Financial Intermediation, International Risk Sharing, and Reserve Currencies

Matteo Maggiori*

March 2017

Abstract

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.

Keywords: Global Liquidity, International Portfolios, Exorbitant Privilege, Global Imbalances, Global Saving Glut, Reserve Currency Paradox.

*Harvard University, Department of Economics; NBER and CEPR. maggiori@fas.harvard.edu. I would like to thank the members of my PhD committee: Nicolae Gârleanu, Pierre-Olivier Gourinchas, Martin Lettau, Maurice Obstfeld, and Andrew Rose. My debt of gratitude to them can hardly be repaid. I would also like to thank: Mark Aguiar, Marty Eichenbaum, Emmanuel Farhi, Xavier Gabaix, Mark Gertler, Gita Gopinath, Nobuhiro Kiyotaki, Robert Kollman, Arvind Krishnamurthy, Tarek Hassan, Hanno Lustig, Anna Pavlova, Hélène Rey, Adrien Verdelhan, and seminar participants at AEA meeting, Boston College, Columbia, Finance Theory Group “Best Finance Theory Papers on the Job market” meeting, Yale, Harvard, LBS, LSE, MIT, NBER IFM meeting, Northwestern, NYU, Princeton, Review of Economic Studies European tour, SED conference, SNB and CEPR conference on “external adjustment”, Stanford, University of Chicago, UC Berkeley, UCLA, UIUC, World Bank, and WUSTL. I am grateful to Miguel de Faria e Castro and Andrew Lilley for excellent research assistance. I gratefully acknowledge the financial support of the NSF (1424690), White Foundation, the UC Berkeley IBER Center as well as the hospitality during part of the research process for this paper by the International Economics Section, Department of Economics, Princeton University.
The global financial architecture is characterized by the existence of a key country. This role has been fulfilled by the United States of America (U.S.) since the Second World War; prior to the First World War it was fulfilled by the United Kingdom (U.K.). 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 U.S. 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 the key country in the global financial architecture and jointly explains the stylized facts that characterize the U.S. 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 U.S. external balance sheet is characterized by risky assets, mainly denominated in foreign currencies, and safer liabilities, mainly denominated in U.S. dollars. The top panel in Figure 1 shows the U.S. external balance sheet, as of year-end 2015. U.S. residents’ holdings of foreign assets were focused on riskier assets, such as equity securities and equity foreign direct invest-
ment (FDI), which together accounted for 60% of total U.S. assets. By contrast, foreign residents’ holdings of U.S. assets were concentrated in safer assets such as debt, which accounted for 61% of total U.S. liabilities. 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 U.S. external assets, 61% on average, are denominated in foreign currencies. U.S. external liabilities are instead mostly denominated in U.S. dollars, 85% on average.

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

**Fact 3:** During global crises, the U.S. transfers substantial amounts of wealth to RoW. The U.S. net foreign asset position deteriorated by $2.7 trillion in 2008. This corresponds to a transfer of 18% of U.S. GDP to RoW over that year.

**Fact 4:** The U.S. dollar is the world reserve currency and earns a safety premium. Institutions around the world, both private and governmental, hold reserves of U.S. dollars. This demand for U.S. dollar reserves is associated with the U.S. exorbitant privilege, the U.S. ability to fund itself more cheaply than other countries.

Lustig et al. (2014), Maggiori (2012), Verdelhan (2016) provide evidence of a positive and countercyclical safety premium for the U.S. 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 U.S. financial institutions, but also that empirical proxies of RoW financial net worth behave in the data in ways consistent

---

1. Source: Bureau of Economic Analysis (BEA). The percentages are: (Equity+Equity FDI)/(Total Assets-Derivatives) and (Debt+Other Investments+Debt FDI)/(Total Liabilities-Derivatives).
3. Source: BEA. The deterioration is due in part to changes in the U.S. portfolio positions and in part to capital losses. See Gourinchas, Rey, and Truempeler (2011).
4. Eichengreen (2011, page 64) shows that 63% of world official reserves were held in U.S. 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 U.S. 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 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.
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 U.S.’s 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 levered 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 of RoW financial institutions and the role of U.S. financial institutions, in addition to the U.S. Treasury, in providing safe assets to RoW. The asymmetric U.S. balance sheet (Fact 1) emerges from this asymmetric risk sharing. The U.S. 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 U.S. 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 U.S. to RoW and the role of the U.S. dollar as a global safe asset. Traditional models predict that a transfer of wealth from the U.S. to RoW during crises results in a U.S. 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 U.S. goods. If this were the case, the U.S. 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 (1929) and Ohlin (1929). In Section IV, I characterize the paradox and show that countervailing forces must be introduced to overcome it. I consider a case in which U.S. relative demand for U.S. goods increases during crises. Following recent debates in the trade literature (Eaton et al. (2016), Amiti and Weinstein (2011)), I study a set-up 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 U.S. and RoW exports are differentiated and, in particular, where the demand for U.S. 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 U.S. compared to RoW is in the spirit of Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Ríos Rull (2009). Kindleberger (1965) and Despres, Kindleberger, and Salant (1966) were among the first to argue that the U.S. asymmetric external

---

6I am not suggesting that financial development is the only characteristic. Recent literature, for example, has emphasized country size (Hassan (2012), Martin (2011)).
balance sheet, and previously that of the UK, could be due to differences in financial development. Caballero et al. (2008) analyze a deterministic model where the U.S.’s greater ability to supply tradable assets rationalizes the emergence of global imbalances, the U.S. trade deficit, and low long-term interest rates. Mendoza et al. (2009) analyze a production economy with idiosyncratic risk and limited contract enforceability, where the U.S.’s greater ability to enforce contracts leads to a lower U.S. interest rate and an asymmetric U.S. balance sheet. The most closely related work is that of Gourinchas, Govillot, and Rey (2010), who study the role of the U.S. as an insurance provider to RoW in a representative agent framework with complete markets, where agents differ in the coefficient of relative risk aversion. Most recently, Chien and Naknoi (2015) emphasize household finance as a source of global imbalances.

I contribute to this literature not only by providing a risk-based view of the role of the key country, which differs from the traditional macroeconomic view; more importantly, I do so by providing the underlying economic foundations through the explicit modeling of financial sector frictions and aggregate risk. Modeling aggregate risk is important to understanding the characteristics that distinguish the key country and its role during global crises. The microfoundations, rather than a preference based analysis, allow me to analyze the benefits and the costs of asymmetric risk sharing and potential inefficiencies of the global financial system. 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.

I also analyze exchange rate dynamics, which are important to understanding why RoW considers U.S.-dollar-denominated short-term debt to be safe. Previous papers do not model the role of the U.S. dollar as a reserve currency or its safety premium. In addition, the risk-based view of the key currency that I provide is in contrast to Krugman (1980) and Matsuyama, Kiyotaki, and Matsui (1993), who instead stress the vehicle role of the key currency for international trade.
II Autarky: the Banking Economy

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

\[
\frac{dY(t)}{Y(t)} = \mu \, dt + \sigma \, dz(t),
\]

(1)

where \(z(t)\) is a standard Brownian motion, and \(\mu\) and \(\sigma\) are constant.

The set-up 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 pre-determined 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:

\[
\max_{\{C(u)\}_{u=0}^\infty} E_t \left[ \int_0^\infty e^{-\rho(u-t)\log(C(u))} du \right]
\]

(2)

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

where \(D\) is the aggregate savers’ deposits and \(\Pi\) 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, upper-case letters denote aggregate quantities, while lower-case letters denote individual agents’ quantities. In addition, I use

\(^7\)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.
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 “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 $\lambda$ and $\lambda \frac{1-\beta}{\beta}$, respectively. When a financier switches role, she pays all her accumulated net worth to her household.

The financier’s optimization problem is, therefore, to maximize the value of

\[^8\]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.
the financial intermediary that she manages, subject to the credit constraint:

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

s.t.

\[
dn(t) = s(t)(dQ(t) + Y(t)dt) - r_d(t)d(t)dt
\]

\[
V(t) \geq 0,
\]

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 \( \delta \) 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: \( (D, \Pi) \). 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.

**Lemma 1. The Saver’s Problem.** The optimality conditions for the saver’s optimization in equation (2) imply that the saver prices risk-free deposits according \(^9\)The credit constraint is written in shorthand notation, but more formally has to hold in all future dates and states of the world.
This and all other proofs are reported in 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, \( \Omega \), 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. The 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:

\[
0 = \lambda \Lambda Q (1 - \Omega) dt + \Lambda \Omega Y dt + E_t [d(\Lambda Q)]
\]

\[
0 = \lambda \Lambda D_a (1 - \Omega) dt + E_t [d(\Lambda \Omega D_a)],
\]

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

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 \( \Lambda \). The latter, which would result in a tightening of the credit constraint, is captured by the multiplicative term \( \Omega \). 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.

\( \Omega \) 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 \( \lambda dt \) 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 \( \Omega \).

**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 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, \( \Omega \), 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

\[
\frac{d\tilde{N}}{N} = \left[ \rho - \lambda + \phi(\mu_Q - r_d + \delta - \sigma\sigma_Q) \right] dt + (\phi\sigma_Q - \sigma)dz
\]

\[
\equiv \mu_{\tilde{N}} dt + \sigma_{\tilde{N}} dz, \quad (7)
\]

where \( \phi \equiv \frac{Q}{\tilde{N}} \) 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, $\Omega(\tilde{N})$: \(^{10}\)

\[
0 = \mu_Q - r_d - \sigma_Q \sigma_\Omega + \sigma_\Omega \sigma_Q \\
0 = \lambda \frac{1 - \Omega}{\Omega} + \mu_\Omega - \sigma_\Omega \sigma_\Omega,
\]

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 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 non-linear: 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 iid 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 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 U.S. 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 U.S. and RoW. The empirical Facts 1-3 emerge from the implementation of this risk sharing.

\(^{10}\)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 $\Omega$ and $\tilde{Q}$. The explicit form of the ODEs is provided in Appendix A.1.
The U.S., 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 et al. (2008), and Mendoza et al. (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, where 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 set-up 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 $\star$.

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 $Q_s = n^\star + d^\star + b^\star$, where $b^\star$ is the amount that the financier has borrowed in the interbank market.

In a technical simplification 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 $\Omega^*$, 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:

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

s.t. \(dn^* = s^*(dQ + Y dt) - r^*_d d^*_dt - r_b b^*_dt\)
\(V^* \geq 0\).

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: $\bar{S}$ and $\bar{S}^*$, respectively. Consequently, new Home financiers receive $\delta \bar{S}Q$ and new Foreign financiers receive $\delta \bar{S}^*Q$. The aggregate net worth dynamics follow:

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

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

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 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 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.
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:

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

(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 \( V^* = \Omega^*(N^*)n^*. \) 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 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:

\[ 0 = \Lambda Y dt + E_t [d(\Lambda Q)] \]  

(12)

\[ 0 = E_t [d(\Lambda D_a)] \]  

(13)

\[ 0 = E_t [d(\Lambda B_a)]. \]  

(14)

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

\[ 0 = \Lambda^* \Omega^* Y dt + E_t [d(\Lambda^* \Omega^* Q)] \]  

(15)

\[ 0 = E_t [d(\Lambda^* D_a)] = E_t [d(\Lambda^* \Omega^* D_a)] \]  

(16)

\[ 0 = E_t [d(\Lambda^* B_a)] = E_t [d(\Lambda^* \Omega^* B_a)], \]  

(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: \( r_b = r_d = r^* \).

**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 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

\[
\frac{d\tilde{N}^*}{\tilde{N}^*} = \left[ (r_d - \lambda 1_{\{t < t'\}} - \mu + \sigma^2) + \phi^*(\mu_Q - r_d - \sigma \sigma_Q) + \delta \frac{\tilde{S}^* Q}{\tilde{N}^*} \right] dt + \left( \phi^* \sigma_Q - \sigma \right) dz \equiv \mu_{\tilde{N}^*} dt + \sigma_{\tilde{N}^*} dz,
\]

where \( \phi^* \equiv \frac{S^* Q}{\tilde{N}^*} \). 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, \( \Omega^*(\tilde{N}^*) \):

\[
0 = \mu_Q - r_d - \sigma \sigma_Q^2, \tag{18}
\]
\[
0 = \mu_{\Omega^*} - \sigma_{\Omega^*}^\sigma, \tag{19}
\]

where \( \frac{dC}{C} = \mu_C dt + \sigma_C dz \) and \( \frac{dC^*}{C^*} = \mu_C^* dt + \sigma_C^* dz \).
Appendix Proposition A.1 derives the equilibrium allocation. In the interest of space, I focus here on the resulting intuitive risk-sharing condition:

\[
\frac{C^*}{C} = \frac{\Omega^*}{\xi},
\]

where \(\xi\) 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 \(\Omega^*\) is counter-cyclical 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 U.S. 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 U.S. economy, thus inducing an asymmetric risk sharing. Figure 4 and Table 1 provide supportive evidence for these modeling elements.

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

Table 1 focuses, instead, on the importance of RoW financial institutions as
buyers of U.S. debt. Panel A focuses on U.S. debt held by foreign countries’
financial sectors as a percentage of each country’s total holding of U.S. debt. For
54 countries in the IMF Coordinated Portfolio Investment Survey, the financial
sector accounted for 66% of U.S. debt holdings on average for the period 2013-
2015. This percentage increases to 86% when countries are weighted by the
market value of their total U.S. debt holdings. Panel B of Table 1 highlights the
role of foreign financial institutions in some of the countries with the largest U.S.
debt holdings. For example, Japan, the largest holder of U.S. debt, reports that its
financial sector accounts for 96% of all Japanese holdings of U.S. 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 does not allow positions at the intermediary
level between RoW and U.S. financial intermediaries to be fully traced. This
prevents a direct analysis of the net effect of international transactions on leverage
at the intermediary 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 U.S. debt (both

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

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). The external adjustment of the U.S. 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), there are expected valuation effects on the NFA portfolio; these are generated in my model by time-varying risk premia. In the data, the U.S. NFA position is actually negative, but the U.S. still runs a trade deficit. The model helps rationalize this seemingly puzzling outcome: despite being a net debtor, the U.S. earns positive financial income on average since its assets, while fewer, are riskier than its liabilities. This income helps finance the U.S. trade deficit. The dynamic portfolio rebalancing of

15In contrast to the Rueff (1971) interpretation of the U.S. deficit as being “without tears”, I emphasize that the U.S. deficit is in fact financed by the “tears” of wealth transfers during crises.
Home and Foreign is consistent with the empirical evidence in Curcuru, Dvorak, and Warnock (2010), who find that RoW switches from equities to U.S. safe assets precisely at times when the future performance of these safe assets is poor compared to equities, which helps finance the U.S. trade deficit.\[^{16}\]

The model offers the view that some of the observed patterns in the data, including the 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 Lucas Open Economy). Even in the very 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 U.S. 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 Datasstream Financial Equity World ex-U.S. index by the World ex-U.S. 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 appendix). Appendix A.3.C provides full details, as well as robustness checks, on the measure construction.

Figure 5 focuses on the global financial crisis and plots the proxy of RoW financial net worth and the U.S. NFA and net exports. As the global financial crisis unfolds in 2008, RoW financial firms’ net worth crashes, going from 22% to 7% of RoW GDP, a 68% fall. At the same time, the U.S. suffers heavy losses in its

\[^{16}\]Curcuru et al. (2010) interpret the evidence in terms of bad timing of the purchase of U.S. safe assets from RoW investors. I interpret the empirical evidence in terms of time-varying risk compensation.
NFA portfolio, which worsens from -9% to -27% of U.S. GDP; this corresponds to a wealth transfer to RoW of 18% of U.S. GDP ($2.7trn in absolute value). U.S. net exports move in the opposite direction, showing an increase (a lower trade deficit) from -5.2% to -2.4% of U.S. GDP. These patterns are consistent with the dynamic predictions of my model, discussed above.

More generally, RoW financial net worth and U.S. 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 U.S. change in NFA minus net exports (NX) as a fraction of U.S. 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:

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

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% loss of RoW financial net worth is associated with a 1.2% deterioration of the U.S. external position (net of any movements in net exports) as a fraction of U.S. GDP. The linear relationship under-predicts U.S. external losses for large losses of RoW net worth (financial crises). For example, the linear relationship predicts a U.S. external loss of 11% in 2008, versus the actual 14%. This is consistent with the non-linearities in the model, which induce bigger Home external losses for bigger losses of RoW net worth (Figure 2 middle right panel). 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.

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 et al. (2014), Muir (2016), He et al. (2016)) 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.

17 Introducing a quadratic term \((\Delta \ln \tilde{N}_t^N)^2\) in the regression in equation (21) confirms this non-linear association in the data, but in the interest of simplicity I maintain the linear specification in the text above.
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 U.S. 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 U.S. 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 U.S. debt in dollar terms, rather than in terms of the local currency of the holder of the asset.18 In this paper, I offer a view of the international role of the U.S. 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, U.S. short-term debt denominated in dollars is safe for foreigners because the U.S. dollar appreciates in times of global crisis. A dramatic example of this behavior is the 24% appreciation of the U.S. 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 U.S. 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 U.S. dollar depreciation, which is inconsistent with the role of the U.S. dollar as a global safe asset. I call this tension between the wealth transfer from the U.S. to RoW during crises and the role of the U.S. 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.

18My view extends the “Global Saving Glut” hypothesis of Bernanke (2005) by emphasizing the role of the exchange rate in making U.S. short-term liabilities safe. After all, not even the safest U.S. 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 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

\[
\frac{dY(t)}{Y(t)} = \mu \ dt + \sigma \ d\bar{z}(t); \quad \frac{dY^*(t)}{Y^*(t)} = \mu \ dt + \sigma^* \ d\bar{z}(t),
\]

where \( \sigma = [\sigma_z \ 0] \), \( \sigma^* = [0 \ \sigma^*_z] \), and \( \bar{z} \) 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:

\[
C = C_H^{\alpha} C_F^{1-\alpha}; \quad C^* = C_H^{*\alpha - \alpha} C_F^{1-\alpha},
\]

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.

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

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

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

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

\footnote{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.}
prices, such that an increase in ToT represents a deterioration in the Home ToT. The real exchange rate \( (E) \) is expressed as the Home price of Foreign currency and is given by the ratio of Foreign to Home price indices (a fall in \( E \) is a Home currency appreciation). Thus, I have: \( \text{ToT} \equiv \frac{p^*}{p} \) and \( E \equiv \frac{P^*}{P} \). I denote the exchange rate dynamics by \( \frac{dE}{E} = \mu dt + \sigma d\tilde{z} \).

