma_{\mathcal{E}}\sigma_{\mathcal{E}}^T dt\right)b_H^* - r_b^*b_F^*dt,$$

$$V^* \geq 0,$$

where $\Lambda^* \equiv e^{-\rho t}\frac{1}{C^*}$, $t' \equiv \inf\{t : \Omega^*(\tilde{N}^*(t)) = 1\}$ and the superscript T denotes the vector transpose.

I assume that the start-up capital provided by foreign households to new foreign financiers is a function of the stochastic steady state holdings of the two stocks: $\{\bar{S}_H^*, \bar{S}_F^*\}$. Consequently, new Foreign financiers receive $\delta\left[\bar{S}_H^* \frac{Q}{\mathcal{E}} + \bar{S}_F^* Q^*\right]$.

The definitions of the Foreign trade balance and the NFA are: $NX^* \equiv \frac{p^*}{P^*} Y^* - C^*$ and $NFA^* \equiv S_H^* \frac{Q}{\mathcal{E}} - S_F Q^* - B_H^* - B_F^*$. The market clearing conditions are

$$C_H + C_H^* = Y; \quad \tau C_F + C_F^* = Y^*; \quad S_H + S_H^* = 1; \quad S_F + S_F^* = 1;$$

$$B_H = -\mathcal{E} B_H^*; \quad B_F = -\mathcal{E} B_F^*; \quad N^* = S_H^* \frac{Q}{\mathcal{E}} + S_F^* Q^* - D^* - B_H^* - B_F^*.$$

Optimal Consumption and Investment.—In line with Section III, the Home financier's value function takes the form $V = n$ and that of the Foreign financier takes the form $V^* = \Omega^*(\tilde{N}^*)n^*$. The Home and Foreign dynamic programming problems of both savers and financiers and the corresponding Euler equations, which are extensions of those in Lemma 3, are reported in online Appendix A.1. Here I want to emphasize the Foreign financier's Euler equation for the optimal trade-off between interbank loans denominated in Home and Foreign currency:

$$r_b^* - r_b + \mu_{\mathcal{E}} - \sigma_{\mathcal{E}}\sigma_{\mathcal{E}}^T = -\text{cov}_t\left(\frac{d\Lambda^*\Omega^*}{\Lambda^*\Omega^*}, \frac{d\mathcal{E}}{\mathcal{E}}\right) = (\sigma_{C^*} - \sigma_{\Omega^*})\sigma_{\mathcal{E}}^T. \tag{27}$$

The Home currency safety premium, the compensation required to invest in Foreign currency by shorting Home currency, is determined by the covariance between Foreign consumption and the marginal value of net worth and the real exchange rate. If the Home currency appreciates ($\downarrow \mathcal{E}$) whenever Foreign consumption is low and/or whenever Foreign financial intermediaries are poorly capitalized, then the Home currency has a positive safety premium. This is the risk-based view of a reserve currency: Home bonds (interbank loans, deposits) are safer than their Foreign counterparts because they pay more in states of the world in which financial net worth is more valuable.

Since deposits and interbank loans are risk-free in their local currency, no arbitrage implies that $r_b = r_d$ and $r_b^* = r_d^*$.

Equilibrium.—In the presence of frictions, and in line with Section III, the equilibrium is characterized by a single state variable, the aggregate scaled[20] net worth of Foreign financiers, and a system of three ODEs.

