A Portfolio Approach to Global Imbalances*

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Abstract

We develop a portfolio-based framework to understand the deterioration of the U.S. net foreign asset (NFA) position and the returns earned on U.S. NFA (exorbitant privilege). We show global savings gluts and monetary policies widened the U.S. NFA position, while investor demand shifts offset this widening. Moreover, U.S. privilege declined after 2010, in accordance with declining debt issuance and increasing foreign demand for U.S. equity. Our framework highlights a quantity dimension of the U.S. privilege: demand for U.S. debt is highly inelastic, allowing the U.S. to issue substantially more debt for a given yield increase.

Key Words: Global Imbalances, Global Savings Glut, Quantitative Easing.

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Foreign holdings of U.S. assets have increased dramatically in the past two decades. At the end of 2019, non-U.S. investors held 16.8 trillion dollars' worth of U.S. assets. By contrast, U.S. investors held only 10.2 trillion dollars in foreign assets[1]. This difference between the portfolio assets and liabilities resulted in a −\$6.6 trillion net foreign asset (NFA) position for the U.S. in 2019, which amounts to 30% of U.S. GDP. This is a substantial deterioration from −\$1.3 trillion in 2002, or 12% of U.S. GDP. The dashed line in Figure 1 shows this downward trend. These sustained net capital flows into the U.S. financial markets have been referred to as *global imbalances* (Lane and Milesi-Ferretti 2007a; Gourinchas and Rey 2014). As these imbalances are closely tied to the global risk-sharing arrangement and unique position of the U.S. in the international financial system, they have been a key focus of the international finance literature.

In addition to the level of the portfolio imbalance, a large literature also focuses on the unique returns on the U.S. external portfolio. By providing insurance to the rest of the world, the U.S. earns a higher return on its external assets than what is earned by foreigners on U.S. external liabilities. This asymmetry in portfolio returns has been referred to as *exorbitant privilege* (Gourinchas, Rey, and Govillot 2010). The solid line in Figure 1 depicts the cumulative net flow of capital to the U.S., which is net of any valuation gains. The difference between the dashed and solid lines therefore measures the returns on the U.S. NFA position. From 2002 to 2010, the U.S. indeed earned an exorbitant privilege—A positive return differential between U.S. external assets and liabilities allowed the U.S. NFA position to decline less than the cumulative net flow of capital. However, from 2010 to 2019, this positive return differential reversed, with the NFA position ending close to the cumulative flows by 2019[2]. The right panel of Figure 1 further illustrates this point by plotting the percent difference between the net portfolio position and cumulative net flows, along with a smoothed trend line. This reversal in the sign of the return differential on the U.S. external portfolio positions signals a potential reversal in the U.S. exorbitant privilege.

In this paper, we use a portfolio-based demand system approach to decompose both

[1] These numbers are measured using our sample of reallocated international portfolio holdings described in the data section. Appendix Figure A.1 shows that the trends which we observe on the portfolio component of NFA align with the overall trends in NFA.

[2] Atkeson, Heathcote, and Perri (2021) also find a decline in returns on the U.S. NFA position in the past decade.

the level of and returns on the portfolio component of the U.S. NFA position. By using bilateral holdings data and a portfolio-based model, our approach allows us to quantitatively attribute the trend in global imbalances, the U.S. exorbitant privilege, and its reversal to various explanations proposed separately in the literature.

Indeed, the literature has provided several explanations for global imbalances and asymmetries. A global savings glut view argues that foreign savings in excess of their domestic investment opportunities contribute to the flows into the U.S. debt market (Bernanke 2005). One source of the savings glut is the strong savings motive of developed countries with aging populations and high inequality (Rachel and Smith 2018; Mian, Straub, and Sufi 2020). Another source is emerging countries with high growth and willingness to save in the developed markets, in particular in the U.S.

In addition to the private savings glut, central banks' monetary policies could play an important role in shaping portfolio imbalances. Changes in interest rates directly alter the returns and appeal of short-term debt assets as well as other assets. Moreover, both foreign central banks and the Federal Reserve influence U.S. asset prices by changing their holdings of U.S. debt in official reserves (Bernanke 2005; Farhi, Gourinchas, and Rey 2011) and via quantitative easing.[3]

A third view focuses on the shortage of safe assets and flight to safety (Krishnamurthy and Vissing-Jorgensen (2012); Caballero, Farhi, and Gourinchas (2017); Maggiori (2017); Jiang, Krishnamurthy, and Lustig (2020b)). As the supply of safe assets is concentrated in a small number of advanced economies, most prominently the U.S., recent crises (the Global Financial Crisis, the European Debt Crisis, and the Covid Crisis) have driven up demand for safe assets and hence flows into the U.S. debt market. More generally, changes in risk appetite and taste have shifted investors' portfolio positions across asset classes and across countries within each asset class.

By using a portfolio-based approach we are able to quantify the effects of these channels on the U.S. NFA position. We use a framework that maps variation in the U.S. NFA to different

[3] A number of recent papers highlight the effectiveness of central banks' unconventional monetary policy and their influence on asset prices (Krishnamurthy and Vissing-Jorgensen 2013; Koijen, Koulischer, Nguyen, and Yogo 2017; Krishnamurthy, Nagel, and Vissing-Jorgensen 2018; Acharya and Krishnamurthy 2018; Jiang, Krishnamurthy, and Lustig 2020a).

drivers of portfolio positions and asset valuations. We model and estimate investors' demand curves for assets as a function of observed and unobserved asset characteristics, and we allow investors to substitute across countries and across asset classes (Koijen and Yogo 2019a,b; Koijen, Richmond, and Yogo 2019). In equilibrium, investor countries and central banks must hold the total quantity of assets available for purchase. The estimated demand curves of investor countries, along with the portfolios of central banks, and the market clearing condition constitute our asset demand system.

This asset demand system allows us to evaluate how asset prices and investor portfolio holdings change in response to three sets of variables: (i) investors' savings and asset issuances, (ii) central banks' monetary policies, and (iii) demand shifts due to changes in asset characteristics and investors' latent demand. These variables are treated as exogenous in our framework, and they jointly determine the endogenous asset prices, exchange rates, investors' wealth and portfolio allocations. For each year, had all of the exogenous variables remained constant since the last year, then the endogenous variables and therefore the U.S. NFA would have stayed the same. Hence, by iteratively restoring the changes in exogenous variables from year to year, and then recomputing equilibrium asset prices and portfolio choices, we can attribute variation in portfolio positions observed in the data into contributions due to different variables.

Our first key finding is that the savings glut and monetary policy channels have contributed to the widening of the U.S. NFA position, while investor's demand shifts have partially offset this trend. These results suggest that different forces underlie the seemingly uniform widening of the U.S. NFA position. As a result, any theory that seeks to explain the decline in the U.S. portfolio imbalance with just one channel alone is unlikely to succeed quantitatively.

Second, we show that while the U.S. benefited from the valuation effects on their asset position earlier in the sample, relatively lower issuances of U.S. debt coupled with a shift in investor demand towards U.S. equities drove up realized returns on U.S. liabilities in the latter period. These shifts in the valuation effects on the U.S. external liabilities were responsible for the decline in the U.S. exorbitant privilege in the past decade.

Finally, our third result showcases a novel quantity dimension of privilege for U.S. debt issuers. Previous analysis of U.S. privilege focus only on prices and on the relatively low returns earned on U.S. liabilities. By contrast, we show that, relative to other developed economies, the U.S. can issue a substantially larger quantity of long-term debt for a given rise in interest rates. This quantity dimension of exorbitant privilege is crucial for fully characterizing the benefits earned by the U.S. through its unique position in the financial system.[4]

We estimate the model using bilateral equity and debt portfolio positions for 31 investor countries and 33 issuer countries. In our data construction, we combine data from different sources that have the best quality. We verify that the U.S. NFA implied from these portfolio positions closely traces out the aggregate NFA data, and that our data properly captures cross-country holdings that are traditionally poorly represented in standard datasets due to indirect holdings through tax havens (Coppola, Maggiori, Neiman, and Schreger (2020)). We also measure the portfolio holdings of the U.S. Federal Reserve and foreign central bank reserves.

We begin by measuring the effects of the global savings glut in excess of domestic investment opportunities. These variables contribute to a 9.59% widening of the U.S. NFA per annum. In comparison, the actual U.S. NFA widens by 9.50% per annum in our sample from 2002 to 2019. In other words, our results imply that the global private savings alone are enough to account for the trend in U.S. portfolio imbalances. We further differentiate the contributions from different regions, and find that savings from the European developed markets are the predominant driver.

Next, we measure the effects of U.S. and foreign monetary policy rates and central bank holdings. We find that these monetary policy variables additionally widen the U.S. NFA by 6.64%. This effect is mainly driven by the U.S. policy rate, which attracts foreign flows to U.S. assets and leads to U.S. asset appreciation whenever the rate increases. Foreign central banks purchases of U.S. debt assets as reserves also contribute to the widening of the U.S. NFA.

Finally, and perhaps most surprisingly, we show that investors' demand shifts partially

[4]In particular, Farhi and Maggiori (2017) characterizes how the demand elasticity for safe assets impacts the quantity of safe assets supplied globally, and, ultimately, the monopoly rents earned by an issuer of safe assets (like the U.S.).

offset these trends, driving a reversal of 6.73% per annum in the trend of the U.S. NFA. This effect is not directly observable in the aggregate time series because it is overshadowed by the effects of savings glut and monetary policies. So, when we combine all these drivers, the U.S. external portfolio imbalances deteriorate considerably, but the deterioration would have been much greater if the investors' demand had stayed constant. We further investigate different components of the investors' demand, and find that this effect is mainly driven by (i) a market-wide shift from debt assets to equity assets, which impacts the U.S. external imbalances because the U.S. debt is widely held by foreigners, and (ii) a deterioration of the appeal of U.S. debt assets in terms of their observable characteristics.