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 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 \( s^*_H \frac{Q}{P} + s^*_F Q^* = n^* + d^* + b^*_H + b^*_F \), 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:

\[
\max_{\{d^*(u),b^*_H(u),b^*_F(u),s^*_H(u),s^*_F(u)\}} \lambda^* (t) V^* (t) = E_t \left[ \int_{t'}^\infty \Lambda^*(u) e^{-\lambda (u-t')} \lambda n^*(u) du \right]
\]

s.t. \( dn^* = s^*_H \left( \frac{d}{E} \right) + p^* Y^* \frac{dt}{P^*} + s^*_F \left( dQ^* + p^* Y^* \frac{dt}{P^*} \right) + \left( -r^*_d dt - (r_b dt - \frac{dE}{E} + \sigma \sigma^T dt) b^*_H - r_b b^*_F dt \right) \]

\( V^* \geq 0, \) (26)

where \( \Lambda^* = e^{-\rho t} \frac{1}{C^*} \), \( t' = \inf \{ t : \Omega^* (\tilde{N}^*(t)) = 1 \} \) 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 \( \delta [\bar{S}^*_H \frac{Q}{E} + \bar{S}^*_F Q^*] \).

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

\[
\begin{align*}
C_H + C_H^* &= Y; \\
t C_F + C_F^* &= Y^*; \\
S_H + S_H^* &= 1; \\
S_F + S_F^* &= 1; \\
B_H &= -\varepsilon B_H^*; \\
B_F &= -\varepsilon B_F^*; \\
N^* &= S_H^* Q^* + S_F^* Q^* - D^* - B_H^* - B_F^*.
\end{align*}
\]

**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 \( V^* = \Omega^* (\bar{N}^*) n^* \). 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 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:

\[
 r_b^* - r_b + \mu_\varepsilon - \sigma_\varepsilon \sigma_\varepsilon^T = -Cov_i \left( \frac{d\Lambda^* \Omega^*}{\lambda^* \Omega^*}, \frac{d\varepsilon}{\varepsilon} \right) = (\sigma_{C^*} - \sigma_{\Omega^*}) \sigma_\varepsilon^T, \tag{27}
\]

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 \((\downarrow \varepsilon)\) 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 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, \( \hat{Q}^*(\hat{N}^*) \), and the marginal value of Foreign net worth, \( \Omega^*(\hat{N}^*) \):

\[
0 = \mu_Q - r_b - \sigma_C \sigma_Q^T \\
0 = \mu_Q^* + \mu_{\hat{\nu}} + \sigma_{\hat{\nu}} \sigma_Q^T - r_b - \sigma_C (\sigma_Q^* + \sigma_{\hat{\nu}})^T \\
0 = \mu_{\Omega^*} - \sigma_C \sigma_{\Omega^*}^T.
\]

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

\[
\frac{P^*C^*}{PC} = \frac{\Omega^*}{\xi} \quad (31)
\]

\[
C_H^* = \frac{(1 - \alpha)\Omega^*}{\alpha \xi + (1 - \alpha)\Omega^* Y}; \quad C_H = \frac{\alpha \xi}{\alpha \xi + (1 - \alpha)\Omega^* Y} \\
C_F^* = \frac{\alpha \Omega^*}{(1 - \alpha)\xi + \alpha \Omega^* Y^*}; \quad C_F = \frac{1}{\tau} \frac{(1 - \alpha)\xi}{(1 - \alpha)\xi + \alpha \Omega^* Y^*}. \quad (32)
\]

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

\[
ToT = \frac{\xi (1 - \alpha) + \alpha \Omega^* Y}{\alpha \xi + (1 - \alpha)\Omega^* Y}; \quad \varepsilon = (ToT)^{2\alpha - 1} \tau^{\alpha - 1}. \quad (34)
\]

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 \( \Omega^* \) weakens the Home ToT. This happens because an increase in \( \Omega^* \), 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 ($\tau$) 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 ($\Omega^*$), 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 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 U.S. 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 U.S. dollar denominated debt (bottom panel in Figure 1 and Figure 4) and the presence of a U.S. dollar safety premium (Fact 4).

The above paradox transcends the specific modeling set up 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 $\alpha$ 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) 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 (2012), Colacito and Croce (2011), Farhi and Gabaix (2016), Burnside et al. (2011), Hassan et al. (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 U.S.

\(^{21}\)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 (1929)). Ohlin, on the contrary, argued that no secondary burden would occur as long as French people spent the transfer on German goods (Ohlin (1929)). In this case, Keynes’ prediction proved closer to the empirical outcome.

\(^{22}\)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.
experienced during the global financial crisis.\textsuperscript{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, non-durables) (Dumas (1992), Obstfeld and Rogoff (2001b), Burstein et al. (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: \( \tau = \Omega^* \epsilon \), where \( \Omega^* \), in line with the previous section, is the Foreign marginal value of net worth and \( \epsilon \geq 0 \).\textsuperscript{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 non-durable goods for Home. The demand for each type of good is affected differently by global crises: trade costs then need to be interpreted as reduced form demand shifts according to economic conditions. Indeed, an alternative set-up in which a shift in Home demand in bad times toward its own good is represented by an \( \alpha \) that depends positively on \( \Omega^* \) has very similar predictions as the set-up with iceberg costs for the exchange rate and global portfolios.\textsuperscript{25} Both set-ups 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 rationalizes the reserve currency paradox by noting that in normal times, or even for mild negative shocks,

\textsuperscript{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 U.S. current account deficit and a large dollar depreciation were going to be the most likely outcomes of a forthcoming financial crisis.

\textsuperscript{24}The functional form is one of convenience. Similar qualitative patterns result from any decreasing function of scaled net worth.

\textsuperscript{25}For models with shocks to domestic bias, see Pavlova and Rigobon (2007, 2010a,b).
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 $\tau$, dominates and the Home currency appreciates. This non-linearity 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.

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. 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 U.S.-dollar-denominated debt liabilities of the U.S. (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 U.S. to RoW happens both because of the asset class mismatch, equity vs. debt as in the previous section, and the currency mismatch, dollar liabilities, in the U.S. external balance sheet.

The trade channel considered in this paper to counteract the reserve currency paradox has empirical predictions related to the dynamics of U.S. trade, particularly during global crises. The key predictions are: during a crisis, the U.S.

---

26Given $\alpha = 0.5$, 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 Appendix A.1 for details.
should experience a relative increase in its import-related trade frictions and a relative decrease in its export-related trade frictions, and U.S. consumption should become more home biased as a result of compositional effects of traded goods (durables vs. non-durables and services). The data are consistent with these predictions. Eaton et al. (2016) find that both channels contributed to a reduction in the U.S. trade deficit during the 2008-09 crisis. They fit a large-scale trade model to the data and find for the U.S. a substantial increase in trade frictions for imports (+18.2%) and a substantial decrease for exports (-14.5%). They also find that U.S. consumption shifts toward domestic goods, which occurred in the crisis because the U.S. had run a trade deficit in durable goods ahead of the crisis (as large as 1.8% of GDP in Q3 2008) and because the crisis redistributed demand away from durables to non-durables and services. They estimate that U.S. trade in durables as a fraction of GDP fell approximately 10% more than for non-durables during the acute phase of the financial crisis between the third quarter of 2008 and the second quarter of 2009. Levchenko et al. (2010) find similar patterns for the U.S. with both compositional effects of exports-imports of durables and trade wedges (frictions) contributing to the fall in U.S. 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 et al. (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 \( \tau \) in the paper for RoW should be interpreted relative to \( \tau_{US} \). 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%) and decrease for exports (-14.5%) 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% drop in Japanese export growth during the 2008-09 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 U.S. in the global financial architecture. I have shown how the greater depth of financial development of the U.S. 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.

References


Obstfeld, M. and K. Rogoff (2001a). Perspectives on OECD capital market in-


Table 1: Share of U.S. Foreign Debt Held by Foreign Financial Institutions

**Panel A: Average aggregate share**

<table>
<thead>
<tr>
<th>Country</th>
<th>Equally weighted by country</th>
<th>Weighted by country’s total U.S. debt holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average share from financials (% of total foreign holdings)</td>
<td>65.83</td>
<td>85.85</td>
</tr>
</tbody>
</table>

**Panel B: Top 5 countries by total U.S. debt held**

<table>
<thead>
<tr>
<th>Country</th>
<th>Share from financials (%)</th>
<th>Total debt holdings (USD bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>95.97</td>
<td>852.4</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>98.10</td>
<td>457.1</td>
</tr>
<tr>
<td>Germany</td>
<td>79.70</td>
<td>168.7</td>
</tr>
<tr>
<td>France</td>
<td>92.12</td>
<td>153.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>94.45</td>
<td>114.4</td>
</tr>
</tbody>
</table>

Notes. Individual country shares are constructed by dividing U.S. debt held by the foreign country’s financial sector by total U.S. 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 U.S. 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 5 largest holders of U.S. 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 U.S. debt held by each country’s financial sector as a share of total U.S. debt holdings by that country. Data are from CPIS published by the International Monetary Fund. Appendix A.3.B provides further details.

Table 2: U.S. NFA and RoW Financial Net Worth

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.0040</td>
<td>0.0034</td>
<td>0.0154</td>
</tr>
<tr>
<td></td>
<td>(0.0062)</td>
<td>(0.0064)</td>
<td>(0.0119)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.1189***</td>
<td>0.0850***</td>
<td>0.1805***</td>
</tr>
<tr>
<td></td>
<td>(0.0266)</td>
<td>(0.0285)</td>
<td>(0.0151)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.4031</td>
<td>0.5794</td>
<td>0.6347</td>
</tr>
</tbody>
</table>

Notes. Dependent variable is the annual change in the net foreign asset position of the U.S. minus net exports of goods and services, expressed as a share of U.S. GDP, $\frac{NFA - NX}{GDP}$. Regressors are a constant, and the logarithmic change in RoW financial net worth as a fraction of RoW GDP, $\Delta N^*$. The measure $\Delta N^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-U.S. index by world GDP ex-U.S. provided by the World Bank. 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 two also includes three dummies for the financial crisis years: 2007, 2008, and 2009. Standard errors are in parenthesis and built with Newey-West with one lag. P-values: ***, $p < .01$, ** $p < .05$, * $p < .1$.
Figure 1: U.S. External Position: Composition and Risk

### U.S. External Balance Sheet: 2015

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity: $6.8tr</td>
<td>Equity: $6.2tr</td>
</tr>
<tr>
<td>FDI: $7.0tr</td>
<td>FDI: $6.5tr</td>
</tr>
<tr>
<td>Derivatives: $2.4tr</td>
<td>Derivatives: $2.3tr</td>
</tr>
<tr>
<td>Debt: $6.8tr</td>
<td>Debt: $15.5tr</td>
</tr>
<tr>
<td>NFA: -$7.3tr</td>
<td></td>
</tr>
<tr>
<td>FX reserves: $0.4tr</td>
<td></td>
</tr>
</tbody>
</table>

### Asset Class Composition of U.S. External Portfolio

- **Riskier Assets**: Blue line
- **Safer Liabilities**: Red line

### Currency Composition of U.S. External Portfolio

- **% Assets in Foreign Currency**: Blue line
- **% Liabilities in U.S. Dollar**: Red line

*Notes. Top:* U.S. external balance sheet at year-end 2015. U.S. external assets: U.S. residents’ holdings of assets abroad, by asset class. U.S. external liabilities: RoW residents’ holdings of assets in the U.S., by asset class. Debt assets and liabilities are (debt + other investments). The net foreign assets (NFA) position is reported in red and as a negative number on the asset side. Source: Bureau of Economic Analysis. *Middle:* 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. *Bottom:* annual data (1990-2012) from Lane and Shambaugh (2010), Bénétrix et al. (2015). Shares of total U.S. external assets denominated in foreign currency and total U.S. liabilities denominated in U.S. dollars.*
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 $(0, \frac{1}{\rho(1+\xi)}]$; in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is $\frac{1}{\rho(1+\xi)}$. 

37
Figure 3: Open Economy Equilibrium, Single Tree: Asset Prices

Equity Excess Return: $\mu_Q - r_b$

Equity Volatility: $\sigma_Q$

Interbank (Risk-free) Rate: $r_b$

Sharpe Ratio: $\frac{\mu_Q - r_b}{\sigma_Q}$

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 $(0, \frac{1}{\rho(1+\xi)}]$; in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is $\frac{1}{\rho(1+\xi)}$. 

38
Figure 4: Foreign Holdings of U.S. External Debt

Notes. Top: RoW portfolio holdings of: debt securities issued by the U.S. government, debt securities issued by U.S. financial institutions, and other debt-like instruments (deposit and loans) that are liabilities of U.S. financial institutions. All data are from TIC: annual June 2002 to June 2015. Middle: RoW portfolio holdings of U.S. 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. Bottom: RoW holdings of debt securities issued by the U.S. government and U.S financial institutions as a percentage of total foreign holdings of U.S. debt securities. Data on holdings by type of security are from TIC, data on total foreign holdings are from Bureau of Economic Analysis. See Appendix A.3.A for full details on data sources and methodology.
Figure 5: U.S. 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 U.S. ($\frac{\text{NX}}{Y}$), net foreign assets as a share of GDP for the U.S ($\frac{\text{NFA}}{Y}$), and RoW financial net worth $\tilde{N}^*$. All series units are expressed as fractions (e.g. $\frac{\text{NX}}{Y} = -0.03$ means that net exports for that year are -3% of U.S. GDP). The outer left axis corresponds to $\tilde{N}^*$, the inner left axis to $\frac{\text{NX}}{Y}$, and the right axis to $\frac{\text{NFA}}{Y}$. The data are quarterly from 2006Q1 to 2011Q4. The measure $\tilde{N}^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-U.S. index by world GDP ex-U.S. provided by the World Bank. Appendix A.3.C provides further details on measure construction and robustness checks. Net exports of good and services, net foreign assets, and GDP for the U.S. are from the Bureau of Economic Analysis.
Figure 6: U.S. NFA and RoW Financial Net Worth: $\Delta \tilde{N}_t^*$ vs. $(\Delta NFA_t - NX_t)/Y_t$

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 U.S. minus net exports, expressed as a share of U.S. GDP: $(NFA_t - NX_t)/Y_t$. The horizontal axis plots the logarithmic change in RoW financial net worth as a fraction of RoW GDP, $\Delta \tilde{N}_t^*$. The measure $\tilde{N}_t^*$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex-U.S. index (code: FINWUS) by world GDP ex-U.S. provided by the World Bank. 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 red star maker. The regression line and coefficient reported here are those estimated in the benchmark regression in Table 2 column 1.
A.1 Appendix: Proofs, Details and Extensions

The Brownian motion in equation (1) is defined on a complete probability space and generates a filtration $\mathcal{F}$. Throughout this appendix, “adapted process” means $\mathcal{F}(t)$ adapted.

**Lemma 1.** Let me scale all variables by output. Then, given the conjecture that the saver’s value function only depends on scaled deposits and scaled net transfers, $U(\tilde{D}, \tilde{\Pi})$, the optimization problem is solved by the following Hamilton-Jacobi-Bellman (HJB) equation:

\[
0 = \sup_{\tilde{C}} \left\{ \log(\tilde{C})dt - \rho U(\tilde{D}, \tilde{\Pi})dt + E_t [dU(\tilde{D}, \tilde{\Pi})] \right\}
\]

s.t. \[
\begin{align*}
\tilde{D} &= \tilde{D}(r_d - \mu + \sigma^2)dt + (\tilde{\Pi} - \tilde{C})dt - \tilde{D}\sigma dz \\
\tilde{\Pi} &= \{\tilde{N}\lambda(r_d - \lambda) + \tilde{Q}[\lambda(\mu_Q + \delta - r_d) - \delta \mu_Q - \sigma \sigma_Q(\lambda - \delta)] + \tilde{\Pi}(\sigma^2 - \mu) + \delta \}dt + [\tilde{Q}\sigma_Q(\lambda - \delta) - \tilde{\Pi}\sigma]dz.
\end{align*}
\]

The first order condition (FOC) is: $\tilde{C}^{-1} = U'_D$, where the left hand side (LHS) is the first derivative of $U$ with respect to the scaled deposits. The verification that the value function only depends on $\{\tilde{D}, \tilde{\Pi}\}$ follows by substituting the FOC back into the HJB equation, from the fact that:

\[
\tilde{N} = \frac{\tilde{\Pi} + \delta \tilde{D}}{\lambda - \delta},
\]
\[
\tilde{Q} = \frac{\tilde{\Pi} + \lambda \tilde{D}}{\lambda - \delta},
\]

and from the fact that $\{\tilde{Q}, \mu_Q, \sigma_Q, r_d\}$ are going to only be functions of $\tilde{N}$ and can therefore be recovered by knowing $\{\tilde{D}, \tilde{\Pi}\}$. The sufficiency of the HJB equation for the solution of the optimization problem follows standard steps from the Verification Theorem.\(^1\) An explicit verification is omitted both here and in the following proofs.

To establish the claim that $-r_d \: dt = E_t \left[ \frac{d\Lambda}{\Lambda} \right]$, I employ the approach in Cox, Ingersoll, and Ross (1985). I take the difference between two expressions. The first expression is obtained by using the FOC above to write $\Lambda = e^{-\rho t \frac{U'}{Y}}$, and by applying Ito’s lemma to this function. The second expression is obtained by taking the partial derivative of the HJB equation above with respect to $\tilde{D}$ and by then multiplying it by $\tilde{e}^m$. Taking the difference between the two expression establishes, after tedious but standard algebra, the claim.

\(^1\)See (Øksendal, 2003, page 241).
Turning to the problem of the financier, notice that the appropriate discount factor in equation (3) is the marginal value of consumption of the agent receiving the dividends. The financier pays a dividend only once, when she is selected to switch role. The term $e^{-\lambda u}$ is the probability density function for this exponentially distributed event.

**Lemma 2.** Given the conjecture that the financier’s value function depends on aggregate scaled net worth and the individual financier’s net worth, $V(\tilde{N}, n)$, the optimization problem is solved by the following HJB equation:

$$0 = \sup_s \left\{ \lambda \lambda n dt + E_t [d(\Lambda V(\tilde{N}, n))] + \chi(t) dt V(\tilde{N}, n) \right\}$$

subject to:

$$dn = s(dQ + Ydt) - r_d dt$$

$$d\tilde{N} = [\tilde{N}(r_d - \lambda - \mu + \sigma^2) + \tilde{Q}(\mu_q - r_d + \delta - \sigma\sigma_Q)] dt + (\tilde{Q}\sigma_Q - \tilde{N}\sigma)dz,$$

where $\chi$ is the Lagrange multiplier. The FOC is:

$$\mu_Q - r_d = \sigma_C \sigma_Q - \sigma_\Omega \sigma_Q.$$  \hspace{1cm} (A.1)

When substituting the FOC back into the HJB equation, I obtain a restriction that the function $\Omega$ has to satisfy for the conjecture of the value function to be valid:

$$0 = \lambda \frac{(1 - \Omega)}{\Omega} + \mu_\Omega - \sigma_C \sigma_\Omega.$$  \hspace{1cm} (A.2)

As long as $\{\tilde{Q}, \mu_Q, \sigma_Q, r_d\}$ only depend on $\tilde{N}$ in equilibrium, then the conjecture that $\Omega$ only depends on $\tilde{N}$ is verified.

Using the saver’s Euler equation in equation (4) and equation (A.2), algebraic manipulations yield the result in equation (6). The additional use of the financier’s FOC yields the result in equation (5).