PROPOSITION 3: *The equilibrium is characterized by a system of three coupled second-order ODEs for the Home price-dividend ratio,* $\tilde{Q}(\tilde{N}^*)$*, the Foreign price-dividend ratio,* $\tilde{Q}^*(\tilde{N}^*)$*, and the marginal value of Foreign net worth,* $\Omega^*(\tilde{N}^*)$*:*

$$0 = \mu_Q - r_b - \sigma_C\sigma_Q^T, \tag{28}$$

[20] Consistently with the previous sections, I normalize by the value of world output expressed in the appropriate currency. Consequently, Home variables are scaled by $\frac{pY + p^*Y^*}{P}$ and Foreign variables by $\frac{pY + p^*Y^*}{P^*}$.

$$0 = \mu_{Q^*} + \mu_{\mathscr{E}} + \sigma_{\mathscr{E}} \sigma_{Q^*}^T - r_b - \sigma_C (\sigma_{Q^*} + \sigma_{\mathscr{E}})^T, \tag{29}$$

$$0 = \mu_{\Omega^*} - \sigma_{C^*} \sigma_{\Omega^*}^T. \tag{30}$$

The risk sharing allocations are a generalization of equation (20):

$$\frac{P^* C^*}{PC} = \frac{\Omega^*}{\xi}; \tag{31}$$

$$C_H^* = \frac{(1-\alpha)\,\Omega^*}{\alpha\xi + (1-\alpha)\,\Omega^*}\, Y; \qquad C_H = \frac{\alpha\xi}{\alpha\xi + (1-\alpha)\,\Omega^*}\, Y; \tag{32}$$

$$C_F^* = \frac{\alpha\,\Omega^*}{(1-\alpha)\,\xi + \alpha\,\Omega^*}\, Y^*; \qquad C_F = \frac{1}{\tau}\frac{(1-\alpha)\,\xi}{(1-\alpha)\,\xi + \alpha\,\Omega^*}\, Y^*. \tag{33}$$

The terms of trade and the exchange rate can also be understood in terms of movements in Ω^*. The risk sharing conditions and the definitions of ToT and of the exchange rate imply that

$$ToT = \frac{\xi(1-\alpha) + \alpha\,\Omega^*}{\alpha\xi + (1-\alpha)\,\Omega^*}\frac{Y}{Y^*}; \qquad \mathscr{E} = (ToT)^{2\alpha-1}\tau^{\alpha-1}. \tag{34}$$

The ToT are determined by two effects. Firstly, movements in the ratio of the two trees affect the ToT by altering the relative supply of the two goods. If the Home good becomes relatively more scarce, then it also becomes relatively more expensive, and the Home ToT improve. This effect is present irrespective of domestic bias. In addition, if there is domestic bias ($\alpha > 0.5$), an increase in Ω^* weakens the Home ToT. This happens because an increase in Ω^*, according to equation (31), increases the relative consumption of Foreign residents. If the preferences of agents are biased toward the Foreign good ($\alpha > 0.5$), this induces a relative increase in the demand for the Foreign good. To clear the market, its price increases relative to the Home good. If these agents have no preference bias ($\alpha = 0.5$), then the ToT are unaffected.

The exchange rate is determined by the combination of three effects. The first two effects derive from the movement in the ToT analyzed above. If $\alpha = 0.5$, these two effects disappear because the Home and Foreign consumption baskets are identical and movements in the ToT have no effect on the exchange rate. In the presence of domestic bias ($\alpha > 0.5$), the exchange rate and the ToT are positively related. If the Home ToT deteriorate, then Home also experiences, all else equal, a currency depreciation. The third effect is caused by variations in trade costs: an increase in Foreign export costs ($\uparrow \tau$) increases the price Home residents pay for the Foreign good (see equation (33)), thus relatively increasing the Home price index and causing the Home currency to appreciate. The effect is absent in the limit $\alpha \uparrow 1$, because countries only consume their own good and never export their good.

The above analysis of the determinants of exchange rates based on shifts in relative wealth and home bias, and the analysis of the determinants of reserve currency status based on risk properties in equation (27), combine to generate the main result of this section: the reserve currency paradox. I collect the result below.

The Reserve Currency Paradox.—Assume that there are no frictions in the goods market ($\tau = 1$). The Home asymmetric risk sharing with Foreign leads to a wealth transfer from Home to Foreign when net worth is more valuable ($\uparrow \Omega^*$), in times of crisis. As long as there is home-bias in consumption ($\alpha > 0.5$), the Home currency depreciates as a consequence of this wealth transfer. The ex post depreciation in times of crisis makes ex ante the Home currency riskier for Foreign financiers since it is a bad hedge for their net worth.