In the next section of the paper, we seek to understand the main drivers of the valuation effects on U.S. NFA. It is well known that, historically, the U.S. has earned a large positive return on its external portfolio. Thus, from 2002 to 2010, valuation effects helped reduce the U.S. NFA position by 6.0% per annum. Perhaps less well-known is that this trend completely reverses after 2010. Between 2010 to 2019, valuation effects actually widen the U.S. NFA by an average of 6.7% per annum. We use our model to shed new light on which economic forces explain the reversal in valuation effects.

We show that an overwhelming share of the trends in realized returns can be explained by decreasing long-term debt issuances, as well as an increase in investor demand for U.S. equity. A lack of U.S. issuances relative to global demand for long-term debt drives up prices and returns on U.S. long-term debt liabilities, and accounts for half of the reversal in the valuation effect post-2010. The remainder of this reversal captures the increase in realized U.S. equity returns, both as a result of both the market-wide shift from debt assets to equity assets, and a within asset class demand shift towards U.S. equity.

In the final section of the paper, we explore how hetereogeneity in investor demand elasticities and downward sloping demand curves influence a novel notion of privilege. Specifically, taking demand curves and portfolios as given in 2019, we estimate the quantity of new long-term debt which can be issued by each of the G10 countries until yields increase by 1%. We find that, relative to all other G10 countries, the U.S. could issue approximately 3 times the amount of debt before its yield increases by 1%. These findings help to further quantify a notion of exhorbitant privilege enjoyed by the U.S.—the ability to borrow large quantities at low rates.

Literature Review. Our paper contributes to an empirical literature studying the drivers of net foreign asset dynamics and the composition of global portfolios (Lane and Milesi-Ferretti 2007b; Gourinchas and Rey 2007a,b; Curcuru, Dvorak, and Warnock 2008). In particular, our paper focuses on the imbalances in the U.S. net foreign asset position (Caballero, Farhi, and Gourinchas 2008; Gourinchas, Rey, and Govillot 2010; Gourinchas and Rey 2014). We contribute to this literature by taking a finance perspective for portfolio allocations that accounts for investor substitution between assets within and across asset classes. A number of papers studies portfolio models and their theoretical implications for international imbalances (Ghironi, Lee, and Rebucci 2007; Devereux and Sutherland 2009; Cova, Pisani, and Rebucci 2009; Tille and Van Wincoop 2010). By contrast, we directly estimate a flexible portfolio choice model which directly matches observed portfolio holdings.

A key contribution to the global imbalances literature showed that the U.S. benefits from an exorbitant privilege in asset returns. From 1952 to 2004, the U.S. external imbalance was partially reduced by a positive difference between the returns on its external asset and liability positions Gourinchas and Rey (2007a). Recently Atkeson, Heathcote, and Perri (2021) show that these return dynamics have changed, and the authors attribute these changes to high returns on U.S. equities driven by mark-ups and profits. Our paper contributes to this literature by, first, highlighting additional drivers of the reversal in U.S. privilege, and, second, illustrating and measuring a novel quantity dimension of U.S. privilege.

A large literature studies various drivers of capital flows to and from countries. Drivers of capital flows in the previous literature include institutional quality (Alfaro, Kalemli-Ozcan, and Volosovych 2008), demographic factors (Lane and Milesi-Ferretti 2001; Carvalho, Ferrero, and Nechio 2016), financial development (Caballero, Farhi, and Gourinchas 2008) , oil shocks (Kilian, Rebucci, and Spatafora 2009), and interactions between financial frictions and international trade (Antras and Caballero 2009)[5]. We are able to evaluate the relative importance of different channels in driving flows using a demand based framework.

[5] Additional drivers of flows include banking flows (Shin 2012), the abilities to insure against idiosyncratic risk (Mendoza, Quadrini, and Rios-Rull 2009; Angeletos and Panousi 2011), information and transaction cost (Portes, Rey, and Oh 2001; Portes and Rey 2005)

Finally, the methodology we use in this paper builds upon a literature that explicitly measures asset demand elasticities to understand changes in asset prices (Krishnamurthy and Vissing-Jorgensen 2012; Koijen and Yogo 2019b; Koijen, Richmond, and Yogo 2019; Koijen, Koulischer, Nguyen, and Yogo 2020).[6] Closely related to our work is Koijen and Yogo (2019b), which develops a demand system for international financial assets and provides a variance decomposition of exchange rates and asset prices globally. However, rather than focus on asset prices, our paper uses the demand system approach to study the drivers of portfolio holdings and the U.S. external imbalance. Our paper also relates to Gabaix and Koijen (2020) who show how flows into and out of asset markets can have substantial price impact when demand is inelastic.

This paper proceeds as follows. Section 1 provides a theoretical framework for estimating asset demand and relating it to global imbalances. Section 2 reports data sources and summary statistics, discusses the estimation procedure, and presents the estimation results. Section 3 presents the results from our decomposition method. Section 4 concludes.

1 Model

In this section, we present our model of international asset markets. Time is discrete. There are N issuer countries in the world which issue assets, and I investor countries which contain representative investors who allocate their wealth across the asset space. These two sets of countries can be overlapping. A salient feature of our model is that we allow investors' wealth to respond endogenously to portfolio choices and asset revaluation over time, which is crucial in our application of demand system in the context of international portfolio dynamics.

1.1 Net Foreign Assets and Portfolio Choice

We begin by providing a broad overview of the components in our model, and by explicitly relating these components to the standard decomposition of NFA. According to the balance

[6] A related literature on the asset price dynamics in the bond market also adopts a quantity-centric view (Vayanos and Vila 2009; Greenwood, Hanson, and Stein 2010; Greenwood and Vayanos 2014; Malkhozov, Mueller, Vedolin, and Venter 2016; Greenwood, Hanson, Stein, and Sunderam 2019; Liao and Zhang 2020).

of payments identity, the law of motion for the U.S. NFA dynamics is

$$NFA_{US,t} - NFA_{US,t-1} \;\; = \;\; TB_{US,t} + IB_{US,t} + CG_{US,t} \tag{1}$$

where TB is trade balance, IB is income balance, and CG is capital gains. The income balance captures earnings on foreign investments minus payments made to foreign investors, and the capital gains capture changes in the value of assets held abroad minus the changes in the value of domestic assets held by foreign investors. A large literature studies the evolution of the NFA position by modeling changes in the current account, which is typically defined as the sum of the trade balance and the income balance, $CA = TB + IB$.

Our approach is to understand NFA dynamics from the perspective of a portfolio allocation decision. Let $A_{i,t}$ denote investor i's total wealth (assets under management), which includes its holdings of domestic and foreign assets. Let $w_{i,t}(k)$ denote the portfolio share of country i's investor on country k's asset, and let $R_t(k)$ denote the cum-dividend return on country k's asset in a common numeraire (i.e., U.S. dollars). A country's NFA position is the difference between the sum of its external assets and its external liabilities. For the U.S., this is

$$NFA_{US,t} = A_{US,t} \sum_{k \neq US} w_{US,t}(k) - \sum_{k \neq US} A_{k,t} w_{k,t}(US),$$

which shows that changes in a country's NFA position reflect changes in all countries' wealth and changes in their portfolio weights. Between any two periods, the law of motion for the U.S. wealth is

$$A_{US,t} - A_{US,t-1} = A_{US,t-1} \sum_{k} w_{US,t-1}(k) R_t(k) + F_{US,t},$$

where $F_{US,t}$ represents the total net financial savings within the U.S. between two periods.

Proposition 1. *Let $V_t(US)$ denote the total market capitalization of all U.S. financial assets. The trade balance is equal to net financial savings $F_{US,t}$ minus the net proceeds the domestic issuer raises from the asset market,*

$$TB_{US,t} \;\; = \;\; F_{US,t} - (V_t(US) - V_{t-1}(US)(1 + R_t(US))),$$

and the sum of the income balance and capital gains is equal to the difference in cum-dividend returns on U.S. external assets minus those on U.S. external liabilities,

$$IB_{US,t} + CG_{US,t} = A_{US,t-1} \sum_{k \neq US} w_{US,t-1}(k) R_t(k) - \sum_{k \neq US} A_{k,t-1} w_{k,t-1}(US) R_t(US).$$

Proposition 1 expresses the components that drive the NFA dynamics in equation (1) in terms of the elements of our portfolio problem.[7] To see why, note that $(V_t(US) - V_{t-1}(US)(1 + R_t(US)))$ is the net proceeds the domestic issuer raises from the asset market and that it is equal to the proceeds from issuance minus the dividend payout. This proposition shows that there are only two ways to generate a positive savings flow $F_{US,t}$ from the U.S. investors. First, the U.S. has to run a positive trade balance (i.e., trade surplus); second, the U.S. asset issuer has positive net proceeds from issuance minus dividend payout.

In the following sections, we provide additional details about the determination of portfolio weights, investor wealth, and asset returns. By using a portfolio model estimated with disaggregated bilateral portfolio holdings data, our approach provides novel insight into the dynamics of U.S. NFA. However, as Proposition 1 shows, the decomposition exercises we perform can be mapped directly to the components of the balance of payments.

1.2 Modeling Demand for Assets

In order to operationalize the model above, we need a realistic specification of portfolio choice $w_{i,t}(k)$. To do so, we adopt a demand system approach based on Koijen and Yogo (2019a); Koijen, Richmond, and Yogo (2019); Koijen and Yogo (2019b).

We first introduce additional asset classes indexed by ℓ: short-term debt ($\ell = 1$), long-term debt ($\ell = 2$), and equity ($\ell = 3$). We use the pair (n, ℓ) to denote country n's asset of the asset class ℓ. For example, we denote investor country i's portfolio weight for this asset as $w_{i,t}(n, \ell)$. Moreover, each asset class is comprised of $N + 1$ assets indexed by n — one for each country and an additional "outside" asset indexed by $n = 0$. The outside assets allows the investors to allocate a portion of their wealth outside of the country specific assets.