**Proposition 1.** The concept of equilibrium is the standard Walrasian one.\(^2\) The proofs of Lemma 1 and 2 state that to solve the saver’s and financier’s optimization problems one only needs to know the variable $\tilde{N}$, as long as $\{\tilde{Q}, \mu_Q, \sigma_Q, r_d\}$ only themselves depend on that variable. The saver’s Euler equation, equation (4), and the market clearing condition $C = Y$ together imply that the deposit rate is constant in equilibrium and is given by $r_d = \rho + \mu - \sigma^2$. Applying Ito’s lemma to $\tilde{Q} = \frac{Q}{Y}$ and to the conjecture $\tilde{Q}(\tilde{N})$ and matching the corresponding drift and diffusion terms yields:

$$\mu_Q(t) = \frac{1 + \tilde{Q}[\mu + \tilde{Q}(\delta - \mu - \rho)] + \tilde{N}\tilde{Q}(\rho - \lambda)}{\tilde{Q}(1 - \tilde{Q})} + \frac{(\tilde{Q} - \tilde{N})\tilde{Q}'\sigma^2}{\tilde{Q}(1 - \tilde{Q})} + \frac{(\tilde{Q} - \tilde{N})^2\tilde{Q}'\sigma^2}{2\tilde{Q}(1 - \tilde{Q})^3}$$

$$\sigma_Q(t) = \frac{\tilde{Q} - \tilde{N}\tilde{Q}'}{\tilde{Q}(1 - \tilde{Q})} \sigma.$$  

\(^2\)Consumption and investment decisions are adapted processes such that the financier’s and saver’s optimization problems are satisfied and markets clear.
Substituting these expressions into the financier’s FOC (equation (A.1)) yields the ODE for $\tilde{Q}(\tilde{N})$, reported in implicit form in equation (9), thus verifying that $\tilde{N}$ is the only state variable. The proof that the state variable is a strong Markov process follows from its dynamics in equation (7), where the drift and diffusion terms only depend on $\tilde{N}$ itself.

Equation (A.2) is the ODE for $\Omega$ reported in equation (9). The ODEs in equations (8-9) are implicit and I report here their explicit expressions:

$$\tilde{Q}'' = \frac{2(-1 + \tilde{Q}) \{-(-1 + \tilde{Q})(1 + \tilde{Q})(\tilde{Q} - \rho)\Omega + (\tilde{N} + \tilde{Q})\Omega - \tilde{N} \tilde{Q}'\sigma^2\Omega'}{(\tilde{N} - \tilde{Q})^2 \sigma^2 \Omega}$$  \hspace{1cm} (A.3)

$$\Omega'' = \frac{2(-1 + \tilde{Q})^2 \lambda \Omega(-1 + \tilde{Q} + \tilde{N} \Omega) + 2 \alpha'\{-(-1 + \tilde{Q})(-1 + \tilde{Q})(\tilde{Q} - \rho)\Omega + (\tilde{N} + \tilde{Q}) \sigma^2\Omega'}{(\tilde{N} - \tilde{Q})^2 \sigma^2 \Omega} + \frac{2 \alpha(-\tilde{N} + \tilde{Q})\tilde{Q}' \Omega}{(\tilde{N} - \tilde{Q})^2 \sigma^2 \Omega},$$  \hspace{1cm} (A.4)

where the superscript $''$ denotes the second derivative of a function.

The system of ODEs has an intuitive interpretation. The ODE (8) implies that the Sharpe ratio is higher than in the Lucas Economy; this occurs because financiers are worried about losses of capital that could restrict their investment opportunity set. To see this, re-write equation (8) as

$$\frac{\mu_Q - r_d}{\sigma_Q} = \sigma - \sigma_\Omega.$$

The Sharpe ratio has two components. The first, the volatility of consumption, which in equilibrium is equal to $\sigma$, is the same as in the Lucas Economy. The second, $\sigma_\Omega$, accounts for financiers’ required compensation, measured per unit of risk, to take on risk that is correlated with their net worth. In equilibrium, $\sigma_\Omega < 0$ because the marginal value of net worth increases when financiers lose capital. The ODE (9) is a restriction on the dynamics of $\Omega$; it ensures that financiers and savers agree on the pricing of risk-free deposits.

**Lucas Economy: Equilibrium Details**

Assuming that there are no frictions in the model removes the constraint $V(t) \geq 0$, by eliminating the incentives of the financiers to walk away from their intermediaries. Since financiers are unconstrained in raising deposits, $\Omega(\tilde{N}) = 1$ and $\tilde{Q}(\tilde{N}) = \frac{1}{\rho}$. These constant functions satisfy the ODEs in (A.3-A.4). The risk premium is constant and is given by $\frac{\mu_Q - r_d}{\sigma_Q} = \sigma^2$. Note that financiers can make arbitrarily large losses on their investment strategies because they are raising risk-free deposits with a positive interest rate, and investing in a risky asset.

---

3The saver’s Euler equation (4) and the fact that, in equilibrium, consumption equals output together imply that the risk-free deposit rate equals the risk-free rate in the Lucas Economy. For financiers to agree on the pricing of the risk-free rate, the ODE (9) requires that the intertemporal (elasticity of substitution) and intratemporal (precautionary) effects of financial risk ($\Omega$) on the risk-free rate exactly offset each other.
with a positive (and finite) risk premium. As a technical condition, to ensure that the financier’s optimization problem is well defined, I rule out the “doubling portfolio strategy” by restricting the set of admissible investment strategies to those that are square integrable.\(^4\)

To confirm that the underlying micro-foundations of the model are economically sensible, I analyze the dynamics of \(\hat{N} \equiv \frac{N}{Q}\):

\[
d\hat{N} = (\lambda - \rho) \left(\frac{\delta}{\lambda - \rho} - \hat{N}\right)dt + \sigma (1 - \hat{N})dz.
\]

Under the restriction \(\delta < \lambda - \rho\), the above stochastic process is mean-reverting and lies in the interval \((-\infty, 1)\).\(^5\) The stochastic steady state is \(\hat{N}^{SS} = \frac{\delta}{\lambda - \rho}\). Note that deposits are always positive.

Under the restriction \(\delta = \lambda - \rho\) the process, started at \(\hat{N}(t = 0) < 1\), will eventually drift to the absorbing upper boundary\(^6\) of 1. Consequently, the stochastic steady state is \(\hat{N}^{SS} = 1\). In this scenario, financiers eventually accumulate enough capital to purchase all shares in the output tree without having to raise deposits.

Notice that in this setting the constraint is violated with positive probability, but the intermediary losses are just accounting between financiers and savers with no effect due to the consumption risk sharing. Following investment losses, and even when net worth becomes negative, depositors are always repaid because when a financier with negative net worth is selected to switch roles, she pays negative net worth out to her household; that is, the household repays in full the selected financier’s depositors. Alternatively, one could achieve the frictionless equilibrium by allowing intermediaries to be financed via equity instead of deposits (which is not allowed under the frictions), at which point shares in the intermediaries and shares in the risky asset become identical.

**Asset Pricing in the Banking Economy: Equilibrium Details**

The financier’s FOC yields:

\[
\mu_Q - r_d = \text{Cov}(t) \left[ \frac{dC}{C}, \frac{dQ}{Q} \right] - \Omega' \Omega \hat{N} \text{Cov}(t) \left[ \frac{d\hat{N}}{\hat{N}}, \frac{dQ}{Q} \right].
\]

This implies that assets are priced according to a two factor asset pricing model, where the risk factors are consumption and the financial system’s net worth, that

\(^4\)See (Duffie, 2001, 6.c) for details.

\(^5\)A precise proof of the boundary behavior is beyond the scope of this paper. I only note that, given that financiers’ starting net worth is less than the price of the risky asset, in the limit of financiers accumulating sufficient net worth for deposits to shrink to zero (i.e. \(\hat{N} \uparrow 1\)) the diffusion term of \(\hat{N}\) approaches zero and the drift term is negative. See Karlin and Taylor (1981) for a precise proof of the boundary behavior.

\(^6\)This occurs because the drift of the process approaching the upper boundary is positive and decreases to zero in the limit, while the diffusion term converges to zero. See Karlin and Taylor (1981) for a rigorous description.
is:

\[ \mu_Q(t) - r_d = \lambda_C \beta_C(t) + \lambda_{\tilde{N}}(t) \beta_{\tilde{N}}(t), \]

and where the prices of risk and betas are defined as:

\[ \beta_C(t) = \frac{\text{Cov}_t \left[ \frac{dC}{C}, \frac{dQ}{Q} \right]}{\text{Var}_t \left[ \frac{dC}{C} \right]}, \quad \beta_{\tilde{N}}(t) = \frac{\text{Cov}_t \left[ \frac{d\tilde{N}}{\tilde{N}}, \frac{dQ}{Q} \right]}{\text{Var}_t \left[ \frac{d\tilde{N}}{\tilde{N}} \right]}, \]

\[ \lambda_C \equiv \text{Var}_t \left[ \frac{dC}{C} \right], \quad \lambda_{\tilde{N}}(t) \equiv -\text{Var}_t \left[ \frac{d\tilde{N}}{\tilde{N}} \right] \frac{\Omega'}{\Omega} \tilde{N}. \]

The first term on the RHS of equation (A.5) is the CCAPM, where assets are risky if their returns covary positively with consumption. Compared to the CCAPM in the Lucas Economy, the volatility of asset prices varies endogenously and, consequently, the beta in the Banking Economy is time-varying. The second term implies that assets are riskier if they covary positively with the financial system’s net worth. Both the market price and the beta of the financial risk factor are time-varying.

The risk-free deposit rate is constant and equal to the one in the Lucas Economy:

\[ r_d = \rho + \mu - \sigma^2 - \lambda (1 - \Omega) - \Omega' \mu_{\tilde{N}} - \frac{1}{2} \Omega'' \sigma_{\tilde{N}}^2 + \Omega' \sigma \sigma_{\tilde{N}} \]

\[ = 0 \text{ by ODE (9)}. \]

The ODE (9) imposes that the increase in the risk-free rate that occurs because of the inter-temporal drift in the value of capital (\( \mu_{\tilde{N}} \)) and the role switching of financiers and savers (\( \lambda (1 - \Omega) \)) is exactly offset by the precautionary motive to save that is induced by intra-temporal financial risk (\( \sigma_{\tilde{N}}^2 \)) and the covariance between consumption and financial risk (\( \sigma \sigma_{\tilde{N}} \)). The result rests on three features of my set-up: savers are atomistic, savers and financiers share risks perfectly, and equilibrium consumption is exogenous. In the autarky model, there is no tension between a higher equity premium and a low and stable risk-free rate, thus accommodating the risk-free rate puzzle.

Even if dividends are a random walk, the model endogenously generates persistent effects of iid shocks and forecastable equity excess returns. This occurs because excess returns are a function of aggregate net worth, which in turn is persistent and pro-cyclical. For example, a negative shock results in a capital loss for financiers and increases the risk premium;\(^7\) the only way to rebuild net worth is to earn the expected risk premium over time. Therefore, on impact, expected returns increase and then gradually decrease as financiers rebuild the stock of net worth.

\(^7\)I refer here to the region of the equilibrium away from zero net worth. The sign of predictability, i.e. that a low price-dividend ratio predicts high excess stock returns, is also maintained in the region close to zero net worth. However, the relationship between net worth and the price-dividend ratio is inverted.
As a technical note on the asset pricing properties of the equilibrium, notice that the FOC of the financiers and savers and the restriction on the dynamics of $\Omega$ imply that the financier is locally indifferent between the optimal investment strategy and investing in the risk-free rate. This occurs because the value function of the financier is linear in her own net worth. The property, however, does not survive globally because of the constraint on financiers’ financing. The financier has access to investment opportunities that are attractive for a logarithmic agent, however, she cannot invest an unlimited amount since the intermediate losses cannot be financed due to the constraint.

I provide here more details on the closed economy dynamics. Figure A.1 shows that the effects of bank capitalization on the equilibrium are non-linear. The dynamics of the first region are described in the main text of the paper. I note here that, as in Shleifer and Vishny (1992), the financiers attempting to sell the asset depress its price because the “natural buyers”, the other financiers, have also suffered capital losses and are also attempting to sell. The risky asset is non redeployable since savers, by assumption, value it at zero (cannot hold it). Fire-sale transactions never occur in equilibrium; financiers’ attempts to sell the asset reduce its price sufficiently to induce them to hold it. As in Kiyotaki and Moore (1997), a dynamic feedback effect amplifies this static effect. In my set-up, however, the dynamic effect arises from endogenous movements in the discount factor rather than in cash flows. Capital losses heighten intermediaries’ concerns about further losses and increase their discount factor for the risky asset. Since capital cannot be immediately replenished, the increase in the discount factor is persistent. The higher discount factor for future cash flows dynamically feeds back into lower present asset prices, thus further lowering intermediaries’ present net worth.

The amplification also generates an increase in the volatility of asset prices. The diffusion terms of the stock and of scaled net worth can be written as

$$\sigma_Q = \frac{\phi - \bar{Q}'}{\phi(1 - \bar{Q}')} \sigma; \quad \sigma_N = \phi \sigma_Q - \sigma. \quad (A.5)$$

Endogenously, $\phi \geq 1$ and $\bar{Q}' < 1$. Asset prices are more volatile than dividends whenever $\bar{Q}'(\phi - 1) > 0$, with the extent of the amplification depending on financial intermediaries’ leverage and on the reaction of the price-dividend ratio to changes in net worth.\(^8\) There is no amplification only if financial intermediaries are not levered ($\phi = 1$) or if the price-dividend ratio does not react to changes in intermediary capital ($\bar{Q}' = 0$). In the first region, amplification is positive since intermediaries are levered ($\phi > 1$) and the price-dividend ratio falls whenever intermediaries lose capital ($\bar{Q}' > 0$).

The equilibrium dynamics in this first region illustrate common characteris-

\(^8\)This emphasizes, as in Brunnermeier and Pedersen (2008), the interaction of market liquidity, i.e. the price impact of transactions in the risky asset ($\bar{Q}'$), and funding liquidity, i.e. the ability of financial intermediaries to raise capital for investment ($\phi$).
tics of financial crises. These dynamics change as further negative shocks push financial intermediaries into the second region, where their capital is close to zero. Recall that, in aggregate, the credit constraint takes the form $\Omega \tilde{N} \geq 0$. The tightness of the constraint is determined by the balance of two opposing effects: losses of capital, reflected in a lower $\tilde{N}$, induce increases in the value of capital, represented by a higher $\Omega$.

In the first region, losses of capital outweigh the effect of increases in the value of capital and tighten the constraint almost linearly. As financial intermediaries’ capital decreases further and we enter the second region, the increase in the value of capital alleviates the losses of capital and the constraint tightens more slowly. Intuitively, the higher Sharpe ratio mitigates the incentives of financiers to walk away from poorly capitalized financial intermediaries. This causes the price-dividend ratio to increase whenever there are intermediary capital losses ($\tilde{Q}' < 0$). In this case, equation (A.5) shows that capital gains have a stabilizing effect on losses of net worth and dampen the volatility of asset prices. The risky asset begins to mimic the risk-free one and, in the limit as net worth approaches zero, the risky asset is locally risk less.9

Under the restriction $\delta = \lambda - \rho$, the economy eventually converges to the Lucas Economy equilibrium. Intuitively, financiers accumulate net worth sufficiently quickly to reach a state where the entire supply of risky investments can be bought with the financial intermediaries’ capital.10 In this state, the absence of leverage induces the financial intermediaries’ capital to move one-for-one with stock prices, and financiers are no longer concerned about losing their net worth. The equilibrium dynamics of this case are illustrated in Figure A.1. In contrast, under the restriction $\delta < \lambda - \rho$ financiers do not converge to the frictionless equilibrium. In this case, deposits are always strictly positive and the levered financiers are forever concerned about potential losses of net worth. The resulting equilibrium dynamics are illustrated in Figure A.2.

In both cases, the stochastic steady state11 is the point in Figure A.3 where

---

9 This second region of the state space provides an endowment economy equivalent to financial depressions, such as the one experienced in Japan starting in the early 1990s. Following the most acute phase of a crisis, where the stock market crashes and volatility increases, further losses of capital lead to a depression region. Here, stock prices are so high compared to dividends that risky investment returns are low. Consequently, existing financiers are not able to quickly escape this region by accumulating net worth through positive returns on investments. Figure A.3 confirms the intuition by showing a fall in the drift and volatility of aggregate financial net worth. In the limit, as $\tilde{N} \downarrow 0$, the drift approaches $\delta \tilde{Q}$ and can be set arbitrarily close to zero by choosing a low value of $\delta$, and the volatility goes to zero. Brunnermeier and Sannikov (2014) provide a similar “area of attraction” in the low region of the state space. In my model, the main difference is that the depression is caused solely by endogenous changes in the discount factor, while cash flows are exogenous.

10 The balance of three effects regulates the asymptotic accumulation of aggregate net worth: financiers accumulate capital at the rate of time preference $\rho$, start-up capital allocated to new financiers increases aggregate net worth by $\delta$, and net worth paid out by exiting financiers reduces aggregate net worth by $\lambda$.

11 The stochastic steady state is defined as the point to which the state variable converges if shocks...
the drift of scaled net worth equals zero. In the first case, the stochastic steady state is the upper boundary of the state space: $\tilde{N}^{SS} = \frac{1}{\rho}$. The limiting distribution of scaled net worth is degenerate, with the entire probability mass concentrated at the stochastic steady state. In the second case, the stochastic steady state is in the interior of the state space; the stationary distribution of scaled net worth is reported in Figure A.4. The distribution has a fat left tail, since negative shocks are amplified more than positive shocks. Therefore, while fundamental shocks are iid Gaussian, the banking economy suffers from endogenous financial disasters. The distribution shows that the system does not spend substantial time near the zero net worth limit. This occurs because, while existing intermediaries might struggle to rebuild capital given their investment opportunity set, there is a continuous inflow of capital from households to incoming financiers. Recall that exiting financiers pay out their net worth, which of course is small in the limit of zero net worth, to households, while households provide capital to starting financiers at rate $\delta Qdt$. This net inflow of capital helps rebuild net worth and move the system back towards the steady state.

Lemma 3. Since the Home country is unconstrained, the proofs for the autarky case make clear that its consumption and portfolio problems are identical to those of a representative agent with logarithmic utility. The Euler equations in (12-14) are standard for such an agent. I focus here only on the optimization problems of Foreign agents.