The paradox is intuitive, but, I believe, surprising both in theory and in practice (see online Appendix A.1 for a detailed discussion). The role of Home as a global risk taker is a result, as in the previous section, of the difference in financial development between Home and Foreign and is confirmed by the asymmetric risk sharing condition in equation (31). This asymmetric risk sharing requires Home to transfer wealth to Foreign in response to negative events, such as a financial crisis. In practice, this occurs in the data thanks to the US external balance sheet being long risky assets, such as equity and FDI, and short safer assets, such as debt, as depicted in the top two panels of Figure 1. In the absence of trade costs and in the presence of home-bias in consumption, the model predicts that an increase in relative wealth and consumption of Foreign leads to a Foreign ToT improvement and a Foreign currency appreciation (see equation (34) and the earlier discussion). The final piece of the paradox emerges by combining the ex post depreciation of the Home currency in bad times with the ex ante demand for bonds denominated in the two currencies in equation (27). In this situation, Foreigners do not demand dollar bonds as safe assets, expecting them to be bad hedges for financial net worth, and the Home currency earns a risk premium rather than a safety premium. This outcome is inconsistent with both the large RoW holdings of US dollar denominated debt (bottom panel in Figure 1 and Figure 4) and the presence of a US dollar safety premium (Fact 4).

The above paradox transcends the specific modeling setup of this paper. It rests on two canonical elements: the ex post behavior of the exchange rate in the presence of relative wealth movements, and the ex ante currency risk premium based on the covariance between the exchange rate and measures of the marginal value of wealth (SDF). The first of these two key elements has some of the deepest roots in international macroeconomics and was first understood in the classic Keynes and Ohlin debate on the "transfer problem": the behavior of exchange rates following a wealth transfer depends on the goods, domestic or foreign, upon which the transfer is spent (the value of α in this paper).[21] Despite its classic roots, the transfer problem is still at the core of international macroeconomic theory. Pavlova and Rigobon (2008) show how the transfer problem can be related to contagion (excess co-movement)

[21] Following World War I, the Dawes committee imposed reparation payments from Germany to France. Keynes argued that, in addition to the primary burden of the wealth transfer, Germany would suffer a secondary burden due to the deterioration in its terms of trade (Keynes 1929a, b, c). Ohlin, on the contrary, argued that no secondary burden would occur as long as French people spent the transfer on German goods (Ohlin 1929a, b). In this case, Keynes' prediction proved closer to the empirical outcome.

in emerging market stocks when investors in developed countries are financially constrained.[22]

The second key element, the determination of the ex ante currency risk premium, has more recent foundations in economic theory. A number of recent advances in the modeling of exchange rates have analyzed currency risk premia in terms of the covariance between exchange rates and the SDF (Hassan 2013; Colacito and Croce 2011; Farhi and Gabaix 2016; Burnside et al. 2011; Hassan, Mertens, and Zhang 2015). In my model this relationship is given by equation (27). I characterize a tension in this risk-based view of currencies, in particular reserve currencies, in reconciling the key country's currency appreciation during a crisis with the country suffering heavier wealth losses relative to other countries. This outcome has been surprising in practice: it is hardly the norm for a country that is a large external debtor and is hit by severe losses in its banking system to experience a currency appreciation and increased demand for its debt, such as the United States experienced during the global financial crisis.[23]

Possible Resolutions of the Paradox: The Role of Trade.—The above discussion of the paradox makes clear that the "transfer problem" is at the core of the paradox. Samuelson (1952, 1954) was among the first to recognize the importance of trade costs in determining the outcome of the transfer problem, and the subsequent literature has expanded on his study by also introducing different types of goods produced in different countries (durables, services, nondurables) (Dumas 1992; Obstfeld and Rogoff 2001b; Burstein, Eichenbaum, and Rebelo 2006; Coeurdacier 2009). The model considered here builds on this tradition by emphasizing that shifts in demand for Home and Foreign goods are important to understanding the dynamics of the real exchange rate, particularly in times of global financial stress.