We model the portfolio weight of investor i in country n and asset class ℓ following a

[7] See Appendix A for a proof the Proposition 1.

nested logit structure:

$$w_{i,t}(n,\ell) = w_{i,t}(n|\ell) \cdot w_{i,t}(\ell), \tag{2}$$

where $w_{i,t}(n|\ell)$ is investor i's portfolio weight on country n within asset class ℓ, and $w_{i,t}(\ell)$ is investor i's total portfolio weight on asset class ℓ.

Step 1: Demand within Asset Class. Within an asset class ℓ, the portfolio weight for investor i at time t in country n is a logistic function:

$$w_{i,t}(n|\ell) = \frac{\delta_{i,t}(n,\ell)}{1 + \sum_{k=0}^{N} \delta_{i,t}(k,\ell)}, \tag{3}$$

where $\delta_{i,t}(n,\ell)$ captures the relative desirability of a country's asset in this asset class:

$$\delta_{i,t}(n,\ell) = \exp(\beta_\ell \mu_{i,t}(n,\ell) + \boldsymbol{\theta}'_\ell \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell)). \tag{4}$$

This desirability term has three components. First, $\mu_{i,t}(n,\ell)$ denotes the expected return at time t for country i's investor in country n's asset of class l[8], which we measure using the combination of market-to-book ratios and exchange rates that best predicts future returns — the details of this regression are in the following section. The second component is the set of observable asset characteristics $\mathbf{x}_{i,j,t}$ that can be asset-specific or bilateral in nature. The third component is the unobserved latent demand $\kappa_{i,j,t}$, which describes additional variation in the demand curve that is not captured by the expected return or observed asset characteristics.

By construction, the total sum of shares invested into each asset equals 1, $\sum_{n=0}^{N} w_{i,t}(n|\ell) = 1$. The portfolio weight in the outset asset in asset class ℓ is therefore given by $w_{i,t}(0|\ell) = 1/(1 + \sum_{k=0}^{N} \delta_{i,t}(k,\ell))$.

Step 2: Demand across Asset Classes. Next, to allow for substitution across asset classes, the asset class portfolio weight is specified as a nested logit. The portfolio weight

[8] Koijen and Yogo (2019a) show that demand curves of this form can be derived as approximation of a Merton (1973) portfolio allocation problem.

for investor i at time t in asset class ℓ is given by

$$w_{i,t}(\ell) = \frac{(1 + \sum_{k=0}^{N} \delta_{i,t}(n,\ell))^{\lambda_\ell} \exp(\alpha_\ell + \xi_{i,t}(\ell))}{\sum_{m=1}^{3} (1 + \sum_{k=0}^{N} \delta_{i,t}(k,m))^{\lambda_m} \exp(\alpha_m + \xi_{i,t}(m))}, \tag{5}$$

where α_ℓ are asset class fixed effects and $\xi_{i,t}(\ell)$ are asset class latent demand. The terms $(1 + \sum_{k=0}^{N} \delta_{i,t}(n,\ell))$ are referred to as inclusive values for a given asset class ℓ. The inclusive value captures the relative attractiveness of each of the asset classes. For example, when average relative prices of assets within an asset class change, so too will the total allocations to these asset classes[9].

Expected Excess Returns. Investors care about expected excess returns in their own currency when forming their portfolios. Let $r_{t+1}(n,\ell) = \log(1 + R_{t+1}(n,\ell))$ denote the log return in USD on asset class ℓ in country n from time t to $t+1$. Then, the log excess return of this asset from the perspective of country i's investor is the difference between its log USD return and the log USD return of country i's short-term debt: $r_{t+1}(n,\ell) - r_{t+1}(i,1)$.

To construct a measure of expected returns, we use a forecasting regression as in Koijen and Yogo (2019b):

$$r_{t+1}(n,\ell) - r_{t+1}(US,1) = \phi_\ell \cdot p_t(n,\ell) + \psi_\ell \cdot (e_t(n) - z_t(n)) + \chi_{n,\ell} + \nu_{t+1}(n,\ell), \tag{6}$$

which project the excess return of each asset n from the US perspective at time $t+1$ onto its log market-to-book ratio $p_t(n,\ell)$ at time t and the log real exchange rate $(e_t(n) - z_t(n))$ between country n and the USD. Specifically, the book value in the market-to-book ratio is the standard equity book value in the case of equity, and the par value in the case of debt. The log real exchange rate is the difference between the log nominal exchange rate $e_t(n)$ and the log consumer price index $z_t(n)$. Lastly, we allow the regression coefficients ϕ_ℓ and ψ_ℓ to be specific to the asset class ℓ.

Based on this forecasting regression, the expected log excess return on asset n in investor

[9] See Koijen and Yogo (2019b) for further discussion of this specification and for some examples of special cases.

i's currency is then given by

$$\mu_{i,t}(n,\ell) = \mathbb{E}_t[r_{t+1}(n,\ell) - r_{t+1}(i,1)]$$
$$= \phi_\ell p_t(n,\ell) + \psi_\ell(e_t(n) - z_t(n)) + \chi_{n,\ell} - \phi_1 p_t(i,1) - \psi_1(e_t(i) - z_t(i)) - \chi_{i,1}.$$

Central Banks. We further split off asset demand by private investors and by central banks. We use $B_{i,t}(n,\ell)$ to denote the holdings of country n's assets by country i's central bank, and we take these central bank holdings as exogenous quantities.

In practice, however, we acknowledge that central banks hold assets for several motives. For example, central banks may hold foreign long-term debt as currency reserves, which can be used to buffer the exchange rate movement of domestic currency. In recent years, central banks have also purchased their own domestic assets in attempts to lower long-term interest rates. By reducing long-term interest rates, the central bank further stimulate the economy even when the short-term interest rate reaches zero.

1.3 AUM Dynamics and Market Clearing

In order to study the variation in portfolio positions across countries, it is also important to have realistic dynamics for investor wealth. A contribution of our paper is to endogenize the AUM dynamics along with prices and portfolio choices in studying the NFA position. In each period, an investor's AUM adjusts according to the returns to the assets the investor holds. Recall, the law of motion for the AUM for investor i in USD terms is:

$$A_{i,t} = A_{i,t-1} \sum_{\ell=1}^{3} \sum_{k=0}^{N} w_{i,t-1}(\ell) w_{i,t-1}(k|\ell)(1 + R_t(k,\ell)) + F_{i,t} \tag{7}$$

where $R_t(k,\ell)$ is the USD cum-dividend return at time t on asset k in asset class ℓ and $F_{i,t}$ is investor i's savings flow at time t in USD terms. The savings flow captures any savings and withdrawals in this investor's financial account.

The cum-dividend return is endogenous and captures both dividends and capital gains:

$$R_t(k,\ell) = \frac{P_t(k,\ell) S_t(k,\ell) E_t(k) + D_t(k,\ell)}{P_{t-1}(k,\ell) S_{t-1}(k,\ell) E_{t-1}(k)} - 1, \tag{8}$$

where $D_t(k,\ell)$ are dividends per share in USD terms, and $S_t(k,\ell)$ is the conversion factor between book value and share number (i.e. book-per-share) in local currency terms. Recall that $P_t(k,\ell)$ denotes the price-to-book ratio. So, $P_t(k,\ell)S_t(k,\ell)E_t(k,\ell)$ is the USD price per share. For bonds, the book value is the par value, and hence the conversion factor $S_t(k,\ell)$ is always 1.

Let $Q_t(n,\ell)$ denote the quantity supplied by country n in asset class ℓ in its local currency terms. It is the book value in local currency for equity, and the par value in local currency for debt. We assume $Q_t(n,\ell)$ is given exogenously. The USD book value $E_t(n)Q_t(n,\ell)$ and the USD market value $P_t(n,\ell)E_t(n)Q_t(n,\ell)$ of the asset, on the other hand, are endogenous.

The market clearing condition for asset (n,ℓ) in USD terms is

$$P_t(n,\ell)E_t(n)Q_t(n,\ell) = \sum_{i=1}^{I} A_{i,t}w_{i,t}(\ell)w_{i,t}(n|\ell) + P_t(n,\ell)E_t(n)\sum_{i=1}^{I} B_{i,t}(n,\ell). \tag{9}$$

The left-hand side is the total market value, and the right-hand side is the sum of the dollar value of investors' portfolio holdings of asset n plus the sum of the dollar value of central banks' reserve holdings. As shown above, portfolio weights are a function of asset prices and exchange rates.

There are 3 asset class with N assets each, which leads to $3N$ market clearing conditions. Taking short-term bond prices as given, there are N long-term bond prices, N equity prices, and $N-1$ exchange rates with respect to the USD. Following Koijen and Yogo (2019b) we assume that the Federal Reserve adjusts the supply of U.S. short term debt to clear markets. This assumption leads to an exactly determined system in the N long-term bond prices, N equity prices, and $N-1$ exchange rates. We use this system in the following section to study how various components which we take as exogenous have driven variation in global imbalances.

2 Model Estimation

2.1 Data Sources

In this section, we describe the data we use to decompose international capital flows and prices. We rely on three types of data: cross-country portfolio holdings, asset characteristics, and the realized asset returns. At each stage of our data construction procedure, we combine the best available data to get an accurate representation of cross-border holdings while paying special attention to the U.S. NFA position and U.S. portfolio returns. In the interest of brevity, we summarize our data contruction here, and relegate the details to Appendix C.