Foreign savers solve a problem analogous to Lemma 1, so an entirely similar proof applies. Consider the problem of the representative financier in equation (10) for $t < t'$. Since the financier pays no net worth to the household for any $t < t'$, the discounted value of her intermediary needs to be a local martingale along the optimal path. The HJB equation is:

$$0 = \sup_{\{b^*(u), s^*(u)\}} E_t[d(\Lambda^*V^*)] + \chi(t)dt V^*,$$

where $\chi$ is the Lagrange multiplier. Conjecture that the value of the intermediary only depends on its capital and aggregate Foreign scaled net worth: $V(\tilde{N}^*, n^*) = \Omega^*(\tilde{N}^*)n^*$. The FOCs are:

$$\mu_Q - r_d^* = \sigma_c^* \sigma_Q - \sigma_{\Omega^*} \sigma_Q$$

$$r_b^* = r_d^*.$$  

Substituting the FOCs into the HJB equation leads to a restriction that $\Omega^*$ has to satisfy:

$$0 = \mu_{\Omega^*} - \sigma_c^* \sigma_{\Omega^*}. $$

are possible but are not ever realized. This is in contrast to the most commonly analyzed deterministic steady state, which is defined as the point of convergence if the model features no shocks ($\sigma = 0$).

A.8
Now consider the problem of the financier for \( t > t' \). I conjecture that in this case \( \Omega^* = 1 \) and the financier will pay out her net worth when she is selected to switch roles. The HJB equation is:

\[
0 = \sup_{\{b^*(u), s^*(u)\}} \left\{ \lambda A^*_t n^* dt + E_t [d(\Lambda^*_t V^*]) + \chi(t) dt V^* \right\},
\]

where \( \Lambda^{s,\lambda} = e^{-(\rho + \lambda) t} \frac{1}{C^*} \). The FOCs are analogous to those above for the case \( t < t' \), except that \( \sigma_{\Omega^*} = 0 \). Plugging the FOCs back into the HJB equation verifies the guess that \( \Omega^* = 1 \). However, for this conjecture to be an equilibrium, the upper boundary of the state space needs to be absorbing. This restriction is verified in Proposition 2.

It remains to be verified that for \( t < t' \) an individual financier will not want to deviate from the HJB problem described above for the representative financier. An individual financier faces the possibility that at some time \( t^A \), where \( t < t^A < t' \), she will switch jobs and the net worth of her intermediary will be reinvested with an incoming financier. Consider intermediary A with capital \( n^*A(t) \) that is liquidated at time \( t^A \), the capital of which is inherited by intermediary B. At time \( t^A \), the value of intermediary B is a linear function of its net worth. The linearity allows me to only concentrate on the capital inherited by intermediary A and, without loss of generality, to ignore the start up capital injected in intermediary B by the household. It follows that \( V^{sB}(t^A) = \Omega^* (\tilde{N}^*(t^A)) n^{sA}(t^A) \). Using the definition of the value of the intermediary and the law of iterated expectations one has:

\[
V^{sA}(t) = E_t \left[ \frac{\Lambda^*(t^A)}{\Lambda^*(t)} V^{sB}(t^A) \right] = E_t \left[ \frac{\Lambda^*(t^A)}{\Lambda^*(t)} E_{t^A} \left[ \int_{t'}^{\infty} \frac{\Lambda^*(s)}{\Lambda^*(t^A)} n^{sB}(s) \lambda e^{-\lambda (s-t')} ds \right] \right] = E_t \left[ \int_{t'}^{\infty} \frac{\Lambda^*(s)}{\Lambda^*(t)} n^{sA}(s) \lambda e^{-\lambda (s-t')} ds \right].
\]

Since the chosen timing of the liquidation \( t^A \) is arbitrary, this argument holds for a generic intermediary. This proves that the maximization problem for an individual intermediary is equivalent to the problem of the representative intermediary.

Using the Foreign saver’s Euler equation and the restriction on the dynamics of \( \Omega^* \) in equation (A.8) yields the financier’s pricing equation for the deposit rate in equation (16). Using equation (A.7) gives the result in equation (17). Equation (A.6), equation (16), and equation (A.8) together yield equation (15).

**Proposition A.1** The Open Banking Economy features an equilibrium risk sharing condition of the form \( \frac{C^*}{\tau} = \frac{\Omega^*}{\xi} \), with \( \xi \) a positive scalar.

The pricing equations for the Open Banking Economy (12-17) and the fact
that bankers can trade both the risk-less interbank rate and the stock together impose that:

\[
\frac{d\Lambda^*\Omega^*}{\Lambda\Omega^*} = -r_b \, dt - \frac{\mu_Q - r_b}{\sigma_Q} \, dz,
\]
\[
\frac{d\Lambda}{\Lambda} = -r_b \, dt - \frac{\mu_Q - r_b}{\sigma_Q} \, dz.
\]

Recalling that \( \Lambda = e^{-\rho t} \frac{1}{C} \) and \( \Lambda^* = e^{-\rho t} \frac{1}{C^*} \), this in turn yields:

\[
\frac{C^*}{C} = \frac{\Omega^*}{\xi},
\]

where \( \xi \) is a positive scaling constant to be determined in equilibrium given the starting conditions.

**Proposition 2.** The verification that the equilibrium can be solved as a function of a single state variable, the scaled net worth of Foreign intermediaries, requires solving a system of equations. As for the autarky case, this is straightforward but algebra intensive. I provide here the steps of the substitutions that I follow, although the substitutions can clearly be made in different orders. To solve for the equilibrium I have normalized all variables for the size of the output tree, so that in the resulting system \( Y \) is no longer a state-variable. The equilibrium risk sharing condition in equation (20) shows that the ratio of the two countries’ consumption is fully summarized by \( \Omega^* \). This relationship and the fact that the Home country is unconstrained together allow me to further reduce the number of state variables, since keeping track of \( \Omega^* \) is sufficient to keep track of the ratio of net-wealth in the two countries.

The conjecture that \( \Omega^* \) only depends on \( \tilde{N}^* \) remains to be verified. The steps are as follows. Use the risk sharing condition and goods market clearing to derive expressions for the drift and diffusion of consumption in each country. To compute the stock and international bond portfolio for each country use the standard derivation, as in frictionless open economies with complete markets à la Lucas. The Home country net wealth is \( W(t) = SQ - B \) and the consumption optimality condition and budget constraint imply \( W(t) = \frac{1}{\rho} C(t) \). Applying Ito’s lemma to both sides of this last equality and requiring the equality of the resulting LHS drift and diffusion terms with those of the dynamic Home net wealth budget constraint yields two equations linear in two unknowns: the stock position \( S^* \), and international borrowing \( B^* \). The market clearing conditions for stock and international bond (interbank loans) markets yield \( S^* \) and \( B^* \).

Use the Home saver pricing equation (13) to derive an expression for the risk-free rate. Finally, use the conjecture that \( \{\tilde{Q}, \Omega^*\} \) only depend on \( \tilde{N}^* \) to derive expressions for the drift and diffusion of these processes using similar steps to those in the proof of Proposition 1. These operations produce a system of equations in
\{\mu_Q, \sigma_Q, r_b, S, B, S^*, B^*\}; its solution expresses these variables as functions of \(\tilde{N}^*\) and the level and first two derivatives of the functions \(\{\tilde{Q}, \Omega^*\}\). Finally, substitute the variables in equations (A.6) and (A.8), the implicit ODEs reported in the main text, to obtain two coupled second order ODEs for \(\{\tilde{Q}, \Omega^*\}\), thus verifying the conjecture. I report here the extensive form of the ODEs:

\[
\begin{align*}
\tilde{Q}'' &= \frac{2(-1 + \tilde{Q}'S^*)^2((1 + \xi)(1 + \tilde{N}\tilde{Q}'\rho) + \tilde{Q}(\tilde{Q}'\delta - (1 + \xi)\rho))}{(\tilde{N} - \tilde{Q}S^*)^2(1 + \xi)\sigma^2} + \\
&\quad \frac{-2(\tilde{Q} - \tilde{N}\tilde{Q}'(1 + \tilde{Q}'S^*)\Omega^{'\prime\prime})}{(\tilde{N} - \tilde{Q}S^*)(\xi + \Omega^{'\prime})} - \frac{2(\tilde{Q} - \tilde{N}\tilde{Q}')\xi\Omega^{'\prime\prime}}{\Omega(\xi + \Omega^{'\prime})^2} + \\
\Omega^{'\prime\prime} &= \frac{2(-1 + \tilde{Q}'S^*)}{(\tilde{N} - \tilde{Q}S^*)^2} \left(\tilde{N} - \tilde{Q}S^* - \frac{(-1 + \tilde{Q}'S^*)(\tilde{Q}\delta + \tilde{N}(1 + \xi)\rho)}{(1 + \xi)\sigma^2}\right)\Omega^{'\prime}\right) + \\
&\quad \frac{2(-\tilde{Q}'S^* (\xi + \Omega^{'\prime}) + \tilde{N}(\xi + \tilde{Q}'S^*\Omega^{'\prime}))\Omega^{'\prime\prime}}{(\tilde{N} - \tilde{Q}S^*)\Omega^{'\prime}} + \frac{2\tilde{N}\xi\Omega^{'\prime\prime}}{\Omega^{'\prime} (\xi + \Omega^{'\prime})^2}.
\end{align*}
\] (A.9)

The system of ODEs has an intuitive interpretation. The ODE (18) is a standard pricing equation: it shows that expected stock excess returns depend positively on the covariance between Home consumption and stock returns. The ODE (19) ensures that Foreign financiers and savers agree upon the price of risk-free deposits.

The scaling constant \(\xi\) is pinned down by requiring that the initial net wealth in each country equal the present value of future consumption. For the Home country, this implies the restriction \(W(0) = \frac{1}{p}C(0)\). The starting conditions, \(\{S(0) = 1/2, S^*(0) = 1/2, B(0) = 0, B^*(0) = 0, Y(0), N^*(0), D^*(0)\}\), are chosen so that countries are symmetric. Each country starts with half of the total shares in the stock and no interbank loans. Within each country, shares are held by its intermediaries, which have a starting balance sheet composed of \(N(0)\) net worth and \(D(0)\) deposits (where \(1/2 Q(0) = N(0) + D(0)\)). Using the starting conditions and consumption rule for the Home country I have:

\[
\frac{1}{2} \tilde{Q}(0) = \frac{\xi}{(\xi + \Omega^*(0))\rho}.
\] (A.11)

Given \(\tilde{N}^*(0)\), the above equation pins down the value of \(\xi\). As discussed in Appendix A.2, the solution for \(\xi\) is unique for all the numerical solutions of the model.

For the equilibrium to be well defined it remains to be verified that, having started the state variable such that \(\tilde{N}^*(0) < \tilde{N}^{**} = \frac{1}{\rho(1 + \xi)}\), the stochastic steady state (i.e. the upper boundary) is reached and is absorbing, and that \(V^*\) exists and is strictly positive for every \(\tilde{N}^*(t)\) with \(t < t'\). The imposed parameter restriction \(\delta = \lambda - \rho\), as discussed in Appendix A.2, ensures that this is the case. The model cannot generate a long-run debtor position for the U.S. because the stochastic
steady state is one where risk taking is symmetric. The stochastic steady state in this model can be interpreted as a “very long run” outcome in which the RoW financial development and accumulation of capital make credit concerns irrelevant.

**Open Lucas Economy: Equilibrium Details**

Assume that there are no frictions in the Foreign financial sector, so that the constraint \( V^*(t) \geq 0 \) is no longer present in the Foreign financier’s optimization problem. Since Foreign financiers are unconstrained in raising deposits, \( \Omega^*(\tilde{N}^*) = 1 \) and \( \bar{Q}(\tilde{N}^*) = \frac{1}{p} \). These constant functions satisfy the ODEs in equations (A.9-A.10). The risk sharing condition in equation (20) now simplifies to the statement that consumption in the two countries is equal in every state (the equality follows from \( \xi = 1 \) since the two countries are symmetric). The risk premium is constant and equal to \( \mu_Q - r_d = \sigma^2 \). The equilibrium allocation is supported by international portfolios, where each country’s financiers own half of the total stock and no interbank loans.

The stochastic steady state is \( \tilde{N}^{*SS} = \frac{1}{2p} \), which is also the absorbing upper boundary of the state space.

**An application of the model to the U.K. before the First World War**

While the motivational evidence for this paper is focused on the U.S., the same theoretical framework also sheds light on the role of the U.K. as the key country before the First World War. London’s funding markets were then the deepest in the world; this was a key factor in determining Britain’s financial dominance (Bagehot (1873)). My model is related to Kindleberger’s (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.

My model also explains the global flight to safety toward the London funding markets, described by Bagehot (1873) for the financial crises of the nineteenth century. In contrast to recent U.S. history, however, Britain ran a sizable trade surplus at the time. In order to reconcile this with my framework recall that, though it is the focus of my model, I am not suggesting that financial development is the only determinant of the trade balance. Instead, my framework indicates that the key country runs either more of a trade deficit or less of a trade surplus than it would have otherwise done, if differences in the extent of financial development were not present. This allows other facts, such as Britain’s industrial base, to also

---

12 An extension of the paper could introduce mean reversion in the state variable, as was done in the closed economy, so that the U.S. has a permanent advantage in financial intermediation. Logic suggests that this would allow the U.S., in extreme cases, to run both an asymptotic trade deficit and a negative NFA position.

13 The similar claim of exploitation, or “exorbitant privilege”, that was later directed at the U.S. by the French Finance Minister Valéry Giscard d’Estaing, is often mentioned in connection with the stylized facts that concern my main analysis. I have shown how this can be demystified as the outcome of equilibrium risk sharing.
play a role in determining the overall trade balance.

**Open Economy, Two Trees: Static Optimization for Consumption Baskets**

Consider the problem for the Home country:

$$\max_{C_H, C_F} C_H^{1-\alpha} C_F\alpha$$

s.t. $$C_H p + C_F p \tau = C P,$$

where $CP$, aggregate expenditure, is given. Substituting the budget constraint for $C_F$, and re-arranging the FOC for $C_H$ yields the results in equations (24-25). The price indices for each country are derived by substituting equations (24-25) in the consumption basket, imposing $C = 1$, and rearranging to yield:

$$P = p^\alpha (p^\tau)^{1-\alpha} \alpha^{-\alpha}(1-\alpha)^{\alpha-1}; \quad P^\ast = p^{1-\alpha} p^{\ast\alpha} \alpha^{-\alpha}(1-\alpha)^{\alpha-1}.$$ 

Simple algebra then yields the expression for the exchange rate as a function of the terms of trade.

**Open Economy, Two Trees: The Home and Foreign Optimal Consumption and Investment Problems**

As in the proof of Lemma 3, since Home agents do not face financial frictions their optimization problem is equivalent to that of a Home representative agent with logarithmic preferences. Since such an optimization problem is standard, I only report here the corresponding Euler equations:

$$0 = \Lambda p Y P dt + E_t [d(AQ)] \quad \text{(A.12)}$$

$$0 = \Lambda p^\ast Y^\ast P dt + E_t [d(AQ^\ast)] \quad \text{(A.13)}$$

$$0 = E_t [d(A D_a)] \quad \text{(A.14)}$$

$$0 = E_t [d(A B_a)] \quad \text{(A.15)}$$

$$0 = E_t [d(A B_a^\ast)] \quad \text{(A.16)}$$

where $\Lambda = e^{-p Y P t}$, $D_a$ is the Home-currency deposit asset, $B_a$ is the Home-currency interbank asset, and $B_a^\ast$ is the Foreign-currency deposit asset with dynamics, respectively:

$$\frac{dD_a}{D_a} = r_d dt; \quad \frac{dB_a}{B_a} = r_b dt; \quad \frac{dB_a^\ast}{B_a^\ast} = r_b^\ast dt.$$ 

The no arbitrage condition implies that: $r_d = r_b$. Equation (27) is derived by rearranging equations (A.15-A.16) and using the dynamics of the exchange rate.

The Foreign saver solves a problem identical to that in the previous sections and the corresponding Euler equation is: $0 = E_t [d(A^* D_a^\ast)].$

The representative Foreign financier’s optimization problem in equation (26)
is solved analogously to the proof of Lemma 3, so I only describe here the differences. For \( t < t' \) the HJB equation is:

\[
0 = \sup_{\{b^*(u), b(u), s^*(u), s(u)\}} E_t [d(\Lambda^*V^*)] + \chi(t)dt V^*,
\]

where \( \chi \) is the Lagrange multiplier. Conjecture that the value of the intermediary has the form: \( V(\tilde{N}^*, n^*) = \Omega^*(\tilde{N}^*)n^* \). The FOCs are:

\[
\begin{align*}
\mu_Q - r_d^* &= \sigma C\sigma_Q^T - \sigma \Omega^* \sigma_Q^T, \\
\mu_Q - \mu_e + \sigma_Q^e \sigma_{Qe}^T - \sigma_Q^e \sigma_{Qe}^T - r_d^* &= \sigma C^e(\sigma_Q^e - \sigma_{Q}^e)T - \sigma \Omega^*(\sigma_Q^e - \sigma_{Q}^e)\tilde{A}, \\
r_b^* - r_b + \mu_e - \sigma_Q^e \sigma_{Qe}^T &= \sigma C^e \sigma_Q^T - \sigma \Omega^* \sigma_{Qe}^T, \\
r_b^* &= r_d^*.
\end{align*}
\]

Substituting the FOCs into the HJB equation leads to a restriction that \( \Omega^* \) has to satisfy:

\[
0 = \mu \Omega^* - \sigma C^e \sigma_{Qe}^T.
\]

The problem for \( t > t' \) follows the same logic as in the proof of Lemma 3 and requires \( \Omega^*(t') = 1 \). Using the FOCs and the Foreign saver’s Euler equation I obtain the Foreign representative financier’s Euler equations:

\[
\begin{align*}
0 &= \Lambda^* \Omega^* \frac{p}{P^*} dt + E_t \left[ d(\Lambda^* \Omega^* \frac{Q}{\xi}) \right], \\
0 &= \Lambda^* \Omega^* \frac{p^*}{P^*} dt + E_t \left[ d(\Lambda^* \Omega^* Q^*) \right], \\
0 &= E_t \left[ d(\Lambda^* \Omega^* D_a^*) \right], \\
0 &= E_t \left[ d(\Lambda^* \Omega^* B_a^*) \right].
\end{align*}
\]

**Proposition 3.** The pricing equations (A.12-A.16,A.22-A.26) and the fact that bankers can trade at least three independent assets imply that \( \Lambda = \Lambda^* \frac{\Omega^*}{\xi} \) and therefore:

\[
\frac{P^* C^*}{P C} = \frac{\Omega^*}{\xi},
\]

where \( \xi \) is a scaling constant to be determined.

Substituting the demand functions for the consumption of each individual good in equations (24-25) and using the goods’ market clearing conditions, \( C_H + C_H^* = Y \) and \( \tau C_F + C_F^* = Y^* \), yields the consumption allocations in equations (32-33).

The proof that the equilibrium can be solved as a function of a single state variable, the scaled net worth of Foreign intermediaries, follows steps similar to
the proof of Proposition 2. The substitutions are algebra intensive but straightforward and are omitted in the interest of space. The ODEs, reported in implicit form in Proposition 3, are obtained by using: the Home Euler equations (A.12,A.15) to derive the Home financier’s trade off between the Home stock and the Home interbank interest rate, which is the ODE in equation (28); the Home Euler equations (A.13,A.15) to derive the Home financier’s trade off between the Foreign stock and the Home interbank rate, which is the ODE in equation (29); and the restriction on \( \Omega^* \) in equation (A.21), which is the ODE in equation (30). The explicit form of the ODEs is omitted here because of the length of the expressions, but can be derived based on the information provided in this proof and is available on request.