I consider a case in which Foreign export transport costs are related to the health of Foreign intermediaries. The most literal interpretation of this channel is that the relative variation in Home versus Foreign transport costs is due to the availability of credit. In this interpretation Foreign exporters can easily access credit when intermediaries are well capitalized, and trade costs are therefore low. In contrast, Foreign exporters' access to credit dries up in periods of financial stress, and trade costs increase correspondingly. This is modeled in reduced form by: $\tau = \Omega^{*\varepsilon}$, where Ω^*, in line with the previous section, is the Foreign marginal value of net worth and $\varepsilon \geq 0$.[24]

A less literal interpretation is that each country specializes in producing certain types of goods, in this case durable goods for Foreign and services and nondurable goods for Home. The demand for each type of good is affected differently by global

[22] In their model, co-movement in stock returns among emerging markets arises because wealth transfers induce a differential response in the terms of trade, and consequently in the stock market, of developed and emerging economies. Their framework and focus is different from those of this paper since they assume perfect goods markets (zero impediments or costs to trade in goods) and direct portfolio constraints on the core (developed) economies rather than emerging economies.

[23] For example, Obstfeld and Rogoff (2001a, 2007) argued, based on a model with home bias in tradable consumption, that a sudden reversal of the US current account deficit and a large dollar depreciation were going to be the most likely outcomes of a forthcoming financial crisis.

[24] The functional form is one of convenience. Similar qualitative patterns result from any decreasing function of scaled net worth.

crises: trade costs then need to be interpreted as reduced form demand shifts according to economic conditions. Indeed, an alternative setup in which a shift in Home demand in bad times toward its own good is represented by an α that depends positively on Ω^* has very similar predictions as the setup with iceberg costs for the exchange rate and global portfolios.[25] Both setups lead to a Home shift in demand toward its own good during bad times; therefore, both have similar equilibrium outcomes.

This model extension shows the mechanisms that help rationalize the reserve currency paradox by noting that in normal times, or even for mild negative shocks, the combination of the various effects (ToT, home-bias, trade frictions) produces an ambiguous exchange-rate response. However, for sufficiently large adverse shocks, such as global crises, the relative shift in demand toward the Home good, caused by an increase in τ, dominates and the Home currency appreciates. This nonlinearity allows for rich exchange rate dynamics. While it is consistent with the traditional view, with the exchange rate behaving much as predicted by traditional models in normal times, it extends this mechanism to make sense of the behavior of the exchange rate during extreme events.

Online Appendix Figures A.7–A.8 isolate the role of the Home currency as a global safe asset by presenting the equilibrium of the model under no domestic bias ($\alpha = 0.5$). In this case, the exchange rate is entirely driven by movements in trade costs. Since the Home currency appreciates whenever intermediaries lose capital, it provides a hedge for the global financial system. Correspondingly, Home currency has a safety premium: financial intermediaries are willing to earn negative expected excess returns as compensation for holding this safe currency.

Figure A.7 shows how the equilibrium risk sharing allocation between Home and Foreign is implemented via the financial intermediaries' portfolios.[26] Foreign intermediaries invest in the risky asset, the stock market, and hold precautionary long positions in Home currency in the interbank market, thus generating the US-dollar-denominated debt liabilities of the United States (part of Fact 1). Following a negative shock, Foreign intermediaries lose capital and their heightened concern for further losses leads to a fall in their investments in the risky asset and an increased demand for the Home currency. This global flight toward the Home currency leads to an increase in its safety premium through both an immediate Home currency appreciation and expected depreciation, and a more pronounced fall in the Home interest rate than in the Foreign one. In this case, the wealth transfer from the United States to RoW happens both because of the asset class mismatch, equity versus debt as in the previous section, and the currency mismatch, dollar liabilities, in the US external balance sheet.