We generate a panel of cross-country asset holdings by combining holdings data from the IMF, the U.S. Treasury, and the U.S. Federal Reserve. For each country i, we observe year-end holdings of foreign financial assets in US dollars by asset class and issuer country. The asset classes comprise short-term debt, long-term debt and equity. The asset holders include government entities, corporations, and individuals. We additionally observe foreign central bank reserve holdings through the SEFER survey, and we observe FRB quantitative easing purchases through the FRB balance sheet. Finally, these portfolio holdings data do not record domestic holdings of financial assets, which we need in order to understand how investors in all asset classes substitute between domestic and international investment. Hence, we estimate domestic portfolio holding data by subtracting foreign asset holdings from total market capitalization.

A well-known issue with portfolio holdings data is that flows to and from offshort financial centers can present a highly distorted view of capital allocation, because these flows are not associated with the investment decisions of their ultimate investor or issuer country. In particular, Coppola, Magiori, Neiman, and Schreger (2020) point out that investment by countries in the European Monetary Union are often funneled through Luxembourg, and separating this investment back to individual countries is impossible.[10] In order to mitigate these problems, we use the reallocation matrices provided by Coppola, Magiori, Neiman, and Schreger (2020) to reattribute portfolio holdings to their investor nationality, as much as possible. We also aggregate all investment holdings by Euro Area countries into a single

[10] As a result, in the raw CPIS data, Luxembourg is in the top 10 investor for all asset classes.

European Monetary Union investor.

In addition to the holdings data, we construct a panel of characteristics. We choose a set of characteristics that investors could potentially use to proxy for expected returns. These characteristics include asset-level characteristics such as the total market-to-book value of equity, the yields on short-term and long-term debt, and the returns from investing in each asset. We use yields on 3-month government debt to capture the yield on short-term debt, and we use the yield on 10-year government debt to capture the yield on long-term debt. We also observe country-level characteristics that may affect the risk profile for all assets in a country. These country-level characteristics include proxies for country size (GDP, GDP per capita), trade network centrality (Richmond 2016), and sovereign default risk. Finally, we include a standard set of macroeconomic characteristics: the real dollar exchange rate, inflation, bilateral export share, bilateral import share and the distance between countries.

Finally, in order to decompose changes in the NFA position into capital flows and realized returns over time, we need reliable aggregate measures of the realized returns earned by global investors. For all countries except for the U.S., we compute returns using short-term and long-term yields for debt instruments, and we compute returns using country-level Datastream Total Return Indexes for equity instruments. For the U.S., we observe both capital flows into the U.S. and holdings in each period. Thus, we can directly compute the returns implied by the difference between the year-to-year changes in holdings and observed flows.[11]

Our sample comprises of asset issued by 33 issuer countries which are held by 31 total investor countries. Appendix B provides the list of countries. We also observe the portfolio position of aggregated foreign central bank reserves and of the U.S. Federal Reserve. The sample period ranges from 2002 to 2019.

Table 1 presents the assets and liabilities of the US for each of the three asset classes. The table presents the top 5 bilateral positions for each asset class in 2002 and 2019 as well as the total holdings for all other countries. On the liability side, the largest long-term debt liability of the US is the European Union in both 2002 and 2019, while China is the second largest in 2019. For equity, the largest liability is again to the European Union with the

[11]See the Appendix C for additional details on calculating returns by asset class.

United Kingdom being second. On the asset side, the largest equity positions in 2019 are China, the United Kingdom, and Japan.

2.2 Demand Estimation and Identification

We now turn to the estimation of the within asset class and across-asset class demand. Our estimation procedure follows Koijen and Yogo (2019b). Equation (3) implies

$$\log\left(\frac{w_{i,t}(n,\ell)}{w_{i,t}(0,\ell)}\right) = \beta_\ell \mu_{i,t}(n,\ell) + \boldsymbol{\theta}'_\ell \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell). \tag{10}$$

This regression is estimated separately for each asset class ℓ using an instrument for expected returns, the panel of bilateral holdings data and our set of characteristics. We detail the construction of these instruments below.

The estimation equation for cross-asset demand is obtained by dividing equation (5) for short-term ($\ell = 1$) and long-term debt ($\ell = 2$) by the equation for equity ($\ell = 3$):

$$\begin{aligned}\log\left(\frac{w_{i,t}(\ell)}{w_{i,t}(3)}\right) &= \lambda_\ell \log\left(1+\sum_{n=0}^{N}\delta_{i,t}(n,\ell)\right) - \lambda_3 \log\left(1+\sum_{n=0}^{N}\delta_{i,t}(n,3)\right) + \alpha_\ell + \xi_{i,t}(\ell) \\ &= -\lambda_\ell \log\left(w_{i,t}(0|\ell)\right) + \lambda_3 \log\left(w_{i,t}(0|3)\right) + \alpha_\ell + \xi_{i,t}(\ell), \end{aligned} \tag{11}$$

where the second equality follows from equation (3) applied to the outside asset 0. This regression is estimated using a panel of aggregate holdings of each asset class ℓ by investors i at time t and instruments for $w_{i,t}(0|\ell)$.

For both sets of regressions equation (10) and equation (11), we use the panel of portfolio shares and characteristics to estimate equation. Each observation records investor i's portfolio share of country j at the end of year t. All portfolio holdings that cannot be attributed to the issuer countries in our sample are instead attributed to an "outside" asset. The issuer country characteristics on the right-hand side of equation (10) are its log nominal GDP, log GDP per capita, trade centrality, sovereign default risk, the real exchange rate and inflation. We also include bilateral import and exports exposures and distance. Finally, we include indicator variables for domestic investment, US issuer, investor country, and year fixed effects.

The main identification challenge is to consistently estimate equations (10) and (11) given that expected returns may be endogenous to the latent demand of investors. We follow the identification strategy of Koijen and Yogo (2019b), which we briefly summarize here. The estimation proceeds by first constructing an instrument for $w_{i,t}(0|\ell)$ in order to consistently estimate equation (11). Then, using these estimates and market clearing, an instrument is constructed for exchange rates and prices. Using the instruments for exchange rates and prices then allows for the consistent estimation of equation (10).

The instruments for $w_{i,t}(0|\ell)$ are constructed by calculating predicted values from equation (10), but using only characteristics that are plausibly exogenous to the system: log GDP, bilateral distance, investor fixed effects, and the own country dummy. Using these characteristics, we use exogenous variation in portfolio weights of individual investors. Furthermore, by using these predicted weights and market clearing, we are able to construct instruments for the endogenous variables in the model. The predicted values from equation (10) using only the exogenous characteristics are denoted by $\hat{\delta}_{i,t}(n,\ell)$, which allow for the construction of the instrument for $w_{i,t}(0|\ell)$:

$$\hat{w}_{i,t}(0|\ell) = \frac{1}{1 + \sum_{n=0}^{N} \hat{\delta}_{i,t}(n,\ell)}. \tag{12}$$

Using these instruments, we estimate $\hat{\lambda}_\ell$ and $\hat{\alpha}_\ell$ from equation (11).

Given $\hat{\delta}_{i,t}(n,\ell)$, $\hat{\lambda}_\ell$, and $\hat{\alpha}_\ell$, we construct an instrument for prices and exchanges rates using market clearing. To do so we first compute a predicted weight for country n in asset class ℓ at time t:

$$\hat{w}_{i,t}(n,\ell) = \frac{\hat{\delta}_{i,t}(n,\ell)}{1 + \sum_{n=0}^{N} \hat{\delta}_{i,t}(n,\ell)} \frac{\left(1 + \sum_{n=0}^{N} \hat{\delta}_{i,t}(n,\ell)\right)^{\hat{\lambda}_\ell} \exp \hat{\alpha}_\ell}{\left(1 + \sum_{n=0}^{N} \hat{\delta}_{i,t}(n,\ell)\right)^{\hat{\lambda}_\ell} \exp \hat{\alpha}_\ell}. \tag{13}$$

The final step is to use market clearing to construct instruments for exchange rates and prices. The market clearing is done using portfolio weights that are constructed using only the exogenous characteristics. We use short-term debt markets to calculate the instrument for exchange rates. In particular, market clearing in the short-term debt market given the predicted weights implies our instrument for exchange rates:

$$\hat{E}_t(n) = \frac{1}{Q_t(n,1)} \sum_{i=1}^{I} \frac{O_{i,t}\hat{w}_{i,t}(n,1)}{1 - \sum_{m=1}^{3}\sum_{k=1}^{N} \hat{w}_{i,t}(k,m)}.$$

The instruments for long-term bond prices and stock prices also clear their markets at the predicted weights

$$\hat{P}_t(n,\ell) = \frac{1}{\hat{E}_t(n)Q_t(n,\ell)} \sum_{i=1}^{I} \frac{O_{i,t}\hat{w}_{i,t}(n,\ell)}{1 - \sum_{m=1}^{3}\sum_{k=1}^{N} \hat{w}_{i,t}(k,m)}.$$

With these instruments in hand we can estimate equation (10). For short-term debt we instrument expected returns with $\hat{E}_t(n)$. For long-term debt and equity we instrument expected returns with $\hat{E}_t(n)$ and $\hat{P}_t(n,\ell)$ for $\ell = 2, 3$.

The estimates for within asset class demand curves are presented in Table A.2 and the across asset parameters are presented in Table A.3 in Appendix B. For the within asset demand curves, the coefficients on expected returns are all positive, which implies that conditional on a set of asset characteristics, assets with higher expected returns are preferred by investors. The coefficients on asset characteristics are all intuitive. Investors prefer assets that provide better hedges against systematic risks. These are assets of larger countries and countries with higher trade centrality. Investors also prefer assets of countries that are closer and with whom they have a stronger trade relationship. Finally, the last row of Table A.2 shows there is strong home bias in all asset classes.