In the models in Sections II and III, logarithmic preferences were mainly a matter of convenience. In the present section, logarithmic preferences permit one further simplification as agents have no desire to hedge their purchasing power risk (movements in the real exchange rate), thus allowing the model to be solved without introducing the ratio of the two trees as a state variable (see Coeurdacier and Gourinchas (2008), Pavlova and Rigobon (2007)). The downside of this simplification is that the equilibrium portfolios do not reflect this extra hedging demand, which would occur under general CRRA preferences. The central results of the paper, however, focus on how the portfolios are affected by the demand to hedge financial risk, which is not materially affected by the simplification to logarithmic preferences.

The international asset market structure of the model includes, by design, redundant assets. Since the fundamental source of risk is the two-dimensional vector of Brownian motions \( \vec{z} \), three assets with linearly independent returns are sufficient for a complete international asset market. For \( \alpha > 0.5 \) the two stocks are linearly independent and, therefore, the addition of either the Home or Foreign interbank asset is potentially sufficient to implement the equilibrium risk sharing. Various combinations are theoretically possible. The implementation that is of interest for this paper is the one where agents are not allowed to short-sell arbitrary large positions in the stocks and where the Foreign interbank market is shut-off. To derive the portfolio implementation of the equilibrium risk sharing recall that since the Home representative agent has logarithmic preferences one has: \( W(t) = \frac{1}{\rho} C(t) \). Applying Ito’s Lemma to both sides of this equation and using the Home dynamic budget constraint one has:

\[
\begin{bmatrix}
Q \sigma^T \Omega, \; Q^* \varepsilon (\sigma + \sigma^T)^T, \; -\sigma^T \varepsilon
\end{bmatrix}
\begin{bmatrix}
S_H, \; S_F, \; B_F
\end{bmatrix}^T = \frac{C}{\rho} \sigma C, \tag{A.27}
\]

and \( B_H \) can be obtained as the residual term in the Home budget constraint. The portfolios are derived by solving this linear system of equations and by imposing restrictions on \( \{S_H, S_F, B_F, B_H\} \).

Note that in the economy with frictions, financial markets are necessary for risk sharing despite agents having log preferences as in Cole and Obstfeld (1991).
Recall that savers cannot directly hold claims to the dividends of the trees so that they have to use the financial intermediaries in order to accumulate claims on output. Similarly to the autarky model, this makes sure that there is a rationale for financial intermediation in the model.

The scaling constant $\xi$ is pinned down in a fashion similar to the proof of Proposition 2. Recall that for the Home country one has $W(0) = \frac{1}{}\rho C(0)$. The starting conditions

$$\{S_H(0) = 1, S_F(0) = 1, B_H(0) = 0, B_F(0) = 0, Y(0) = Y^*(0), N^*(0), D^*(0)\}$$

are chosen so that countries are symmetric. Each country starts with all the shares in the domestic-tree stock and no interbank loans. Within each country, the shares are held by its intermediaries, which have a starting balance sheet composed of $N(0)$ net worth and $D(0)$ deposits (where $Q(0) = N(0) + D(0)$). Using the starting conditions and the consumption allocation for the Home country I have:

$$\tilde{Q}(0) = \frac{\xi}{(\alpha \xi + (1 - \alpha)\Omega^*(0))\rho}. \quad (A.28)$$

Given $\tilde{N}^*(0)$, the above equation pins down the value of $\xi$. The solution for $\xi$ is unique for all the numerical solutions of the model.

The stochastic steady state of this economy is $\tilde{N}^{**SS} \frac{1}{\rho(1+\delta)}$. Given the restriction $\delta = \lambda - \rho$, Appendix A.2 verifies that this is the absorbing upper bound of the state space. The steady state stock positions $\{\tilde{S}_H, \tilde{S}_F\}$ are defined as the limits of the positions approaching the steady state.

**Case $\alpha = 0.5$**

In the absence of home bias, stock returns, expressed in the same currency, are perfectly correlated. Therefore I focus on the intermediaries’ holdings of the aggregate stock market. The portfolio implementation of the equilibrium risk sharing can be derived using equations (A.27) and by imposing $B_F = 0$ and collapsing $\{S_H, S_F\}$ into a single world stock market position $S$. Equations (A.27), in this case, are a system of two equations in one unknown ($S$), but they admit a unique solution since the two equations are linearly dependent. This proves the claim in the main text that two assets are sufficient to implement the equilibrium allocation.

**Cole and Obstfeld Economy: Equilibrium Details**

In their classic analysis of the irrelevance of asset markets for international risk sharing, Cole and Obstfeld (1991) show that in an open economy with differentiated goods, agents with logarithmic preferences, and no trade costs, the

---

14The drawback is that in this case the NFA and CA are indeterminate because the equity holdings of each stock are indeterminate. Only aggregate equity holdings in each country are determinate. Determinacy of the NFA and CA can be restored via stronger assumptions on the composition of the equity portfolio.
central-planner’s allocation can be achieved even without trade in asset markets.\footnote{This occurs because the endogenous response of the ToT to supply shocks to the two goods is sufficient to implement the international wealth transfers that support the central planner’s consumption allocation.}

If there are no frictions, then the equilibrium of my model reduces to that of the Cole and Obstfeld Economy. Intuitively, if Foreign financiers face no frictions then: $\Omega^*(t) = 1$, so that the Euler equations and the demand equations for goods simplify to those in the frictionless world of Cole and Obstfeld.

As is well known, the Cole and Obstfeld equilibrium features: perfectly correlated Home and Foreign stock markets, symmetric aggregate stock market portfolio holdings,\footnote{Individual stock market positions are indeterminate since the two stocks are perfectly correlated, but each country’s holding of the aggregate stock market is determinate.} zero holdings of risk-free bonds,\footnote{In my setting there are zero holdings in the interbank market, which is equivalent to the risk-free international bonds in Cole and Obstfeld (1991), but the deposit market is still active. However, note that without frictions trading in the deposit market is merely a matter of internal accounting between the savers and financiers in each country, without any real effects. In this sense, the Cole and Obstfeld (1991) result on the irrelevance of international asset markets for risk sharing holds in my set-up when there are no frictions.} equal consumption state by state, zero NX, and indeterminate\footnote{The NFA indeterminacy is a consequence of the indeterminacy of the portfolio holdings of each stock. The CA is indeterminate because it is the change in NFA.} NFA and CA. The exchange rate is either constant ($\alpha = 0.5$) or positively related to the ToT ($\alpha > 0.5$). These results are a far cry from the stylized facts in Facts 1-4.

More formally, in this economy one has $\Omega^*(\tilde{N}^*) = 1$ and $\tilde{Q}(\tilde{N}^*) = \tilde{Q}^*(\tilde{N}^*) = \frac{1}{\rho}$. These constant functions satisfy the ODEs in equations (28-30). The risk sharing condition in equation (31) now simplifies to the statement that consumption in the two countries is equal in every state (the equality follows from $\xi = 1$ since the two countries are symmetric). The two stocks have perfectly correlated returns: $Q = Q^* \xi$. The equilibrium allocation can be implemented with no trading in the stock and in the interbank market, and trading only in the deposit and goods markets.

The stochastic steady state is $\tilde{N}^{SS} = \frac{1}{2\rho}$, which is also the absorbing upper boundary of the state space.

The Exchange Rate Paradox I expand here on the statement of the paradox in the main text.

Consider a loss of net worth for Foreign financiers, this leads to an increase in the marginal value of net worth $\Omega^*$. The equilibrium risk sharing condition, equation (31), implies that the real value of Foreign consumption goes up relative to Home consumption expressed in the same units. Equation (34) correspondingly shows the impact of this relative shift in consumption/wealth on the ToT and the exchange rate. A necessary condition for the ToT to depend positively on $\Omega^*$ is that $\alpha > 0.5$: $\text{sign} \left( \frac{\partial \text{ToT}}{\partial \Omega^*} \right) = 2\alpha - 1$. Similarly, if $\alpha > 0.5$ the real exchange rate
depends positively on the ToT: \( \text{sign}\left( \frac{\partial E}{\partial \text{ToT}} \right) = 2\alpha - 1 \). This shows that an increase in \( \Omega^* \) is associated with a contemporaneous Home ToT deterioration and a Home currency depreciation. Note that, as in the statement in the text, the trade frictions are assumed to be absent (\( \tau = 1 \)) so that the exchange rate only depends on the terms of trade.

Equation (27) illustrates the ex ante consequences of the expected positive association between the marginal value of net worth and the exchange rate:

\[
r_b^* - r_b + \mu_{\delta} - \sigma_{\delta}\sigma_{\delta}^T = -\text{Cov}_t \left( \frac{d\Lambda^*\Omega^*}{\Lambda^*\Omega^*}, \frac{d\delta}{\delta} \right)
\]

All else equal, a positive covariance between the marginal value of net worth and exchange rate changes makes the Home currency riskier for Foreign financiers. The Home currency depreciates in states of the world in which financiers’ marginal value of capital is higher and this ex-ante induces them to require higher expected returns (a risk premium) for holding Home currency.

### A.2 Numerical Solution Methods

The systems of ODEs in this paper are solved as boundary value problems (BVP) using the Matlab routine \texttt{bvp4c}.

**Section II: Autarky**

The system of coupled second order ODEs in equations (A.3-A.4) is to be solved over the interval \((0, \tilde{N})\), where \( \tilde{N} \) is unknown. The ODEs are singular at both boundaries of the interval. To deal with the singularity, I use asymptotic approximations to derive the boundary conditions. The boundary conditions are: \(^{19}\)

\(^{19}\)Intuitively, seven boundary conditions are required to solve the system: four boundary conditions because it is a system of two second order ODEs, one boundary condition to pin down the unknown parameter \( \tilde{N} \), and two boundary conditions to pin down the unknown parameters \( \{a, e\} \) introduced by the asymptotic approximations of the ODEs at the lower boundary.
\[ \dot{Q}(\tilde{N}) = \tilde{N} \tag{A.29} \]
\[ \dot{Q}(\tilde{N}) = \frac{1}{\rho + \dot{Q}'(\tilde{N}) (\lambda - \delta - \rho)} \tag{A.30} \]
\[ \Omega(\tilde{N}) = \frac{\lambda + \Omega'(\tilde{N}) \dot{Q}(\tilde{N}) (\delta + \rho - \lambda)}{\lambda} \tag{A.31} \]
\[ \dot{Q}(\varepsilon) = a - \sqrt{\frac{a\sigma^2}{\delta} \varepsilon^{\frac{1}{2}}} \tag{A.32} \]
\[ \dot{Q}'(\varepsilon) = -\frac{1}{2} \sqrt{\frac{a\sigma^2}{\delta} \varepsilon^{-\frac{1}{2}}} \tag{A.33} \]
\[ \Omega(\varepsilon) = 1 + \frac{e[1-a(\rho+\sigma^2)]}{\lambda \sqrt{\frac{a\sigma^2}{\delta}}} + e \varepsilon^{\frac{1}{2}} \tag{A.34} \]
\[ \Omega'(\varepsilon) = \frac{1}{2} e \varepsilon^{-\frac{1}{2}} \tag{A.35} \]

where \(\{a, e\}\) are unknown parameters, and \(\varepsilon\) is “small”. The boundary condition in equation (A.29) is obtained by imposing that \(\sigma_{\tilde{N}}(\tilde{N}) = 0\). The boundary conditions in equations (A.30-A.31) are obtained by imposing that \(\lim_{\tilde{N} \to \tilde{N}} \dot{Q}'(\tilde{N} - \tilde{N}) = 0\) and \(\lim_{\tilde{N} \to \tilde{N}} \Omega'(\tilde{N} - \tilde{N}) = 0\). Intuitively, these conditions require \(\tilde{N}\) to be an upper bound for the state space and, since intermediaries are highly capitalized, the solutions to change “smoothly” when approaching this upper bound.

The boundary conditions in equations (A.32-A.35) are obtained by using Laurent asymptotic approximations of the ODEs in the limit as \(\tilde{N}\) approaches zero, and by requiring zero to be a reflective boundary.

To adapt the problem to the Matlab routine \textit{bvp4c}, I re-write the system of ODEs by changing variables. Letting \(x = \frac{\tilde{N}}{\tilde{N}}\), I solve for the functions \(\{\dot{Q}(x), \Omega(x)\}\) on the interval \([\varepsilon, 1 - \varepsilon]\).

Note that simpler boundary conditions can be used under the parameter restriction \(\delta = \lambda - \rho\). In this case, \(\tilde{N} = \frac{1}{\rho}\) and the upper boundary conditions are \(\dot{Q}(\frac{1}{\rho}) = \frac{1}{\rho}\) and \(\Omega(\frac{1}{\rho}) = 1\). Intuitively, in this case the upper bound of the state space is absorbing and coincides with the Lucas Economy equilibrium.

The upper boundary conditions impose that \(\sigma_{\tilde{N}}(\tilde{N}) = 0\); it remains to be verified that \(\mu_{\tilde{N}}(\tilde{N}) \leq 0\). An inspection of the dynamics of \(\tilde{N}\) in equation (7) confirms that under the parameter restriction \(\delta = \lambda - \rho\) one has \(\mu_{\tilde{N}}(\tilde{N}) = 0\), and under the restriction \(\delta < \lambda - \rho\) one has \(\mu_{\tilde{N}}(\tilde{N}) < 0\).

**Section III: Open Economy Single Tree**

\(^{20}\)I report here the first two terms of the approximations, which I found to be sufficient in practice for an accurate numerical solution. I have also experimented with including higher order terms.
The system of coupled second order ODEs in equations (A.9-A.10) is to be solved over the interval \((0, \frac{1}{\rho(1+\xi)})\). The ODEs are singular at both boundaries of the interval. To deal with the singularity, I use asymptotic approximations to derive the boundary conditions. The boundary conditions are:\(^21\)

\[
\begin{align*}
\hat{Q} \left( \frac{1}{\rho(1+\xi)} \right) &= \frac{1}{\rho} \\
\Omega^*(\rho) \left( \frac{1}{\rho(1+\xi)} \right) &= 1 \\
\frac{\hat{Q}''(\epsilon) \epsilon}{\hat{Q}'(\epsilon)} &= -\frac{1}{2} \\
\frac{\Omega^{*''}(\epsilon) \epsilon}{\Omega^{*'}(\epsilon)} &= -\frac{1}{2}.
\end{align*}
\]

where \(\epsilon\) is “small”. The boundary conditions in equations (A.36-A.37) are the equilibrium solutions for the Open Lucas Economy. Intuitively, the upper bound of the state space is absorbing and coincides with the Lucas Economy equilibrium. The boundary conditions in equations (A.38-A.39) are obtained by using Laurent asymptotic approximations of the ODEs in the limit as \(\tilde{N}^*\) approaches zero and by requiring zero to be a reflective boundary.\(^22\)

The upper boundary conditions impose that \(\sigma_{\tilde{N}^*}(\frac{1}{\rho(1+\xi)}) = 0\); it remains to be verified that the upper bound of the state space is the absorbing stochastic steady state of the model. This is achieved by requiring that \(\delta = \lambda - \rho\). Under this restriction, the numerical solution shows that \(\mu_{\tilde{N}^*} > 0\) on the open interval \((0, \frac{1}{\rho(1+\xi)})\) and that \(\mu_{\tilde{N}^*}(\frac{1}{\rho(1+\xi)}) = 0\). Intuitively the state variable, having started at \(\tilde{N}^*(0) < \tilde{N}^{*SS}\), drifts toward the upper bound of the state space and remains there once it has been reached. Finally, the numerical solution shows that \(\Omega^*(t) > 1 \ \forall \ t < t'\), thus confirming that \(V^*\) exists and is non-zero.

As with the autarky case, to deal with the singularities I solve the system on the interval \([\epsilon, \frac{1}{\rho(1+\xi)} - \epsilon]\).

For simplicity, instead of selecting a starting value \(\tilde{N}^*(0)\), I guess a value for \(\xi\), solve the ODE system, and then back out the implied value for \(\tilde{N}^*(0)\) using equation (A.11). In all my numerical trials the implied value for \(\tilde{N}^*(0)\) is unique.

**Section IV: Open Economy Two Trees**

The system of coupled second order ODEs in equations (28-30) is to be solved over the interval \((0, \frac{1}{\rho(1+\xi)})\). The ODEs are singular at both boundaries of the

---

\(^{21}\)Intuitively, four boundary conditions are required to solve the system of two second order ODEs.

\(^{22}\)In contrast with the autarky model, where the first two terms of the approximations are used as boundary conditions, it is sufficient for an accurate numerical solution to provide the numerical solver with information about the rate at which the solutions move approaching zero (i.e. the exponent of the series expansion, which I find to be equal to \(\frac{1}{2}\)).
To deal with the singularity, I use asymptotic approximations to derive the boundary conditions. The boundary conditions are:

\[
\begin{align*}
\bar{Q} \left( \frac{1}{\rho(1+\xi)} \right) &= \frac{1}{\rho} \\
\bar{Q}^* \left( \frac{1}{\rho(1+\xi)} \right) &= \frac{1}{\rho} \\
\Omega^* \left( \frac{1}{\rho(1+\xi)} \right) &= 1 \\
\frac{\tilde{Q}''(\epsilon)}{\tilde{Q}'(\epsilon)} \epsilon &= -\frac{1}{2} \\
\frac{\tilde{Q}''''(\epsilon)}{\tilde{Q}''(\epsilon)} \epsilon &= -\frac{1}{2} \\
\frac{\Omega''(\epsilon)}{\Omega'(\epsilon)} \epsilon &= -\frac{1}{2} 
\end{align*}
\]

where $\epsilon$ is “small”. The intuition for the boundary conditions, the solution method, and the verification of the stochastic steady state are analogous to those for the Open Banking Economy with a single tree in the previous section.

### A.3 Appendix: Data Sources, Empirical Methodology, and Robustness Checks

This appendix details all data sources and methodologies, as well as provides further descriptions and robustness checks of the empirical results in the main text of the paper.

#### A Data and Methodology For Figure 4

I describe here the data sources and methodology used to generate the aggregate financial holdings described in Figure 4. I used three main data sources:

1. The Bureau of Economic Analysis (BEA) data on the U.S. International Investment Position. These data provide U.S. foreign assets and liabilities, divided into broad asset classes. The data are annual since 1976 and quarterly since 2006.

2. The Treasury International Capital (TIC) System provides annual detailed surveys of U.S. foreign assets and liabilities for portfolio holdings of securities. The surveys on “Foreign Portfolio Holdings of U.S. Securities” are

---

\(^{23}\)Intuitively, six boundary conditions are required to solve the system of three second order ODEs.
available annually (in June) for the period 2002-2015. Two earlier surveys of lower quality from March 2000 and December 1997 are also available. Similarly, surveys on “U.S. Residents’ Portfolio Holdings of Foreign Securities” are available annually (in December) for the period 2003-2015, with three earlier surveys of lower quality available from December 2001, 1999, and 1997. The detailed data used in this paper are only available in the TIC surveys’ “appendix tables” for the years 2003-2015, hence I do not use data from the earlier ad-hoc surveys.