The trade channel considered in this paper to counteract the reserve currency paradox has empirical predictions related to the dynamics of US trade, particularly during global crises. The key predictions are: during a crisis, the United States should experience a relative increase in its import-related trade frictions and a relative decrease in its export-related trade frictions, and US consumption

[25] For models with shocks to domestic bias, see Pavlova and Rigobon (2007, 2010a, b).

[26] Given $\alpha = 0.5$, the returns of the two stocks in the same currency are perfectly correlated, as in Cole and Obstfeld (1991), because changes in the ToT exactly offset the dividend shocks. Therefore, I focus on intermediaries' holdings of the aggregate world stock market. Figure A.7 presents the case where intermediaries can trade the world stock market and lend or borrow in the Home-currency interbank market. See online Appendix A.1 for details.

should become more home biased as a result of compositional effects of traded goods (durables versus nondurables and services). The data are consistent with these predictions. Eaton et al. (2016) find that both channels contributed to a reduction in the US trade deficit during the 2008–2009 crisis. They fit a large-scale trade model to the data and find for the United States a substantial increase in trade frictions for imports (+18.2 percent) and a substantial decrease for exports (−14.5 percent). They also find that US consumption shifts toward domestic goods, which occurred in the crisis because the United States had ran a trade deficit in durable goods ahead of the crisis (as large as 1.8 percent of GDP in 2008:III) and because the crisis redistributed demand away from durables to nondurables and services. They estimate that US trade in durables as a fraction of GDP fell approximately 10 percent more than for nondurables during the acute phase of the financial crisis between the third quarter of 2008 and the second quarter of 2009. Levchenko, Lewis, and Tesar (2010) find similar patterns for the United States with both compositional effects of exports-imports of durables and trade wedges (frictions) contributing to the fall in US imports during the crisis.

Since the focus of this paper is not on explaining the collapse in gross trade (sum of imports and exports) during a crisis, I want to clarify which elements of the empirical trade literature are relevant here. I am interested in the relative variation in demand, according to the state of the economy, between the two countries for both Home and Foreign goods. Overall increases or decreases in world trade costs (see Ready, Roussanov, and Ward 2017 for evidence of a decrease in global freight costs and Amiti and Weinstein 2011 for evidence of an increase in trade finance costs during the crisis) or world demand, while complementary and interesting, are not the focus of this paper. Similarly, the τ in the paper for RoW should be interpreted relative to τ_{US}. For simplicity and consistency with the rest of the paper, I considered a frictionless Home country (set $\tau_{US} = 1$), but the statement is clearly to be interpreted as relative in the data. Indeed, Eaton et al. (2016) find that a modest increase in overall trade frictions, in the case of the United States, masked the substantial increase for imports (+18.2 percent) and decrease for exports (−14.5 percent) frictions during the global financial crisis.

Amiti and Weinstein (2011) focus on providing evidence on the deeper source of variation in trade frictions during the crisis; they identify a causal link between banks' credit constraints and the level of exports of their domestic clients. Using a sample of Japanese firms, they estimate that financial constraints from banks accounted for a 20 percent drop in Japanese export growth during the 2008–2009 financial crisis (see also Chor and Manova 2012). They highlight that trade is particularly exposed to financial frictions, since it is a capital intensive activity with substantial delays between when costs are incurred and when revenues are received.

V. Conclusion

A simple asymmetry in the global financial system, heterogeneity in financial development, can rationalize the economic role of the United States in the global financial architecture. I have shown how the greater depth of financial development of the United States leads to its role as the global risk taker with respect to both fundamental and financial risk. Empirical evidence on RoW financial intermediaries net worth and portfolio holdings broadly confirms the predictions of the model.

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