Turning to the cross-asset substitution parameters, we see that all λ_ℓ values are between 0 and 1. This implies that there is some substitution between asset classes when the relative value of an asset class varies. This is in contrast to the case when $\lambda_\ell = 0$ where asset level allocations are independent of the relative values of the asset classes. In contrast, when $\lambda_\ell = 1$, substitution between assets only depends on the individual country level prices, as discussed in Koijen and Yogo (2019b).

3 Decomposition of U.S. NFA Position

3.1 Decomposition Method

With our estimated demand system, we are in a position to measure the impact of different factors on the trend in the U.S. NFA position. To decompose the trend we begin by setting all primitive variables in year t to their values in the previous year, $t-1$.[12] We compute the equilibrium NFA position through market clearing, and refer to this equilibrium as the *baseline* step. By construction, the year t NFA position in the baseline is unchanged from the data in the previous year. We then sequentailly restore the changes in primitive variables to their year t values, recomputing the NFA position at each stage. After restoring all variables, we arrive at the actual observed NFA in the data which we refer to as *observed* step.

Specifically, consider a sequence of $J+1$ steps that start with the baseline step and end with the observed step. For each step, we iteratively restore a set of primative variables to their time t values, and calculate an equilibrium NFA position. Let $\widetilde{NFA}^{j}_{US,t}$ denote the NFA from step j at time t. $\Delta_{j,t}$ denotes the difference in the log of the implied U.S. NFA between the j-th step and the $(j-1)$-th step

$$\Delta_{j,t} \quad = \quad \log \widetilde{NFA}^{j}_{US,t} - \log \widetilde{NFA}^{j-1}_{US,t}.$$

Because the U.S. NFA position is negative over our sample, a positive value for $\Delta_{j,t}$ implies widening of the NFA position to a more negative level. The sum of $\Delta_{j,t}$ across all steps J is equal to the actual change in the U.S. NFA:

$$\sum_{j} \Delta_{j,t} \quad = \quad \log NFA_{US,t} - \log NFA_{US,t-1}.$$

To understand the drivers of the trend in the U.S. NFA position, we report the average

[12]The only exception is the net savings $F_{i,t}$, which we set to offset the assets' dividend payouts, such that there are no net inflows of capital into the demand system.

of the incremental contribution of each step across years:

$$\overline{\Delta}_j = \frac{1}{T}\sum_j \Delta_{j,t}. \tag{14}$$

Changes in NFA positions comprise both capital flows and changes in asset values. We find it useful to think about these flow and revaluation effects separately. For each step j, we compute a hypothetical "constant-price" NFA position by holding asset prices and exchange rates constant at the values in the $(j-1)$-th case:

$$\widetilde{NFA}_{US,t}^{ConstPrice,j} = \sum_{k\neq US} \widetilde{A}_{US,t}^{j}\widetilde{w}_{US,t}^{j}(k)\frac{\widetilde{P}_t^{j-1}(k)\widetilde{E}_t^{j-1}(k)}{\widetilde{P}_t^{j}(k)\widetilde{E}_t^{j}(k)} - \sum_{k\neq US} \widetilde{A}_{k,t}^{j}\widetilde{w}_{k,t}^{j}(US)\frac{\widetilde{P}_t^{j-1}(US)\widetilde{E}_t^{j-1}(US)}{\widetilde{P}_t^{j}(US)\widetilde{E}_t^{j}(US)}.$$

Then, we define the flow effect as the change in the NFA position while holding asset prices and exchange rates constant:

$$\Delta_{j,t}^{Flow} = \log\left(1+\frac{\widetilde{NFA}_{US,t}^{ConstPrice,j} - \widetilde{NFA}_{US,t}^{j-1}}{\widetilde{NFA}_{US,t}^{j-1}}\right),$$

and we define the revalation effect as the change in the NFA position that is due to updates in asset prices and exchange rates:

$$\Delta_{j,t}^{Reval} = \log\left(1+\frac{\widetilde{NFA}_{US,t}^{j} - \widetilde{NFA}_{US,t}^{ConstPrice,j}}{\widetilde{NFA}_{US,t}^{j-1}}\right).$$

Thus, $\Delta_{j,t}^{Flow}$ sheds light on how capital flows affect the U.S. NFA position, holding asset prices and exchange rates constant, while $\Delta_{j,t}^{Reval}$ sheds light on how changes in asset prices and exchange rates affect the U.S. NFA position. The flow and valuation components sum together to equal the overall change in the NFA position in the j-th case in levels:

$$\exp(\Delta_{j,t}) - 1 = \left(\exp(\Delta_{j,t}^{Flow}) - 1\right) + \left(\exp(\Delta_{j,t}^{Reval}) - 1\right).$$

In logs, however, this summing-up relationship is approximate if each component is small,

$$\Delta_{j,t} \;\approx\; \Delta_{j,t}^{Flow} + \Delta_{j,t}^{Reval}.$$

Having specified our decomposition framework, we now detail the specific sequence of steps we evaluate in our exercise.

Savings and Investments We start by measuring the contribution of investors' savings $F_{i,t}$, and asset and liability issuances $Q_t(n,\ell)$ in various geographic regions. In each step, we restore investors' savings and asset issuance simultaneously for a given geographic region.[13] Thus, our exercise helps us evaluate the effects of savings gluts, which are driven by an excess of foreign savings relative to domestic investment opportunities. In particular, we first restore U.S. savings and issuances. Second, we additionally restore developed markets in the Asia Pacific region. Third, we additionally restore developed markets in the Europe region. Fourth, we additionally restore the remaining developed (i.e. Canada) and emerging markets.

Monetary Policy Next, we account for the effect of various forms of monetary policy. We start by restoring the changes in U.S. short-term interest rate. Then, we restore the U.S. holdings of domestic debt assets via quantitative easing (QE). Lastly, we restore foreign short-term interest rate and foreign central banks' reserve holdings for non-U.S. assets.

Demand Shifts Finally, we restore the asset characteristics $\mathbf{x}_{i,t}(n)$, the within-asset latent demand $\kappa_{i,t}(n,\ell)$, and the across-asset latent demand $\xi_{i,t}(\ell)$. This step accounts for changes in the relative desirability of assets and asset classes over time, which are captured by changes in asset characteristics and latent demand. After these steps, we reach the J-th case and have therefore restored all variables, fully accounting for the trend in the U.S. NFA position.

[13] Proposition 1 shows that, as a result, we also restore the changes in the trade balance.

3.2 Trend Decomposition of the U.S. NFA Position

Table 2 reports the results of our trend decomposition of the U.S. NFA position. In Column (1), we report the average contribution $\overline{\Delta}_j$ of each set of variables to the log growth of the U.S. NFA in the full sample, the first half of the sample (2002—2010) and the second half of the sample (2011—2019). In Columns (2) and (3), we report the separate components due to capital flows and due to asset price and exchange rate changes. As we discussed in the previous subsection, this decomposition separates the effect of capital flows from that of endogenous asset price and exchange rate changes on the U.S. NFA positions. By comparing the NFA dynamics with and without price adjustments, we can derive a better understanding about the nature of each channel.

We also report the total contriribution for three blocks of variables: savings and issuances, monetary policies, and demand shifts. The three block's average contribution sums up to 9.50, meaning that the average log growth rate of the U.S. NFA is 9.50% per annum within this time period.

The three blocks have different contributions. First, savings and issuances around the world lead to a widening in the U.S. NFA of 9.59% per annum. Second, monetary policies around the world contribute to another 6.64% per annum. Third, and most surprisingly, demand shifts partially reverse the widening trend in the U.S. NFA, offsetting its growth by 6.73% per annum. These results suggest that different forces underlie the seemingly uniform trend in the U.S. NFA. We next discuss these forces in detail.

Savings and Issuances Our first block describes the incremental contributions of different countries' savings and issuances. Intuitively, the first-order effect of asset issuances is to dilute the value of local assets and exchange rates. As the assets become cheaper, this should encourage a net inflow from foreign investors. On the other hand, the first-order effect of investor savings depends on their preferred investment destination. If they allocate most of their savings to domestic assets, these savings will appreciate the local assets; if they allocate most of their savings to the U.S. assets, then, these savings will appreciate the U.S. assets.

We find that the U.S. savings and issuances lead to a 1.96% reduction of the U.S. NFA per annum. Recall that the the U.S. NFA position was consistently negative throughout our sample, so a reduction of the NFA position implies a less negative level. On the other hand, when the asset price and exchange rate adjustments are turned off, the contribution of the U.S. savings and issuances switches sign and becomes a 7.60% widening in the U.S. NFA per annum. These effects are mainly driven by the U.S. asset issuances, which encourage net flows from foreign countries and increases foreign holdings of U.S. assets when holding prices constant. At the same time, the issuances dilute the relative value of the U.S. assets and raise the relative valuation of the foreign assets. The revaluation effect dominates the flow effect, and therefore leads to a net reduction of the U.S. NFA.

In comparion, the savings and issuances from the Asia Pacific and Europe developed markets lead to widening of the U.S. NFA position with and without the effect of price changes. The effect due to the European developed markets is particularly large, contributing to a 9.74% increase in the U.S. NFA per annum. These effects are mainly driven by these countries' savings instead of their investments. Since foreign investors have a bias towards U.S. assets rather than a bias towards local assets, their savings flow to the U.S. asset market more than to domestic asset markets, which also pushes up the value of the U.S. assets more than that of domestic assets. As a result, we observe positive flow effects on the U.S. NFA without price adjustments, and even stronger effects on the U.S. NFA with price adjustments.

Interestingly, the sign is reversed for the other foreign markets. In these markets, investors' savings are dominated by local asset issuances, which reverses the mechanism described above and leads to negative effects on the U.S. NFA. Specifically, these issuances dilute the valuation of local assets and encourage net flows from the U.S., leading to a reduction in the U.S. NFA position with respect to these countries.