3. The Financial Accounts of the United States (Z.1) data released by the Federal Reserve and, in particular, the flow of funds and balance sheet account data. I use the quarterly releases for the period 2002-2015.

Sources and Methodology for Top Panel in Figure 4. This figure plots the foreign portfolio holdings of: debt securities issued by the U.S. government, debt securities issued by U.S. financial institutions, and other debt-like instruments (deposit and loans) that are liabilities of U.S. financial institutions. All data are from TIC. Publicly available TIC reports include a table that provides a breakdown of foreign holdings of U.S. securities by the U.S. sector of issuance.24

The foreign portfolio holdings of U.S. government debt securities primarily include U.S. Treasuries, as well as some bonds issued by state and local governments.25 TIC specifies that “when state and local bonds are clearly associated with a particular industry, such as utilities or education, they are classified by that industry” (Department of the Treasury (2015)).

The foreign portfolio holdings of debt securities issued by U.S. financial institutions include debt securities issued by firms classified as “financials” in the Global Classification Industry Standard Code (GICS) developed by Morgan Stanley Capital International and Standard & Poor’s. For the years 2002-2014, I have included debt issued by the sector Total Financials (code: 4000), with sub-sectors: Commercial Banks (401010), Thrifts and Mortgage Finance (401020), Diversified Financial Services (402010), Consumer Finance (402020), Capital Markets (Mutual Funds) (402030), Insurance (403010), Real Estate Investment Trusts (REITS) (404020), Real Estate Management and Development (404030).26 Starting with the 2015 survey, TIC switched its sector classification to the North Amer-

24Unfortunately, the numbering of this table in TIC PDF reports changes from year to year. As guidance for the reader, the Table is number 19 in the 2015 TIC report (and number A11 in the related appendix) and number 20 in the 2014 TIC report (and number A11 in the related appendix).
25Mymodel could be extended to formally account for the role of the government and government securities. Alfaro, Kalemli-Ozcan, and Volosovych (2014) show that a number of foreign central banks are official holders of U.S safe assets. The model can accommodate this phenomenon by introducing a Foreign central bank that buys the Home safe asset and then issues safe bonds to domestic financial intermediaries. Future research could also build on this framework by explicitly modeling governments and their policies to study the international monetary system.
26In earlier surveys, 2002-2007, the last two codes are aggregated in a broader sector called “Real Estate”.

A.22
ican Industry Classification System (NAICS) developed by the U.S. Census Bu-
reau. For the year 2015, I have included debt issued by the following sectors: De-
pository Credit Intermediation (Banking) (code: 5221), Other Financial (codes:
5222-5239, including Real Estate Credit, Investment Banking, and Other Credit
Intermediated as sub-codes), Insurance (code: 524), Funds, Trusts, and Other
Financial Vehicles (code: 525).

The foreign holdings of U.S. “Deposits, Loans and Other” debt-like financial
instruments as reported from banks are from TIC. This series includes deposits,
brokerage balances, loans, repurchase agreements, and trade payables and ad-
vance receipts. The data are from Table 20 of the June 2015 TIC report, which
also makes available historical data starting from 2002.27

Interestingly, the Top Panel in Figure 4 shows a strong increase in the value
of U.S. government debt held by foreigners since the 2008 financial crisis: the
value of the holdings doubled from $3trn in 2006 to $6trn in 2015. This increase
in holdings is consistent with an increased (precautionary) motive for RoW to
hold the ultimate safe asset in the aftermath of the financial crisis. RoW holdings
of debt issued by U.S. financial institutions show a marked increase from $1trn
to over $3trn in the years just preceding the global financial crisis (2004-2007).
This pattern is consistent with the U.S. private sector and, in particular, the fi-
nancial sector expanding its supply of safe assets in response to increased foreign
demand. However, the marked increase (especially 2006 and 2007) has to be
viewed with caution: several authors (Bernanke et al. (2011), Shin (2012)) have
commented on European financial institutions performing a kind of off-shore fi-
nancial intermediation vis-à-vis the U.S. during this period. More specifically,
European financial institutions borrowed in the U.S. wholesale funding market
via their U.S. branches, and transferred the funds to Europe to then reinvest them
in the U.S. in higher yielding debt securities. Since International Investment Po-
sition and TIC data are based on the residency principle, these transactions affect
the data, even though from an economic perspective it is ambiguous whether they
should be classified as U.S. domestic financial intermediation.28 Similarly, the
residency principle of the statistics means that foreign holdings are affected by
off-shore financial centers. For example, if a U.S. resident institution (or individ-
ual) holds a U.S. debt security via an account in an off-shore financial center (e.g.
Cayman Islands), then the security is incorrectly classified as an external liability
of the U.S. rather than as a domestic transaction (Bernanke et al. (2011), Shin
(2012), Department of the Treasury (2015)). Even with these reasonable caveats
about overstating the foreign financial sector holdings of U.S. securities, a pattern
emerges of substantial holdings both before and after the 2008 financial crisis.

27 Data on deposits, loans, and other reported in this table are themselves sourced from the TIC
reporting on forms BL1, BL2, BQ2, CQ1, and CQ2.
28 Since the focus of my paper is on explaining the aggregate U.S. international position, I have
grouped the RoW intermediaries into one homogenous class. This simplification allows the model
to sharpen its focus on aggregate flows, and leaves it to future research to also model the hetero-
geneity of the RoW intermediaries.
Sources and Methodology for Middle Panel in Figure 4. The middle panel of Figure 4 builds on the series in the top panel of the same figure, described above. The middle panel plots the foreign portfolio holdings of U.S. debt securities issued by each sector, i.e. the government and financial institutions, as a fraction of the total outstanding stock of debt issued by that sector. I estimate the total outstanding stock of debt issued by the U.S. government and U.S. financial institutions using the Financial Accounts of the United States (Z.1) data released by the Federal Reserve.

For government securities, the middle panel of Figure 4 plots the percentage of marketable U.S. Treasury debt held by foreign residents. I follow the TIC reports’ methodology and source the total outstanding stock of marketable U.S. Treasury debt from the Bureau of Public Debt, Table 1, Summary of Public Debt, Summary of Treasury Securities Outstanding. Total marketable debt is debt held by the public, including the Federal Reserve System but excluding Treasury Bills. I focus on the percentage of Treasury debt held by foreigners, rather than all government debt, because TIC does not provide an exact account of local and state government debt holdings by foreigners; it is therefore not possible to build the corresponding stock of outstanding debt. Overall, focusing on Treasuries rather than total government debt does not appear problematic, since foreign holdings of marketable U.S. Treasury debt account for the vast majority (80%) of all government debt holdings by foreigners. On the one hand, one might think that excluding state and local government debt may overstate the fraction owned by foreigners, since foreigners might be more likely to buy treasury debt than local or state debt. On the other hand, one can think that including Fed holdings of Treasuries in the marketable stock (the denominator) might understate the fraction owned by foreigners, since inter-holdings of U.S. government agencies should be netted out and not be considered debt issuance. Nonetheless, these reasonable concerns are unlikely to change the overall conclusion that a substantial fraction (between 40-60%) of U.S. government debt is held by foreigners.

Foreigners have historically held more U.S. Treasuries than agency debt (both in absolute terms, and as a percentage of the available stock). For example, TIC analysts estimate that foreigners owned $880bn of agency debt (11.9% of the total stock) compared to $5,450bn of treasuries (48.2% of the stock) in 2015. This pattern holds more generally over the 2002-2015 period, during which foreigners owned on average 14.5% of total agency debt, compared to 51.5% of marketable Treasuries. Foreign holdings of U.S. agency debt reached their zenith in the years preceding the global financial crisis: holdings in 2007 and 2008 were $1,304bn and $1,464bn, or 20.7% and 20.8% of the stock, respectively. Bernanke et al. (2011) showed that these heightened holdings were largely related to European financial institutions buying agency debt while funding themselves in the U.S. with

---

29 Agencies include U.S. government agencies and corporations as well as federally sponsored enterprises, such as the Federal National Mortgage Association.

30 The statistics reported in this paragraph on foreign holdings of U.S. government agency debt are from Department of the Treasury (2015)[Table 2].
short-term wholesale debt, a form of off-shore financial intermediation. Since these patterns are not the main focus of this paper, I have not focused on agency debt in the main body of the paper.

The middle panel of Figure 4 also plots the percentage of long-term debt issued by U.S. financial institutions and held by foreign residents. I built this series by dividing the foreign holdings of long-term debt issued by U.S. financial institutions by the total stock of long-term debt securities issued by these institutions. The foreign holdings of long-term debt issued by U.S. financial institutions are almost entirely identical to the total holdings (both short and long term), as reported in the top panel of Figure 4 and described above. In this case, I exclude short-term (less than 1 year) debt holdings to make the numerator most comparable to the denominator estimated below the using Flow of Funds data. This adjustment is minimal, since long-term debt holdings accounted for an average of 98% of total holdings of debt issued by U.S. financial institutions over the period 2002-2015. I obtain the total stock of debt for U.S. financial institutions by adapting the procedure used by TIC analysts to estimate the stock of total corporate debt (financial and non-financial). I use the Federal Reserve Statistical Release Z.1, Financial Accounts of the United States.

Starting from Table L.213 Corporate and Foreign Bonds, I first estimate the stock of financial liabilities by removing “Nonfinancial Corporate Business” (series: Z1/Z1/FL103163003.Q, row 2 of Table L.213) and “Rest of the World” (series: Z1/Z1/LM263163005.Q, row 11 of Table L.213) from “Total Liabilities” (series: Z1/Z1/FL893163005.Q, row 1 of Table L.213). This stock still includes debt issued by state and local government entities and classified as corporate. In estimating the total stock of corporate debt (financial and non-financial), TIC analysts then proceed by further subtracting “Long-term Debt Securities issued by State and Local Governments” (series: Z1/Z1/FL213162200.Q, row 21 of Table L.107). While I follow this procedure in producing the data for Figure 4 in the main text, I report in Figure A.5 a robustness check that does not exclude from the denominator (the total stock of debt issued by U.S. financial institutions) debt issued by “Long-term Debt Securities issued by State and Local Governments”. In computing foreign holdings of debt issued by state and local governments, TIC analysts exclude situations “when state and local bonds are clearly associated with a particular industry, such as utilities or education, [and those bonds are then] classified as being issued by that industry” (Department of the Treasury (2015)). This opens up the possibility, however remote, that a substantial portion of state and local government debt is being classified as debt issued by financial institutions because it is associated with that industry. If this were the case, the procedure adopted in producing Figure 4 in the main text would overstate the percentage of bonds issued by U.S. financial institutions and held by foreigners, because it would include state and local government bonds classified as financials in the numerator and not in the denominator. Figure A.5 illustrates what would happen if I made, incorrectly, the extreme assumption that all debt by state
and local governments should be included in the denominator. The fraction of U.S. financial institution debt held by foreigners would clearly be lower, but still substantial at 20% to 30%.

When buying corporate debt (which includes financial institutions), foreigners predominantly focus on U.S. financial institutions. Indeed, TIC reports that foreigners held 26% of all U.S. corporate debt in 2015, but the fraction (which I estimated above) is considerably higher at 47% when focusing on debt issued by U.S. financial institutions. The pattern holds more generally: for the period 2008-2015, foreigners on average held 23% of all U.S. corporate debt, but a higher 44% of the subset of corporate debt issued by U.S. financial institutions.\(^\text{31}\) This shows that foreigners are providing a substantial part of the debt financing (leverage) of U.S. financial institutions, more so than they do directly for non-financial U.S. corporations.\(^\text{32}\)

**Sources and Methodology for Bottom Panel in Figure 4.** This panel plots the foreign holdings of debt securities issued by the U.S. government and U.S. financial institutions as a percentage of total foreign holdings of U.S. debt securities. The foreign holdings of debt securities issued by the U.S. government and U.S. financial institutions are those illustrated in the top panel in Figure 4 and described above. The total holdings of U.S. debt securities by foreign residents are sourced from the BEA (U.S. Liabilities, Debt Securities). The bottom panel in Figure 4 also plots the foreign holdings of debt-like securities issued by the U.S. government and U.S. financial institutions as a percentage of total foreign holdings of U.S. debt-like securities. This expands on the previous series by adding to the numerator the foreign holdings of U.S. “Deposits, Loans and Other” debt-like financial instruments from TIC (as illustrated in the top panel in Figure 4 and described above) and by adding to the denominator the total holdings of “Other Investment” by foreign residents sourced from the BEA (U.S. Liabilities, Other Investment, subcategories: Currency and Deposits, Loans, Insurance Technical Reserves, Trade Credit and Advances, Special Drawing Rights Allocations).

**B RoW Financial Sector Holdings in the U.S. in Table 1**

I provide here further details, robustness checks, and data sources, and describe the methodologies used to produce the results reported in Table 1.

**Data Sources.** I use the Coordinated Portfolio Investment Survey (CPIS) to analyze the importance of the foreign financial sector in portfolio investment in the U.S.; in particular, I focus on foreign financial sector holdings of U.S. debt

---

\(^{31}\)The statistics reported in this paragraph on foreign holdings of U.S. corporate debt are from Department of the Treasury (2015)[Table 2].

\(^{32}\)U.S. financial institutions might pass on part of the foreign funding (leverage) to U.S. corporates via lending agreements.
securities. CPIS is collected and published by the International Monetary Fund. The IMF has recently revamped this survey and, in particular, has encouraged more countries to provide data on sectoral holdings of foreign securities. These data allow me to analyze the fraction of U.S. debt liabilities to foreigners that is held by foreign financial institutions. These more detailed data are available for more countries bi-annually in June and December, starting with the enhanced survey in June 2013. Therefore, in this paper I use the data release of May 2016, and focus on the surveys between June 2013 and June 2015.

CPIS data provide bilateral holdings of debt (long-term and short-term) and equity for countries that participate in the survey. For the purpose of this paper, I focus on the subset of the data containing countries’ investments in the United States. These data are obtained by focusing on foreign countries’ assets in the U.S., which are measured directly in the surveys, rather than on U.S. liabilities, which are derived from the asset-side of the remaining countries. For example, U.S. foreign liabilities are derived from investments in the U.S. reported (on the foreign-asset side) by other countries included in the survey. To avoid redundancies, I only focus on investments in the U.S. by other countries. I include only the subset of the survey data beginning June 2013 and ending June 2015, as only few countries reported sectoral holdings, often on an infrequent basis, prior to the June 2013 update to the survey methodology (see also Galstyan et al. (2015)).

**Financials Shares.** For each country and asset class I focus on the total holdings of securities by the following sectors: Central Bank, General Government, Other Financial Corporations, Nonfinancial Corporations, Households and NPISHs, Depository-taking Corporations except the Central Bank. From these original sectors, I aggregate the data into a new set of sectors called: Government, Financials, Nonfinancials. The mapping from CPIS classification to this paper’s classification is intuitive and summarized in Table A.1. The CPIS field “Other Financial Corporations” includes the sub-fields: Insurance Corporations and Pension Funds, Money Market Funds, and Other.

For each instance of the survey $t$, country $i$, and asset class $j$, I build the share of portfolio investment in the U.S. held by each of the three sectors $s$ as:

$$\phi_{i,j,s,t} = \frac{X_{i,j,s,t}}{X_{i,j,ToT,t}}, \quad (A.40)$$

where $X_{i,j,s,t}$ is the investment in the U.S. in asset class $j$ from country $i$’s sector $s$ for the survey period $t$, and $X_{i,j,ToT,t} = \sum_s X_{i,j,s,t}$ is the total investment across all sectors.\(^{34}\)

---

\(^{33}\)I also exclude the few instances in which short positions are recorded on the asset side. Excluding short positions does not alter the results, as they comprise less than 0.01% of the dataset in value terms.

\(^{34}\)For approximately 5% of the dataset, the sum of reported subtotals across sectors does not match the corresponding reported total in CPIS. In these instances of internal inconsistency in CPIS, I use the reported total in the denominator of equation (A.40) rather than the sum of the
For robustness, I exclude records that appear very likely to have been incorrectly filled out in the surveys, using as a guiding principle that no country’s financial sector can account for either exactly 100% or 0% of the country’s portfolio investment. I clean the data from these spurious records using the following procedure:

1. If for all surveys the values of $\phi_{i,j,Financials,t}$ for a specific country and asset class combination are all either equal to 0 or 1, or larger than 1, I treat $\phi_{i,j,Financials,t}$ as missing for that country and asset class for all surveys.\footnote{Due to survey rounding, I allow a margin of 0.0001 around the values of 0 and 1. This means that a value of 0.0001 is considered equivalent to 0, and similarly a value of 0.9999 is considered equivalent to 1.}

2. If for any survey the value of $\phi_{i,j,Financials,t}$ is either equal to 0 or 1 or larger than 1, and at the same time also further than 1 standard deviation from the mean financial share for that country and asset class across surveys, I then treat that specific observation as missing.

The first step in this procedure drops the debt holdings for the following 15 countries: Bahamas, Belarus, Bolivia, Cayman Islands, Curacao and St. Maarten, Egypt, India, Republic of Kosovo, Kuwait, Lebanon, Malta, Netherlands Antilles, New Zealand, Pakistan, and Vanuatu. The second step in the procedure drops a subset of observations on debt holdings for the following 17 countries (on average, 2.2 of the 5 surveys are dropped for each of these; in total 12% of all observations are dropped): Australia, Kingdom of Bahrain, Bangladesh, Barbados, Belgium, Bermuda, Brazil, Colombia, Guernsey, Honduras, Jersey, Norway, Russian Federation, Spain, Sweden, United Kingdom, and Uruguay.

In addition to the above two rules, I also drop Ireland’s records due to its inconsistent reporting style. Ireland does not report its holdings of U.S. securities for the debt and equity asset classes, although it does report its total holdings. In the first and second surveys of each year, it reports 0% and 99.7% of its holdings as being in the financial sector, respectively. While these data are not excluded under the above rules, I remove them as the reporting style appears to be inconsistent. Importantly, the exclusion of Ireland does not have any effect on the results in Table 1 in the main paper, since Ireland only reported its total holdings of assets in the U.S. but not the debt/equity breakdown. The exclusion only affects the result in Table A.4 for the category Total (third row).

**Country Weights.** Each country is assigned a weight corresponding to its share of portfolio investments in the U.S. in each asset class, compared to total investments in the U.S. in that asset class by all countries. The weights are computed according to:

\[ \text{subtotals}. \] Either using the sum of the subtotals or dropping these data points completely does not have a significant effect on the results in this paper.
\[
\theta_{i,j} = \frac{1}{5} \sum_{t=1}^{5} \frac{X_{i,j,ToT,t}}{\sum_{i} X_{i,j,ToT,t}}.
\]

In building the weights, I only use values of \(X_{i,j,ToT,t}\) for which \(\phi_{i,j,Financials,t}\) is not missing. Therefore, if fewer than 5 observations are available for a country-asset-class pair, then the average share is defined over the available observations.