Monetary Policy Our second block measures the contributions of different countries' monetary policies. The U.S. short-term interest rate plays the major role in this block, widening the U.S. NFA by 5.25% per annum. This effect can be decomposed into a quantity effect of 1.29% per annum, and a revaluation effect of 2.28% per annum. By inspecting these effects year by year, we find that an increase in the U.S. short-term interest rate makes U.S. debt assets and the U.S. dollar more attractive, raising the U.S. external liabilities as a result. On the other hand, a decline in the U.S. short-term interest rate makes U.S. debt assets and the U.S. dollar less attractive, thereby lowering the U.S. external liabilities. Our sample of 2002 to 2019 is dominated by rate increases, first in early 2000s and then after the financial crisis, and the U.S. short-term interest rate at the end of 2019 is slightly higher than the interest rate in 2002. As a result, the overall effect is dominated by the rising policy rate that makes the U.S. assets more attractive.

Next, we find that U.S. QE plays a minor role. Without asset price and exchange rate adjustments, QE absorbs U.S. debt assets that are available to domestic and foreign private investors, which squeezes out foreign holdings of U.S. assets and leads to a reduction of the U.S. NFA in magnitude. However, QE also raises the value of U.S. assets, and, through appreciation of the U.S. external liabilities, offsets the flow effect.

Foreign monetary policies, including both interest rates and reserve holdings, further contribute to a 1.32% widening in the U.S. NFA per annum. The dominant effect stems from the foreign reserves' purchases of U.S. safe assets, which drives an inflow into the U.S. debt market.

Demand Shifts Lastly, demand shifts partially offset the trend in the U.S. NFA. Specifically, after we restore the variables in the Savings and Issuances block and the Monetary Policy block, the implied U.S. NFA dynamics has a cumulative increase of 16.23% per annum.[14] After we additionally restore the variables in the Demand Shifts block, we exactly match the NFA widening in the data of 9.50% per annum, which is about the half of the effect without demand shifts.

The major drivers are asset characteristics and across-asset-class latent demand shifts, both of which contributed to the reversal in the U.S. NFA. Specifically, changes in asset characteristics in isolation made U.S. assets less desirable relative to foreign assets, leading to a 2.51% reduction in the U.S. NFA due to revaluation. In addition, there has been a shift in latent demand from debt to equity assets. Since the U.S. is the preferred destination for bond investors, this shift further reduces the U.S. NFA by 3.96% per annum.

[14] We arrive at 16.23% by summing up the total contributions of the Savings and Issuances block and the Monetary Policy block.

3.3 Revaluation Effects and the Decline of Exorbitant Privilege

In the previous section, we highlighted the main drivers of the widening of the U.S. portfolio imbalance over the last two decades. Returning to Figure 1, we observe that, on top of the overall downward trend in the U.S. NFA, valuation effects drive additional variations in the global imbalances. Specifically, from 2002 to 2010, the U.S. earned an exorbitant privilege, which balanced the capital flows into the U.S. and contributed to a narrowing of U.S. NFA. From 2011 to 2019, the U.S. exorbitant privilege reversed, and the valuation effects further widened the U.S. NFA.

To further understand the valuation effects on the U.S. NFA, Column (2) of Table 3 shows that between 2002 and 2010, the U.S. earned an average return of 11.75% per annum on its external asset position, while paying an average return of -2.35% per annum on the external liabilities. The difference in returns on U.S. external assets and external liabilities helped temper the widening U.S. portfolio imbalance—a phenonmenon commonly referred to as "exorbitant privilege" (Gourinchas and Rey 2007a). However, since 2010, the U.S. only earned an average of 5.53% per annum on its external assets while paying 3.78% per annum on its external liabilities. In a dramatic reversal, the data reveals the U.S. has been paying substantially more returns to foreigners while simultaneously earning less on its external asset position. Given that the U.S external liabilities are substantially larger than the external assets, this has led to a shrinking gap betwen flows and levels since 2010.

In this section, we seek to understand both the growth and the subsequent decline of U.S. exorbitant privilege over the last 20 years. We first document the differences in returns between U.S. external assets and external liabilities across financial asset classes (e.g., long-term debt, short-term debt and equity), as well as over time. Afterwards, we use our model to decompose the changes in revaluation effects. Although a number of economic forces influenced the relative returns between U.S. external assets and liabilities, an overwhelming share of the variation in valuation effects can be explained by decreasing long-term debt issuances, as well as shifts in demand curves that have made U.S. equity assets more desirable for foreign investors.

Before turning to our decomposition, we highlight two more features in the raw data that manifest themselves in Table 3. First, before 2010, the U.S. dollar depreciation increased the return on U.S. external assets by 3.2% per annum. After 2010, dollar appreciation lowered the return by 2.2% per annum. This difference in dollar returns can account for the majority of the difference in returns on the U.S. portfolio position between the two subsamples. Second, the U.S. paid much higher average returns on its external liability position in both the long-term debt and equity market from 2011 to 2019.

While the numbers in Table 3 are suggestive of the main drivers of valuation changes, the raw data suffer from a major drawback. The raw data only capture realized returns, which may differ from pure valuation effects, because realized returns can confound changes in quantity holdings with changes in prices.

Thus, we turn to our decomposition exercise to quantitatively attribute the variation in the returns of the U.S. external positions to economic primitives. Analogous to the previous section, Table 4 shows the contribution of each primitive variable in driving the revaluation of U.S. external portfolio position. The final row of Table 4 shows that, on average, valuation effects helped shrink the U.S. portfolio imbalance between 2002 and 2010 by an average of 6.0% per annum. Thus, the U.S. indeed earned positive net returns during the earlier sample, which helped reduce its net portfolio imbalance. However, in the 2010 to 2019 sample, valuation effects completely reversed and widened the U.S. portfolio imbalance by an average of 6.7% per annum. Thus, Table 4 provides an even starker contrast of the change in the impact of asset revaluation on trends in the portfolio imbalance than Table 3.

Looking down columns (1) and (2) of Table 4, we can see a primary contributor to change in revaluation effects over time is the pattern of savings and issuances in the U.S. On average, U.S. savings and issuances helped reduce the portfolio imbalance in both subsamples. However, between pre-2010 and post-2010 subsamples, the effect of U.S. savings and issuances declined from reducing the imbalance by 16.5% per annum to reducing the imbalance by just 9.5% per annum. This change of 7.0% per annum alone can explain about half of the change in the revaluation effect between the first and second halves of the sample.

The reason patterns in savings and issuances have first-order effects on revaluation is because the low realized returns the U.S. pays on its external liability position largely reflect the substantial amount of U.S. long-term debt issuances relative to U.S. savings. When

U.S. investors save, they tend to purchase U.S. financial assets, which drives up the realized returns on U.S.-issued bonds — thereby increasing the realized return on U.S. liabilities. On the other hand, U.S. issuances decrease the prices and realized returns on U.S. liabilities. Thus, the declining contribution of U.S. savings and issuances towards reducing the U.S. portfolio imbalance indicates that U.S.-based entities issued substantially less debt relative to demand after 2010, leading to higher prices and realized returns on U.S. external debt liabilities.

Figure 2 shows the above mechanism at work in the raw data. We compute the total quantity of U.S. long-term debt issued at the end of each year, and normalize by the total AUM invested in the long-term debt sector from all countries.[15] In this sense, we seek to capture the total quantity of U.S. long-term debt available relative to the total demand for long-term debt assets. The left-hand panel of Figure 2 shows the overall time-series of issuances, and reveals a distinct drop in the total amount of U.S. long-term debt outstanding relative to demand between the pre-2010 and post-2010 subsamples. The right-hand panel of Figure 2 plots changes in issuances against the realized returns on U.S. long-term debt. Even in the raw data, there is a clear inverse relationship between the quantity of debt issued in a given year, and the realized return in that year. Moreover, we have labeled each data point in the right-hand panel of Figure 2 with its corresponding year. Indeed, we observe that the earlier years in the sample tend to be associated with relatively more debt issuance and lower realized returns, while later years are associated with less issuance and higher realized returns. Therefore, our model shows that capturing the variation in U.S. issuances is quantitatively important for understanding the change in valuation effects of the U.S. portfolio position, and the decline in U.S. exorbitant privilege.

The decomposition in Table 4 highlights one other block of forces crucial for explaining the change in valuation effects over time. These are the shifts in demand curves, which capture changes in asset characteristics, changes in within-asset latent demand, and changes in across-asset latent demand.

In particular, shifts in latent demand both within and across asset classes are principally

[15] For this illustrative figure, we focus on the long-term debt asset class, because U.S. external liabilities comprise mostly of long-term debt.

responsible for driving a dramatic increase in investor demand for U.S.-issued equity in the 2010 to 2019 subsample. For illustrative purposes, Figure 3 presents the relative latent demand for U.S.-issued financial assets relative to the latent demand for foreign-issued financial assets within the long-term debt and equity markets. Increases in these measures imply a stronger demand for U.S.-issued financial assets. As is evident from Figure 3, the latent demand for U.S. long-term debt assets remained relatively flat over time, but latent demand for U.S. equity assets, relative to equity from different countries, exhibited a strong V-shaped pattern of much greater magnitude. Prior to 2010, U.S. equities became increasingly less desirable relative to foreign equities, which depressed U.S. equity values and the realized returns paid on equity liabilities. After 2010, however, this narrative completely reverses. A substantial increase in latent demand for U.S. equity captures a significant rise in U.S. equity returns, and a significant widening of the U.S. portfolio imbalance.

These shifts in latent demand capture changes in economic forces currently outside of our model. For example, a recent paper by Atkeson, Heathcote, and Perri (2021) also highlight the surge in U.S. equity valuations as the primary driver of change in valuation effects over time, and attribute the rise in U.S. equity valuations to rising markups and after-tax profits. Our estimates support this narrative of rising markups through an interpretation where the impact of rising markups are captured by changes in latent demand.