**Building Table 1, Further Details, Robustness Checks.** Panel A of Table 1 summarizes the fraction of U.S. foreign debt held by foreign financial institutions. The average reported in the first column is obtained by first averaging \(\phi_{i,Debt,Financials,t}\) across countries \((i)\) for each survey instance \((t)\), and then averaging the resulting numbers across the different survey periods \((t)\). The average reported in the second column follows the same procedure, except that when averaging across countries for each instance of the survey, countries are weighted by their corresponding share of debt investment \(\theta_{i,Debt}\).

Panel B of Table 1 first selects the five countries with the highest reported value of average debt holdings in the U.S. for the period 2013-2015. This corresponds to selecting the highest values across countries \((i)\) of the statistic

\[
\bar{\phi}_{i,Debt,Financials,t} \equiv \frac{1}{5} \sum_{t=1}^{5} \phi_{i,Debt,Financials,t}.
\]

These values are reported in the second column of Panel B of Table 1. The first column reports the average share of U.S. debt held by each country’s financial sector, compared to the country’s total holdings:

\[
\tilde{\phi}_{i,Debt,Financials,t} \equiv \frac{1}{5} \sum_{t=1}^{5} \phi_{i,Debt,Financials,t}.
\]

Table A.2 provides further details by reporting these shares \(\tilde{\phi}_{i,Debt,Financials,t}\) for all countries in the dataset. While the foreign financial sector accounts for a large share of most countries’ debt holdings in the U.S., there appear to be three broad patterns. The share is lowest for countries such as Chile, Norway, and Kazakhstan (17%, 12%, 4%, respectively), which have large sovereign wealth funds that invest wealth related to commodity exports. The share is highest for off-shore financial centers such as Bermuda, Guernsey, Jersey (99.94%, 99.79%, 99.98%, respectively), which, by design, have wealth entirely concentrated in the financial sector. These countries are problematic in many ways for the analysis, since they do not invest their own wealth but are largely a conduit for investment from third-party countries. The possibility that U.S. residents might actually hold U.S. debt via off-shore accounts in these centers is a well known problem with U.S. international investment position data that are based on the residency principle. For this reason, I have performed a robustness check that drops the major
The results of repeating the analysis in Table 1 Panel A excluding off-shore financial centers are little changed, especially when using the weighted average, which is then lower at 85.13%, compared to 85.85% reported in Table 1 Panel A. The final pattern shows that the share is relatively high even among developed nations with substantial debt holdings in the U.S.: France 92%, Germany 80%, Italy 71%, Japan 96%, and the U.K. 98%. Overall, it is important to emphasize that there is selection in which countries decide to participate in the IMF surveys for CPIS. For example, China, one of the largest holders of U.S. debt and a country with very large government holdings, does not participate in CPIS. While the absence of such countries in CPIS biases upward the average fraction of U.S. debt held by RoW financial sector, the importance of RoW financial sector in understanding U.S. debt holdings is nonetheless based on evidence from a broad set of countries and still holds (Table A.2).

Table A.3 shows the average financial share across countries for each survey between June 2013 and June 2015. This table expands on Table 1 in the main text by providing not only the average financial share over all surveys (as reported in Table 1 Panel A) but also the financial share for each individual survey. Both the equally weighted (column one of Table A.3) and the debt-weighted (column two) financial share are stable over the different surveys, oscillating between 65% and 69% for the equally weighted measure and 83% and 88% for the debt-weighted measure.

C Data and Methodology for Measuring RoW Financial Net Worth

I provide here data sources, methodologies, and further robustness checks for the construction of the empirical proxy for RoW financial net worth $\tilde{N}^*$ used in the regressions that are reported in Table 2 and Figures 5 and 6.

Data Sources. I use Thomson Reuters Datastream (TRD) data for the aggregate value of foreign financial firms, the World Bank Databank (WBD) data on world and individual countries or geographic areas GDP, and the Bureau of Economic Analysis (BEA) data on the U.S. international investment position and net exports of good and services. Table A.5 outlines the data sources, including individual series’ codes.

The key state variable in the model, $\tilde{N}^*$, measures the RoW financial sector’s net worth scaled by output. I construct a proxy for this variable by dividing the market value of RoW financial firms by measures of economic activity for the world excluding the U.S.: 36

Note that a number of off-shore financial centers were also dropped earlier due to missing or incorrect data (e.g. Cayman Islands and Bahamas).
\[
\tilde{N}_{i,j,t}^* \equiv \frac{MV_{i,j,t}}{Y_{i,t}},
\]

where \(MV_{i,j,t}\) is the market value of financial firms in index \(j\) for geographical region \(i\) in month \(t\), and \(Y_{i,t}\) is a measure of economic activity for the same geographic region. In the benchmark measure, I use the market value of firms included in the Datastream Financial Equity World ex U.S. index (code: FINWUS), and proxy economic activity by GDP for the World ex U.S. provided by the World Bank.\(^{37}\) Both the denominator and numerator are expressed in U.S. dollars, but notice that by taking the ratio the currency of denomination is neutral. In robustness checks I vary both the geography, the sub-sector of financial corporations being included, and the measure of economic activity.

For geographies I consider: World ex-developed Europe and U.S., World ex-Japan and U.S., and World ex-U.K. and U.S.\(^{38}\) For sub-sectors of financial firms I consider: Financials ex-Banks, Financials ex-Insurance, and Financials ex-Financial Services. Data for each of these sub-sectors are available from Datastream and use the classification structure based on the Industry Classification Benchmark jointly created by FTSE and Dow Jones. For alternative measures of economic activity I consider: Dividends, Cash Flows, and Earnings. It is convenient to normalize RoW financial net worth by global output in the theoretical model; however, it is potentially important to consider different measures in the data since these would have behaved similarly in the model, but potentially not in the data. The proxy for \(\tilde{N}^*\) should capture the level of intermediary net worth compared to a measure of potential need for financial intermediation services. It therefore appears appropriate to consider normalizing \(N_{i,j,t}^*\) by measures of the dividends, cash flows, or earnings of the financial firms in geography \(i\) and sub-sector \(j\). I build the values of dividends, earnings, and cash flows for each geography and sub-sector using the raw data from Datastream according to:

\[
\begin{align*}
D_{i,j,t} &= DY_{i,j,t} \times MV_{i,j,t}, \\
E_{i,j,t} &= MV_{i,j,t} / PE_{i,j,t}, \\
CF_{i,j,t} &= MV_{i,j,t} / PCF_{i,j,t},
\end{align*}
\]

where \(D\) is the dollar value of dividends, \(E\) is the dollar value of earnings, \(CF\) is the dollar value of cash flows, \(DY\) is the dividend yield, \(PE\) is the price-to-earnings ratio, and \(PCF\) is the price-to-cash-flow ratio.

The independent variable for the regressions reported in Table 2 and Figure 6

\(^{37}\)I build the series for \(\tilde{N}_{i,j,t}^*\) at monthly frequency. Since U.S. GDP data are annual, I linearly interpolate GDP during the 12 months of the year. Note that this interpolation does not affect any of the results in the regressions, since those are run at annual frequency due to data availability for the U.S. net investment position (dependent variable).

\(^{38}\)For each of these areas, the corresponding GDP was built by subtracting the GDP of the stated country (e.g. Japan) and the United States from World GDP, with the exception of developed Europe, which was proxied by the European Union.
and for the robustness regressions in Table A.7 is then built by taking log differences of \( \tilde{N}_{i,j,t} \):

\[
\Delta \tilde{N}_{i,j,t} = \ln \left( \frac{MV_{i,j,t}}{Y_{i,j,t}} \right) - \ln \left( \frac{MV_{i,j,t-1}}{Y_{i,j,t-1}} \right).
\]  

(A.41)

Figure A.6 plots different proxy measures of \( \tilde{N}_{i,j,t} \). The top left panel plots the times series of the benchmark measure (RoW financials normalized by RoW GDP). Financial net-worth shows a clear upward trend compared to GDP for the period 1976 to 2016, which is consistent with the secular trend of an increase in financial intermediation and growth of the financial sector as a share of the overall economy. To filter out the historical upward trend in financial net-worth and prevent issues related to non-stationary regressors, I perform all regressions using first differences of \( \tilde{N}_{i,j,t} \), as in equation (A.41). The other most notable pattern in the empirical proxy for net worth, especially for the purpose of this paper, is that financial net worth tends to collapse during adverse economic events. The global financial crisis of 2007-2008 provides a particularly dramatic example, with financial net worth dropping from a high of 22% of RoW GDP to a low of 7%. Similar patterns also emerge for the dot-com stock-market collapse in the early 2000s and for the 1998 LTCM crisis. This behavior is consistent with my theoretical model, in which scaled net worth is a pro-cyclical variable \( \sigma_{\tilde{N}} > 0 \): levered financial intermediaries are long risky assets and funded in short term safe assets and lose capital as a result of negative shocks in the world economy. I confirm the pro-cyclicality of RoW financial net worth more generally in Table A.9, which shows net worth to be positively correlated with world stock market returns (0.88) and U.S. consumption growth (0.28), and negatively correlated with implied volatility as proxied by VIX (-0.592). The other noticeable pattern in the top left panel of Figure A.6 is the strong increase in financial net worth compared to world GDP in the second half of the 1980s. As I explain below, this strong increase is in large part due to the Japanese stock market boom of those years.

The remaining three panels of Figure A.6 plot various robustness measures of \( \tilde{N}_{i,j,t} \). The top right panel plots the measure \( \tilde{N}_{i,j,t} \) for different geographies \( i \). While the measure is clearly highly correlated across geographies, the most noticeable pattern is the boom of stock market valuations of Japanese financial institutions in the late 1980s and the subsequent reversal in the early 1990s. This large stock market boom-bust cycle and the large overall capitalization of Japanese financial institutions means that the pattern is reflected in my benchmark measure for RoW. Therefore, in Table A.7 Panel A third column I verify that the benchmark results in Table 2 are robust to excluding Japanese financial firms from the RoW financial net worth measure. The bottom left panel of Figure A.6 plots the

\[ I have used log differences in the benchmark regression, but taking level differences does not materially affect results. When running the regression in Table 2 column one using a measure of \( \Delta \tilde{N}_{i,j,t} \) obtained with level differences, the coefficients are: \( \alpha = .007, S.E.(\alpha) = .006, \beta = 1.170, S.E.(\beta) = .156 \) with a \( R^2 \) of .49.
measure $\tilde{N}_{i,j,t}$ for different sub-sectors of financial firms ($j$). All sub-sectors are highly correlated; the most noticeable pattern is the quantitative importance of banks, since these firms account for a large share of the overall market value of all financial firms. The bottom right panel of Figure A.6 plots the measure $\tilde{N}_{i,j,t}$ for different measures of economic activity. Purely for visualization purposes, the series in this panel have been rescaled by a constant such that all series have the same mean. All series have largely similar behavior, with the correlation being particularly high for series scaled by earnings, cash flows, and dividends. The main difference is that measures of $\tilde{N}_{i,j,t}$ built by scaling by earnings, cash flows, or dividends, rather than GDP, do not display a strong upward trend. The economics behind this finding is simple to understand: measures of earnings, cash flows, or dividends for financial firms scale with the overall size of the financial sector. If the financial sector grows as a share of the overall economy, scaling net worth by GDP does display an upward trend, while scaling net worth by financial firms earnings, cash flows, or dividends does not.

Table A.6 confirms the broadly similar and robust behavior of my empirical proxies for RoW financial net worth by reporting the pairwise correlation between log-changes of all the proxies. Correlations between the benchmark measure and each of the alternative measures are high, often exceeding 0.9, and never lower than .88. Similarly, pairwise correlations are high among each of the alternative measures, with the lowest correlation (0.75) resulting from excluding Japan and Europe as geographical areas. I have discussed above the role of Japan in generating Japan-specific variation in the aggregate RoW measures.

Table 2 and Figures 6 in the main text report the results of the regression specification in equation (21). Table 2 provides the main result, the positive association between U.S. NFA net of net-exports and RoW financial net worth, as well as subsample robustness checks. I explore here further robustness of the main result by using the alternative measures of RoW net worth discussed above. Table A.7 shows that U.S. NFA net of net-exports are positively associated with all 9 alternative proxies for RoW financial net worth. The estimated coefficients and resulting $R^2$ are stable across all the different robustness checks. This confirms that the main result holds across broad definitions of the financial sector (banks, insurance, financial services), geographical areas (excluding: U.K., Japan, Europe), and different scaling variables for RoW net worth (earnings, cash flows, dividends).

Table A.8 build on the main result in Table 2 by adding controls for measures of U.S. fundamentals to the regression specification in equation (21). The aim is to verify that RoW financial net worth has independent explanatory power from U.S. fundamentals in explaining the dynamics of U.S. NFA. In particular, I focus on U.S. consumption growth as a measure of U.S. fundamentals since it is a natural summary of economic conditions in aggregate representative agents models (such as the Lucas Economy) and should be strongly associated with risk premia, including those driving movements in U.S. NFA. I use the log-growth of
U.S. real consumption expenditure, and provide a robustness check by excluding expenditure on durable goods.\textsuperscript{40} Columns 4 and 5 of Table A.8 show that U.S. consumption growth is not associated with changes in U.S. NFA net of net-exports: the regression coefficients are not statistically significant and the $R^2$ is extremely low. Similarly, columns 2 and 3 of Table A.8 show that controlling for U.S. consumption growth leaves the explanatory power of RoW financial net worth essentially unchanged, and that U.S. consumption growth remains statistically not significant (it even changes sign from columns 4 and 5). This confirms that RoW financial net worth, while positively correlated with U.S. consumption growth (correlation coefficient of 0.28), has independent information about global imbalances, especially the part associated with global risk premia. This is consistent with the long-standing failure of consumption based models to explain global risk premia, and the more favorable evidence that is emerging, and to which this paper contributes, for measures of financial net worth (Adrian et al. (2014), Muir (2016), He et al. (2016)).

\textsuperscript{40}U.S. real personal consumption expenditure (series code: PCECCA) is available from the BEA. I build real personal consumption expenditure excluding durable goods by summing nominal expenditure on non-durable goods (series code: PCNDA) and services (series code: PCESVA), and deflating them by the total personal consumption expenditure deflator. Durable goods are generally excluded from empirical tests of U.S. consumption behavior due to the lumpiness of durable purchases, the consumption benefits of which are then spread over several periods.
Appendix References


Table A.1: Aggregation of CPIS Categories

<table>
<thead>
<tr>
<th>Sectors in this Paper</th>
<th>Corresponding Sectors in CPIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>General government, Central bank</td>
</tr>
<tr>
<td>Financials</td>
<td>Deposit-taking corporations except for the central bank, Other financial corporations</td>
</tr>
<tr>
<td>Nonfinancials</td>
<td>Nonfinancial Corporations, HHs and NPISHs</td>
</tr>
</tbody>
</table>

*Notes.* Mapping of the sectors in the Coordinated Portfolio Investment Survey of the International Monetary Fund to the sectors used for the empirical analysis in this paper.
Table A.2: U.S. Debt Held by Financial Institutions by Country, Survey Average

<table>
<thead>
<tr>
<th>Country</th>
<th>Financial Share (%)</th>
<th>Country</th>
<th>Financial Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Argentina</td>
<td>0.28</td>
<td>28. Indonesia</td>
<td>67.55</td>
</tr>
<tr>
<td>2. Aruba</td>
<td>83.38</td>
<td>29. Israel</td>
<td>32.78</td>
</tr>
<tr>
<td>3. Australia</td>
<td>85.82</td>
<td>30. Italy</td>
<td>70.64</td>
</tr>
<tr>
<td>4. Austria</td>
<td>88.58</td>
<td>31. Japan</td>
<td>95.97</td>
</tr>
<tr>
<td>5. Bahrain, Kingdom of</td>
<td>98.85</td>
<td>32. Jersey</td>
<td>99.98</td>
</tr>
<tr>
<td>6. Bangladesh</td>
<td>25.11</td>
<td>33. Kazakhstan</td>
<td>4.00</td>
</tr>
<tr>
<td>7. Barbados</td>
<td>99.06</td>
<td>34. Korea, Republic of</td>
<td>81.43</td>
</tr>
<tr>
<td>8. Belgium</td>
<td>88.07</td>
<td>35. Latvia</td>
<td>96.89</td>
</tr>
<tr>
<td>9. Bermuda</td>
<td>99.94</td>
<td>36. Lithuania</td>
<td>88.53</td>
</tr>
<tr>
<td>10. Brazil</td>
<td>80.89</td>
<td>37. Malaysia</td>
<td>59.59</td>
</tr>
<tr>
<td>11. Bulgaria</td>
<td>98.52</td>
<td>38. Mexico</td>
<td>6.68</td>
</tr>
<tr>
<td>12. Chile</td>
<td>16.63</td>
<td>39. Netherlands</td>
<td>94.45</td>
</tr>
<tr>
<td>14. Colombia</td>
<td>76.67</td>
<td>41. Poland</td>
<td>8.83</td>
</tr>
<tr>
<td>15. Costa Rica</td>
<td>64.03</td>
<td>42. Portugal</td>
<td>57.24</td>
</tr>
<tr>
<td>16. Cyprus</td>
<td>87.88</td>
<td>43. Romania</td>
<td>99.18</td>
</tr>
<tr>
<td>17. Czech Republic</td>
<td>83.97</td>
<td>44. Russian Federation</td>
<td>87.60</td>
</tr>
<tr>
<td>18. Denmark</td>
<td>97.94</td>
<td>45. Slovak Republic</td>
<td>96.16</td>
</tr>
<tr>
<td>19. Estonia</td>
<td>92.57</td>
<td>46. Slovenia</td>
<td>34.15</td>
</tr>
<tr>
<td>20. Finland</td>
<td>50.82</td>
<td>47. South Africa</td>
<td>94.27</td>
</tr>
<tr>
<td>21. France</td>
<td>92.12</td>
<td>48. Spain</td>
<td>69.07</td>
</tr>
<tr>
<td>22. Germany</td>
<td>79.70</td>
<td>49. Sweden</td>
<td>59.77</td>
</tr>
<tr>
<td>23. Greece</td>
<td>41.31</td>
<td>50. Thailand</td>
<td>63.74</td>
</tr>
<tr>
<td>24. Guernsey</td>
<td>99.79</td>
<td>51. Turkey</td>
<td>50.74</td>
</tr>
<tr>
<td>25. Honduras</td>
<td>62.60</td>
<td>52. United Kingdom</td>
<td>98.10</td>
</tr>
<tr>
<td>26. Hungary</td>
<td>27.38</td>
<td>53. Uruguay</td>
<td>72.02</td>
</tr>
<tr>
<td>27. Iceland</td>
<td>99.38</td>
<td>54. Venezuela, Republica de</td>
<td>10.97</td>
</tr>
</tbody>
</table>

Notes. Country shares are constructed by dividing U.S. debt held by the foreign country’s financial sector by total U.S. debt held by the country, averaged over time. The financial sector includes sectors defined as “Deposit-taking corporations except the central bank” and “Other financial corporations”. Data are sourced from the Coordinated Portfolio Investment Survey published by the International Monetary Fund, using the June 2013 through June 2015 surveys.
Table A.3: Average Share of U.S. Debt Held by Foreign Financial Institutions, by Survey

<table>
<thead>
<tr>
<th></th>
<th>Mean Financial Share (Unweighted) (%)</th>
<th>Mean Financial Share (Weighted) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013Q2</td>
<td>64.59</td>
<td>82.74</td>
</tr>
<tr>
<td>2013Q4</td>
<td>65.78</td>
<td>85.43</td>
</tr>
<tr>
<td>2014Q2</td>
<td>63.20</td>
<td>87.53</td>
</tr>
<tr>
<td>2014Q4</td>
<td>68.97</td>
<td>85.65</td>
</tr>
<tr>
<td>2015Q2</td>
<td>66.63</td>
<td>87.90</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>65.83</strong></td>
<td><strong>85.85</strong></td>
</tr>
</tbody>
</table>

*Notes.* Individual country shares are first constructed by dividing U.S. debt held by the foreign country's financial sector by total U.S. debt held by the country. Country shares are weighted by equal weights in the unweighted column, and by the country's total holdings of U.S. debt in the weighted column. The financial sector includes sectors defined as “Deposit-taking corporations except the central bank” and “Other financial corporations”. Data source is the Coordinated Portfolio Investment Survey published by the International Monetary Fund, using the June 2013 through June 2015 surveys.

Table A.4: Average Share of U.S. Portfolio Investment Held by Foreign Financial Institutions, by Asset Class.

<table>
<thead>
<tr>
<th></th>
<th>Mean Financial Share (Unweighted) (%)</th>
<th>Mean Financial Share (Weighted) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt</td>
<td>65.83</td>
<td>85.85</td>
</tr>
<tr>
<td>Equity</td>
<td>65.04</td>
<td>82.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>64.45</strong></td>
<td><strong>83.83</strong></td>
</tr>
</tbody>
</table>

*Notes.* Financial sector shares for each asset class are first constructed by dividing portfolio investments in the U.S. held by the financial sector by total portfolio investments in the U.S. for each time period. Country shares are averaged using equal weights to create an average share within each time period in the unweighted column, and are weighted by the country’s total holdings of U.S. securities in each asset class in the weighted column. Time periods are then weighted equally. The financial sector includes sectors defined as “Deposit-taking corporations except the central bank” and “Other financial corporations”. Data are sourced from the Coordinated Portfolio Investment Survey published by the International Monetary Fund, using the June 2013 through June 2015 surveys.
Table A.5: Data Sources Summary

<table>
<thead>
<tr>
<th>Provider</th>
<th>Name / Series ID</th>
<th>Period</th>
<th>Periodicity</th>
<th>Aggregation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRD</strong></td>
<td><strong>WORLD-DS,WORLD EX DEV.EUR-DS.,</strong></td>
<td>1976</td>
<td>Monthly</td>
<td>End of period</td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX JAPAN-DS, WORLD EX UK-DS,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX US-DS, US-DS</strong>}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>× <strong>Sector:</strong> {Financials, Banks, Insurance, Real Estate, Financial Svs, Market} : <strong>Field:</strong> MV (Market Value)</td>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TRD</strong></td>
<td><strong>WORLD-DS,WORLD EX DEV.EUR-DS.,</strong></td>
<td>1976</td>
<td>Monthly</td>
<td>End of period</td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX JAPAN-DS, WORLD EX UK-DS,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX US-DS, US-DS</strong>}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>× <strong>Sector:</strong> {Financials, Banks, Insurance, Real Estate, Financial Svs, Market} : <strong>Field:</strong> PE (Price to Earnings)</td>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TRD</strong></td>
<td><strong>WORLD-DS,WORLD EX DEV.EUR-DS.,</strong></td>
<td>1976</td>
<td>Monthly</td>
<td>End of period</td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX JAPAN-DS, WORLD EX UK-DS,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX US-DS, US-DS</strong>}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>× <strong>Sector:</strong> {Financials, Banks, Insurance, Real Estate, Financial Svs, Market} : <strong>Field:</strong> DY (Dividend Yield)</td>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TRD</strong></td>
<td><strong>WORLD-DS,WORLD EX DEV.EUR-DS.,</strong></td>
<td>1976</td>
<td>Monthly</td>
<td>End of period</td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX JAPAN-DS, WORLD EX UK-DS,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>WORLD EX US-DS, US-DS</strong>}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>× <strong>Sector:</strong> {Financials, Banks, Insurance, Real Estate, Financial Svs, Market} : <strong>Field:</strong> PC (Price to Cash Flow Ratio)</td>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WBD</strong></td>
<td><strong>World Development Indicators</strong></td>
<td>1976</td>
<td>Annual</td>
<td>Per period flow</td>
</tr>
<tr>
<td></td>
<td>(GDP (Current US$): <strong>{WLD, USA, GBR, JPN, EUU}</strong>)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BEA</strong></td>
<td><strong>U.S. Net International Investment Position</strong></td>
<td>1976</td>
<td>Quarterly</td>
<td>End of period</td>
</tr>
<tr>
<td></td>
<td>(Net international investment position)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BEA</strong></td>
<td><strong>Table 1.1.</strong></td>
<td>1976</td>
<td>Quarterly</td>
<td>Per period flow</td>
</tr>
<tr>
<td></td>
<td><strong>Table 1.1.5.</strong></td>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BEA</strong></td>
<td><strong>Gross Domestic Product</strong></td>
<td>1976</td>
<td>Quarterly</td>
<td>Per period flow</td>
</tr>
<tr>
<td></td>
<td>(Exports of goods and services - Imports of goods and services)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. Table describes data sources, series codes, sample size, and frequency for data sources used to measure proxies of RoW financial net worth.
Table A.6: Correlation Among Different Proxies for RoW Financial Net Worth

<table>
<thead>
<tr>
<th>Alternative Geographical Regions</th>
<th>Alternative Scaling Variables</th>
<th>Alternative Financial Sub-sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>Benchmark</td>
<td>Ex Banks</td>
</tr>
<tr>
<td>Ex-{US, Developed Europe}</td>
<td>0.924</td>
<td>0.972</td>
</tr>
<tr>
<td>Ex-{US, Japan}</td>
<td>0.751</td>
<td>0.925</td>
</tr>
<tr>
<td>Ex-{US, UK}</td>
<td>0.890</td>
<td>0.966</td>
</tr>
<tr>
<td>Dividends</td>
<td>0.932</td>
<td>0.911</td>
</tr>
<tr>
<td>Earnings</td>
<td>0.919</td>
<td>0.850</td>
</tr>
<tr>
<td>Cash Flows</td>
<td>0.940</td>
<td>0.941</td>
</tr>
</tbody>
</table>

Notes. Pairwise correlation among different proxy measures for RoW financial net worth ($\tilde{N}^*$). Correlations are for the logarithmic change in each proxy measure. The benchmark measure is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex U.S. index (code: FINWUS) by GDP for the world ex U.S. provided by the World Bank. The first robustness check varies the geographical areas of the RoW that are included in the measure $\tilde{N}^*$. The second robustness check varies the measure of economic activity that is used to scale financial net worth $\tilde{N}^*$. The third robustness check varies the sub-sectors of financial firms that are included in the measure $\tilde{N}^*$. Appendix A.3.C provides further details on these alternative measures. All data are annual from 1976 to 2015, except for the cash-flow-based measure, which starts in 1980.
### Table A.7: U.S. NFA and RoW Financial Net Worth: Robustness Checks

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>0.0040</td>
<td>0.0042</td>
<td>0.0033</td>
</tr>
<tr>
<td></td>
<td>(0.0062)</td>
<td>(0.0056)</td>
<td>(0.0063)</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.1189***</td>
<td>0.1195***</td>
<td>0.1131***</td>
</tr>
<tr>
<td></td>
<td>(0.0266)</td>
<td>(0.0290)</td>
<td>(0.0248)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.4031</td>
<td>0.4488</td>
<td>0.3886</td>
</tr>
</tbody>
</table>

**Notes.** The dependent variable is the annual change in the net foreign asset position of the U.S. minus net exports, expressed as a share of U.S. GDP: \(\frac{NFA-\Delta NX}{GDP}\). In the benchmark columns, 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 U.S. index (code: FINWUS) by world GDP ex U.S. provided by the World Bank. Panel A varies the geographical areas of the RoW that are included in the measure \(\tilde{N}^*\). Panel B varies the measures of economic activity that are used to scale financial net worth \(N^*\). Panel C varies the sub-sectors of financial firms that are included in the measure \(\tilde{N}^*\). Appendix A.3.C provides further details on these alternative measures. Net exports of goods and services and net foreign assets of the United States are from the Bureau of Economic Analysis. All regressions use annual data from 1976-2015 except for the “Cash Flow” measure of GDP, which uses annual data from 1980. Standard errors are reported in parenthesis and are built with the Newey-West procedure including one lag. P-values: *** \(p < .01\), ** \(p < .05\), * \(p < .1\)
Table A.8: U.S. NFA, RoW Financial Net Worth, and U.S. Consumption

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta N^\ast$</td>
<td>0.1189***</td>
<td>0.1272***</td>
<td>0.1228***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0266)</td>
<td>(0.0257)</td>
<td>(0.0261)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta C$</td>
<td>-0.4620</td>
<td>0.0792</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.2857)</td>
<td>(0.5048)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta C_{ex-D}$</td>
<td>-0.4190</td>
<td></td>
<td>0.0227</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.4157)</td>
<td></td>
<td>(0.6741)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0040</td>
<td>0.0170</td>
<td>0.0164</td>
<td>0.0087</td>
<td>0.0103</td>
</tr>
<tr>
<td></td>
<td>(0.0062)</td>
<td>(0.0099)</td>
<td>(0.0134)</td>
<td>(0.0184)</td>
<td>(0.0234)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.4031</td>
<td>0.4269</td>
<td>0.4158</td>
<td>0.0007</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes. The dependent variable is the annual change in the net foreign asset position of the U.S. minus net exports, expressed as a share of U.S. GDP: \( \frac{NFA_t - NX_t}{GDP_t} \). Column (1) reports the benchmark regression. Regressors are: a constant and the logarithmic change in RoW financial net worth as a fraction of RoW GDP, $\Delta \tilde{N}^\ast$. The measure $\tilde{N}^\ast$ is built by dividing the total equity market valuation of financial firms included in the Datastream Financial Equity World ex U.S. index (code: FINWUS) by world GDP ex U.S. provided by the World Bank. Column (2) adds to the regression in column (1) the log-change in U.S. real personal consumption expenditure. Column (3) adds to the regression in column (1) the log-change in U.S. real personal consumption expenditure, excluding durable goods. Columns (4) and (5) use as regressors only the consumption measures and exclude the financial net-worth measure. Personal consumption expenditure data are from the Bureau of Economic Analysis. Standard errors are reported in parenthesis and are built with the Newey-West procedure including one lag. P-values: *** $p < .01$, ** $p < .05$, * $p < .1$.

Table A.9: Pro-cyclical Behavior of RoW Financial Net Worth

<table>
<thead>
<tr>
<th></th>
<th>VIX</th>
<th>World Equity Returns</th>
<th>$\Delta C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \tilde{N}^\ast$</td>
<td>-0.592</td>
<td>0.883</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Notes. Correlation coefficients between changes in RoW financial net worth and VIX, World equity returns, and U.S. consumption growth. World equity returns are total returns for the World Equity Index provided by Datastream (code: WORLD-DS). U.S. consumption data are Personal Consumption Expenditures from the BEA. All data series are annual 1976 to 2015, except VIX which starts in 1990.
Figure A.1: Autarky Equilibrium

Marginal Value of Net-Worth: \( \Omega \)

- **Banking Economy**
- **Lucas Economy**

Price Div. Ratio: \( \hat{Q} \)

Equity Excess Return: \( \mu_Q - r_d \)

- **Banking Economy**
- **Lucas Economy**

Equity Volatility: \( \sigma_Q \)

Deposit (Risk-free) Rate: \( r_d \)

Sharpe Ratio: \( \frac{\mu_Q - r_d}{\sigma_Q} \)

Notes. Numerical solution for the equilibrium in Section II for the case \( \delta = \lambda - \rho \): the Banking Economy eventually converges to the Lucas Economy. Parameter values: \( \rho = 0.01 \), \( \delta = 0.022 \), \( \mu = 0.01 \), \( \sigma = 0.1 \). Note that the graphs plot the solution for the state space of the Banking Economy, the range of the state variable \( \hat{N} \). The Lucas Economy solution is plotted over the same state space for comparison purposes, but the state space of the Lucas Economy extends beyond the one of the Banking Economy. The state space of the Banking Economy is \((0, \frac{1}{\rho})\), and the stochastic steady state is \( \frac{1}{\rho} \).
Figure A.2: Autarky Equilibrium: Interior Stochastic Steady State

Notes. Numerical solution for the equilibrium in Section II for the case $\delta < \lambda - \rho$: the Banking Economy has an interior stochastic steady state. Parameter values: $\rho = 0.01$, $\delta = 0.022$, $\lambda = 0.0398$, $\mu = 0.01$, $\sigma = 0.1$. Note that the graphs plot the solution for the state space of the Banking Economy, the range of the state variable $\tilde{N}$. The Lucas Economy solution is plotted over the same state space for comparison purposes, but the state space of the Lucas Economy extends beyond the one of the Banking Economy. The state space of the Banking Economy is $(0,95.43)$, and the stochastic steady state is 69.76.
Figure A.3: Autarky Equilibrium: Stochastic Steady State

Notes. Numerical solution for the equilibrium in Section II for the case $\delta = \lambda - \rho$ (top two graphs) and $\delta < \lambda - \rho$ (bottom two graphs). Parameter values for the first case: $\rho = 0.01$, $\delta = 0.022$, $\lambda = 3.98$, $\mu = 0.01$, $\sigma = 0.1$. These are the drift and diffusion of the state variable, scaled net-worth $\tilde{N}$, for the equilibrium in Figure A.1. Parameter values for the second case: $\rho = 0.01$, $\delta = 0.022$, $\lambda = 0.0398$, $\mu = 0.01$, $\sigma = 0.1$. These are the drift and diffusion of the state variable, scaled net-worth $\tilde{N}$, for the equilibrium in Figure A.2. The red dot in the two graphs on the left corresponds to each case’s stochastic steady state. The state space of the case $\delta = \lambda - \rho$ is $[0, \frac{1}{\rho}]$, and the stochastic steady state is $\frac{1}{\rho}$. The state space of the case $\delta < \lambda - \rho$ is $(0, 0.9543)$, and the stochastic steady state is 69.76.
Figure A.4: Autarky Equilibrium: Stationary Distribution

Notes. Plot of the limiting stationary distribution of the state variable, scaled net-worth $\tilde{N}$, for the equilibrium in Section II for the case $\delta < \lambda - \rho$. Parameter values: $\rho = 0.01$, $\delta = 0.022$, $\lambda = 0.0398$, $\mu = 0.01$, $\sigma = 0.1$. This is the stationary distribution for the equilibrium in Figure A.2. The state space is (0,95.43), and the stochastic steady state is 69.76. The approximation to the stationary distribution is obtained by simulating 5,000 paths for 100 years at daily frequency (36,500 periods) for the process $\tilde{N}$.
Figure A.5: Foreign Portfolio Holdings as Percentage of U.S. Debt Securities: Robustness Check

Notes. RoW portfolio holdings of debt securities issued by U.S. financial institutions as a fraction of the total outstanding stock of debt issued by that sector. “Financial” is the benchmark estimate, as reported in the middle panel of Figure 4. “Financial L” is a robustness check that includes all U.S. debt issued by state and local governments in the denominator. Data on RoW securities holdings in the U.S. are from TIC and data on the stock of securities are from the Flow of Funds (annual June 2002 to June 2015). See Appendix A.3.A for full details on data sources and methodology.
Notes. Top left panel plots the benchmark proxy of $\tilde{N}^*$, which is built by dividing the market value of firms included in the Datastream Financial Equity World ex U.S. index (code: FINWUS) by the world ex U.S. GDP provided by the World Bank. Top right panel plots alternative specifications of $\tilde{N}^*$ that exclude further geographical areas in both the numerator and denominator: Developed Europe, Japan, and the U.K.. Bottom left panel plots alternative specifications of $\tilde{N}^*$ that exclude sub-sectors of financial firms from the numerator: Banks, Insurers, Financial Services. Bottom right panel plots alternative specifications of $\tilde{N}^*$ that use different proxies of economic activity in the denominator: dividends, cash-flows, earnings. Purely for visualization purposes, the series in the bottom right panel have been rescaled by a constant such that all series have the same mean. All data series are monthly between January 1976 to June 2016. See Appendix A.3.C for full details on data sources and methodology.
Figure A.7: Open Economy Equilibrium, Two Trees, No Domestic Bias: Allocations

Notes. Numerical solution for the equilibrium in Section IV. Parameter values: \(\rho = 0.01\), \(\delta = 0.004\), \(\lambda = 0.014\), \(\mu = 0.01\), \(\sigma_z = \sigma_z^* = 0.05\), \(\alpha = 0.5\). The starting scaled net-worth is \(\tilde{N}^*(0) = 3.5\), which results in \(\xi = 1.12\). Note that the graphs plot the solution for the state space of the Open Banking Economy with two trees, the range of the state variable \(\tilde{N}^*\). The Cole and Obstfeld Economy solution is plotted over the same state space for comparison purposes, but the state space of the Cole and Obstfeld Economy extends beyond the one of the Open Banking Economy. The state space of the Open Banking Economy is \((0, \frac{1}{\rho(1+\xi)})\); in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is \(\frac{1}{\rho(1+\xi)}\).
Figure A.8: Open Economy Equilibrium, Two Trees, No Domestic Bias: Asset Prices

Equity Excess Return: \( \mu_Q - r_b \)

Home Currency Safety Premium: \( r_b^* - r_b + \mu \xi \)

Interbank (Risk-free) Rates: \( r_b, r_b^* \)

Sharpe Ratio: \( \frac{\mu_Q - r_b}{\sigma_Q} \)

Notes. Numerical solution for the equilibrium in Section IV. Parameter values: \( \rho = 0.01, \delta = 0.004, \lambda = 0.014, \mu = 0.01, \sigma_z = \sigma_z^* = 0.05, \alpha = 0.5. \) The starting scaled net-worth is \( \tilde{N}^* (0) = 3.5, \) which results in \( \xi = 1.12. \) Note that the graphs plot the solution for the state space of the Open Banking Economy with two trees, the range of the state variable \( \tilde{N}^*. \) The Cole and Obstfeld Economy solution is plotted over the same state space for comparison purposes, but the state space of the Cole and Obstfeld Economy extends beyond the one of the Open Banking Economy. The state space of the Open Banking Economy is \( (0, \frac{1}{\rho(1+\xi)}) \); in the figures above it has been cut on the right to allow for better visualization. The stochastic steady state is \( \frac{1}{\rho(1+\xi)}. \)