In sum, our decomposition of the valuation effect shows a variety of forces coalesced to drive up realized returns of U.S. external liabilities, and widened the U.S. external position over the last ten years. Declines in U.S. long-term debt issuance relative to investor demand drove up long-term debt prices. Meanwhile, differences in growth rates across countries and shifts in investor latent demand drove up U.S. equity valuations.

3.4 Exorbitant Privilege in Debt Issuance

Up to this point, we have studied the sources of variation in U.S. NFA position and its returns over the last 20 years. In particular, our estimated demand system highlights the large differences in investor demand for different assets. These differences give rise to substantial hetereogeneity in countries' ability to borrow in international financial markets. In this section, we take a forward-looking perspective and ask the question: how much additional long-term debt can a country issue until its long-term yield increases by 1%? These results help quantify a quantity dimension of the U.S. exorbitant privilege, which depends not only on the relatively high prices investors pay to hold U.S. assets, but also on the enormous quantity of long-term debt that the U.S. can issue without affecting prices too much (Farhi and Maggiori 2017).

Formally, we take the state of the economy at the end of 2019 as given, and conduct the following experiment. For each issuer country, we increase the amount of its long-term debt outstanding until its (endogenous) long-term yield increases by 1%. Figure 4 shows the results of this exercise for the G-10 countries. The left-hand panel of Figure 4 shows, clearly, that global investors have the greatest appetite for U.S. long-term debt in pure dollar amounts. Investors would absorb 1.8 trillion dollars of U.S. long-term debt before requiring U.S. issuers to pay an additional 1% in yield. This amount is more than triple the implied quantity for any other G-10 country, suggesting the U.S. has the potential to extract more surplus from international bond markets.

The right-hand panel of Figure 4 scales issuances by 2019 GDP, and reveals that although global investors are willing to absorb much more U.S. debt in absolute terms, the U.S. had much less room to issue debt at the end of 2019, after accounting for the size of the U.S. economy. Instead, our estimates suggest Norway and the United Kingdom have the most room to issue long-term debt as a share of their respective GDPs. In this sense, Figure 4 suggests that the glass is half full and half empty: the U.S. can still issue a fairly large amount of debt assets before yields go up, but this amount is quite small relative to the size of its economy.

4 Conclusion

This paper uses a portfolio approach to evaluate the impact of savings gluts, monetary policies, and investor demand shifts on the evolution of the U.S. NFA. Our framework highlights three key insights that are important to consider for theories of global imbalances. First, the simple downward trend of the U.S. NFA position masks the countervailing forces of global savings gluts, central bank policies, and shifts in U.S. demand curves. Second, a decline in

U.S. debt issuance relative to demand for U.S. debt liabilities, and an increase in investor demand for U.S. equity liabilities lead to a decline in U.S. exorbitant privilege after 2010. Finally, although the U.S. has experienced a decline in its returns earned on its NFA position, demand for U.S. debt is particularly inelastic. As a result, U.S. debt issuers have the privilege of issuing substantially more debt before suffering from higher yields. These results shed new light on the sources of the global imbalances, as well as reveal a new quantity dimension of U.S. privilege.

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Tables and Figures

Table 1
Top Holdings in U.S. External Assets and Liabilities

2002				2019			
Assets		Liabitlities		Assets		Liabitlities	
Long-Term Debt							
Canada	90	European Union	526	Canada	377	European Union	2,828
United Kingdom	79	Japan	410	United Kingdom	354	China	1,904
Germany	48	China	227	France	155	Japan	1,622
France	39	United Kingdom	157	Japan	144	United Kingdom	632
Japan	33	Singapore	53	Australia	135	Switzerland	317
All Other	167	All Other	241	All Other	681	All Other	1,668
Short-Term Debt							
United Kingdom	71	Japan	108	Canada	105	European Union	273
Germany	12	European Union	73	United Kingdom	80	Japan	62
Canada	12	Mexico	23	Japan	57	United Kingdom	47
France	9	China	15	Australia	46	Switzerland	39
Sweden	6	Turkey	8	France	24	Singapore	33
All Other	27	All Other	48	All Other	92	All Other	84
Equity							
United Kingdom	224	European Union	402	China	1,829	European Union	2,536
Japan	154	United Kingdom	160	United Kingdom	1,037	United Kingdom	1,091
France	91	Canada	142	Japan	931	Canada	945
Switzerland	85	Japan	117	Canada	568	Japan	589
Canada	74	Switzerland	93	France	496	Switzerland	378
All Other	385	All Other	167	All Other	2,446	All Other	1,711
Total	1,605	Total	2,971	Total	9,558	Total	16,760

This table reports the top destinations of U.S. external assets and the top holders of U.S. external liabilities, in each asset class and in billion dollars.

Table 2
Trend Decomposition of U.S. NFA

	(1) NFA	(2) Flow	(3) Revaluation
Savings and Issuances			
U.S.	-1.96	7.60	-12.78
Asia Pacific Dev. Markets	3.60	2.15	1.96
Europe Dev. Markets	9.74	5.67	6.93
Other Markets	-1.80	-2.28	0.72
Total Savings and Issuances	9.59	13.06	-2.20
Monetary Policies			
U.S. Rate	5.25	1.29	2.28
U.S. QE	0.07	-1.73	1.42
Foreign Rates and Reserves	1.32	0.80	0.61
Total Monetary Policies	6.64	2.93	2.18
Demand Shifts			
Characteristics	-2.51	-0.25	-2.01
Within-Asset Latent Demand	-0.25	-5.66	11.49
Across-Asset Latent Demand	-3.96	-1.17	-3.00
Total Demand Shifts	-6.73	-5.66	6.84
Total			
Total	9.50	8.78	0.75

Column (1) reports the trend decomposition of the log U.S. NFA. The last row in each block reports the cumulative effect of all components within the block. Columns (2) and (3) decompose each component's contribution to movements due to capital flows and movements due to asset revaluation.

Table 3

Components of U.S. External Portfolio Return Differential

	(1) Full Sample	(2) 2002-2010	(3) 2010-2019
Panel (a) All Asset Classes			
Asset Return (USD)	7.65	11.75	5.53
Asset Return (LC)	7.27	8.55	7.75
Asset Return (FX)	0.38	3.20	-2.22
Liability Return (USD)	1.30	-2.35	3.78
Panel (b) Long-term Debt			
Asset Return (USD)	5.44	9.04	2.14
Asset Return (LC)	5.22	5.95	4.51
Asset Return (FX)	0.22	3.09	-2.37
Liability Return (USD)	-3.27	-7.34	0.06
Panel (c) Short-term Debt			
Asset Return (USD)	2.03	5.76	-1.53
Asset Return (LC)	2.26	3.38	1.19
Asset Return (FX)	-0.23	2.38	-2.72
Liability Return (USD)	1.64	2.57	0.88
Panel (d) Equity			
Asset Return (USD)	8.78	13.24	7.05
Asset Return (LC)	8.35	10.05	9.20
Asset Return (FX)	0.43	3.19	-2.15
Liability Return (USD)	8.60	4.50	9.98

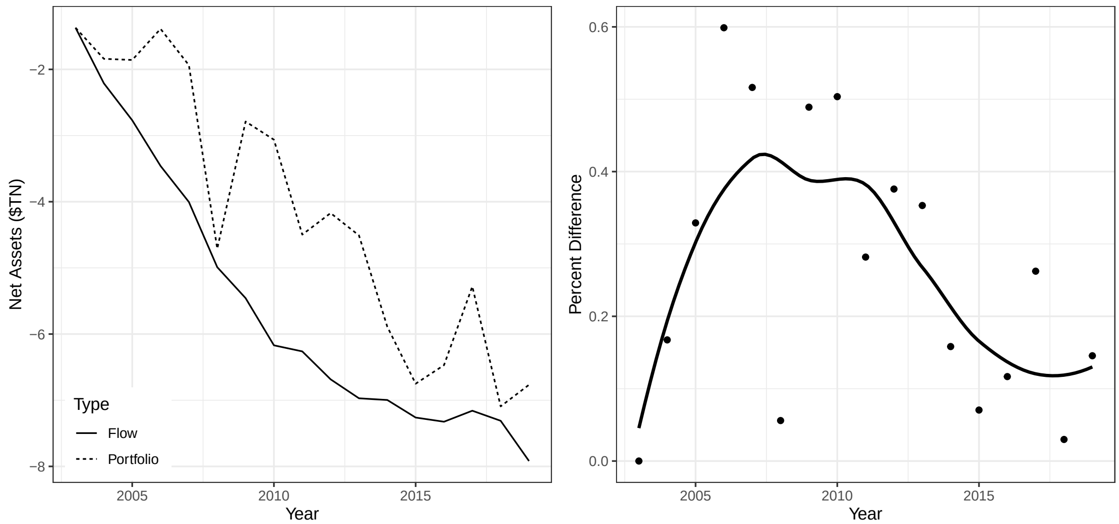
This table decomposes the average returns on U.S. external assets and U.S. external liabilities by asset class. Asset Return (USD) reports the average return of U.S. external assets in U.S. dollars. Asset Return (LC) and Asset Return (FX) attribute Asset Return (USD) into local currency returns and exchange rate changes, respectively. Liability Return (USD) reports average returns on the U.S. liability position. Column (1) reports the average return for the full sample period, while columns (2) and (3) report average returns for two subsamples.

Table 4
Trend Decomposition of U.S. Revaluation: Subsamples

	2002-2010	2010-2019
Savings and Issuances		
U.S.	-16.49	-9.47
Asia Pacific Dev. Markets	5.67	-1.34
Europe Dev. Markets	11.00	3.31
Other Markets	3.92	-2.13
Total Savings and Issuances	6.29	-9.74
Monetary Policies		
U.S. Rate	2.05	2.48
U.S. QE	1.75	1.12
Foreign Rates and Reserves	3.62	-2.07
Total Monetary Policies	4.54	0.08
Demand Shifts		
Characteristics	-4.90	0.56
Within-Asset Latent Demand	6.47	15.96
Across-Asset Latent Demand	-6.39	0.01
Total Demand Shifts	-3.25	15.81
Total		
Total	-5.95	6.71

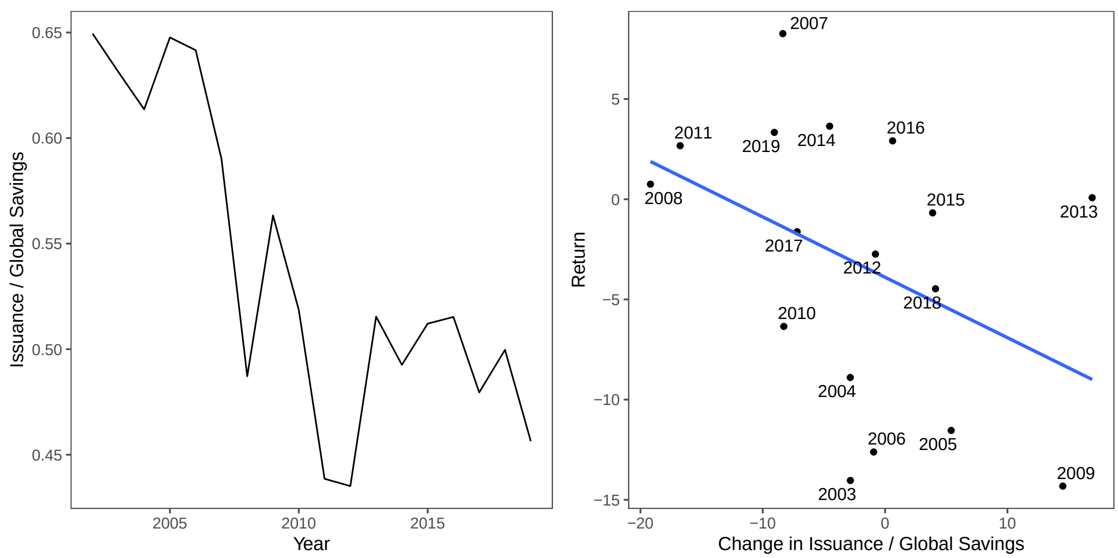
This table reports the revaluation component in the trend decomposition of log U.S. NFA revaluation, in two subsamples.

Figure 1. U.S. Net Portfolio Position



Notes: The left-hand panel plots the aggregate U.S. net portfolio along with the cumulative sum of portfolio flows since 2002. The right-hand panel plots the realized return earned on the U.S. external asset position minus the realized return on the U.S. external liability position.

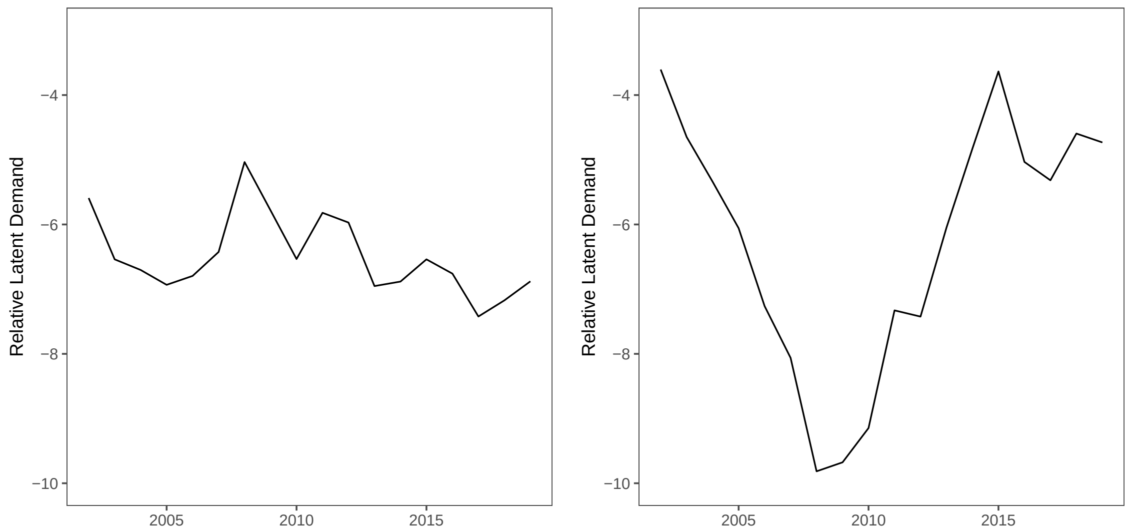
Figure 2. U.S. Long-term Debt Issuance and Realized Returns



Notes: The left-hand panel plots the aggregate quantity of U.S. long-term debt outstanding in each year divided by the total AUM allocated to the long-term debt sector. The right-hand panel plots the change in the quantity of debt outstanding (normalized by total AUM) against the realized return on U.S. long-term debt in each year.

Figure 3. Relative Latent Demand for US Long-term Debt and Equity

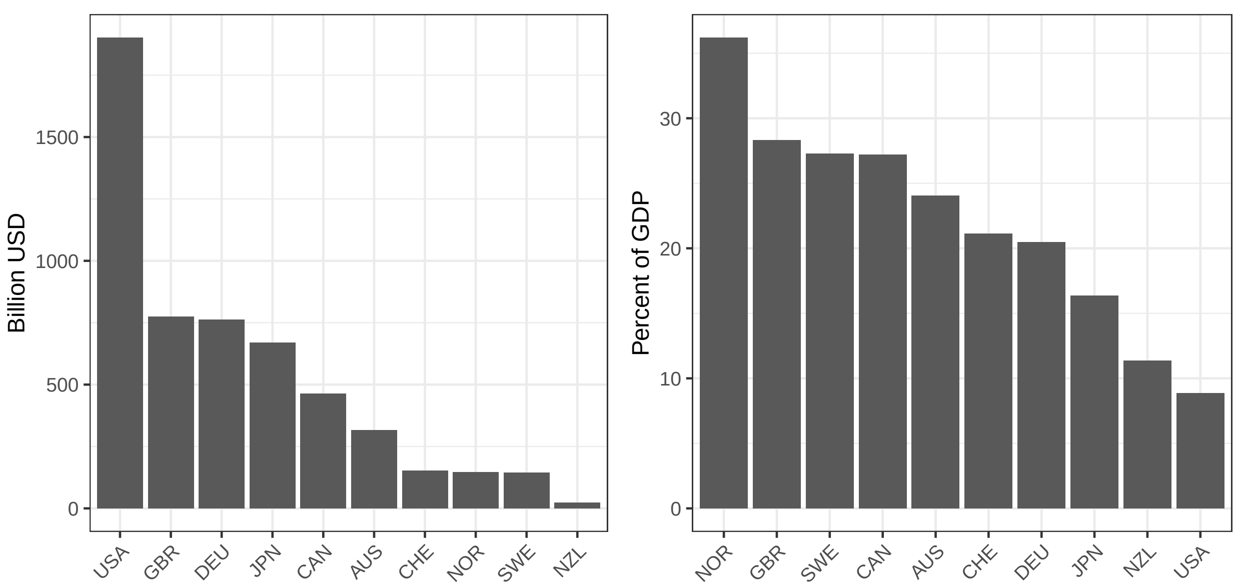
(a) Long-term Debt (b) Equity



Notes: The figure plots the relative latent demand for investing in U.S. long-term debt and equity relative to the rest of the world. For each year t and sector ℓ, we compute and plot the following:

$$\underbrace{\sum_i A^i \frac{\exp(\kappa_{i,t}(US,\ell))}{1+\sum_n \delta_{i,t}(n,\ell)}}_{\text{Latent demand for U.S.}} - \underbrace{\sum_{j \neq US} \sum_i A^i \frac{\exp(\kappa_{i,t}(j,\ell))}{1+\sum_n \delta_{i,t}(n,\ell)}}_{\text{Latent demand for non-U.S.}}$$

Figure 4. Additional Issuance Needed to Change Long-term By 1%



Notes: The figure plots the amount of additional long-term debt each country can issue before increasing its domestic long-term yield by one percent at the end of 2019. The left-hand panel shows the values in billions of U.S. dollars, and the right-hand panel shows the values as a percent of each country's GDP.

Appendix

A Proof

Proposition 1

Proof. The expression of $IB + CG$ follows from their definition:

$$IB_{US,t} + CG_{US,t} = A_{US,t-1} \sum_{k \neq US} w_{US,t-1}(k) R_t(k) - \sum_{k \neq US} A_{k,t-1} w_{k,t-1}(US) R_t(US).$$

Substitute the NFA and $IB + CG$ expressions into Eq. (1):

$$\begin{aligned} & A_{US,t} \sum_{k \neq US} w_{US,t}(k) - \sum_{k \neq US} A_{k,t} w_{k,t}(US) \\ = \ & TB_{US,t} + A_{US,t-1} \sum_{k \neq US} w_{US,t-1}(k)(1 + R_t(k)) - \sum_{k \neq US} A_{k,t-1} w_{k,t-1}(US)(1 + R_t(US)) \end{aligned} \tag{A.1}$$

The AUM dynamics can be rewritten as

$$A_{US,t} = F_{US,t} + A_{US,t-1} \sum_{k} w_{US,t-1}(k)(1 + R_t(k)) \tag{A.2}$$

Then, subtract Eq. (A.1) from this equation:

$$\sum_{k} A_{k,t} w_{k,t}(US) = F_{US,t} - TB_{US,t} + \sum_{k} A_{k,t-1} w_{k,t-1}(US)(1 + R_t(US)) \tag{A.3}$$

which implies the proposition after reordering.

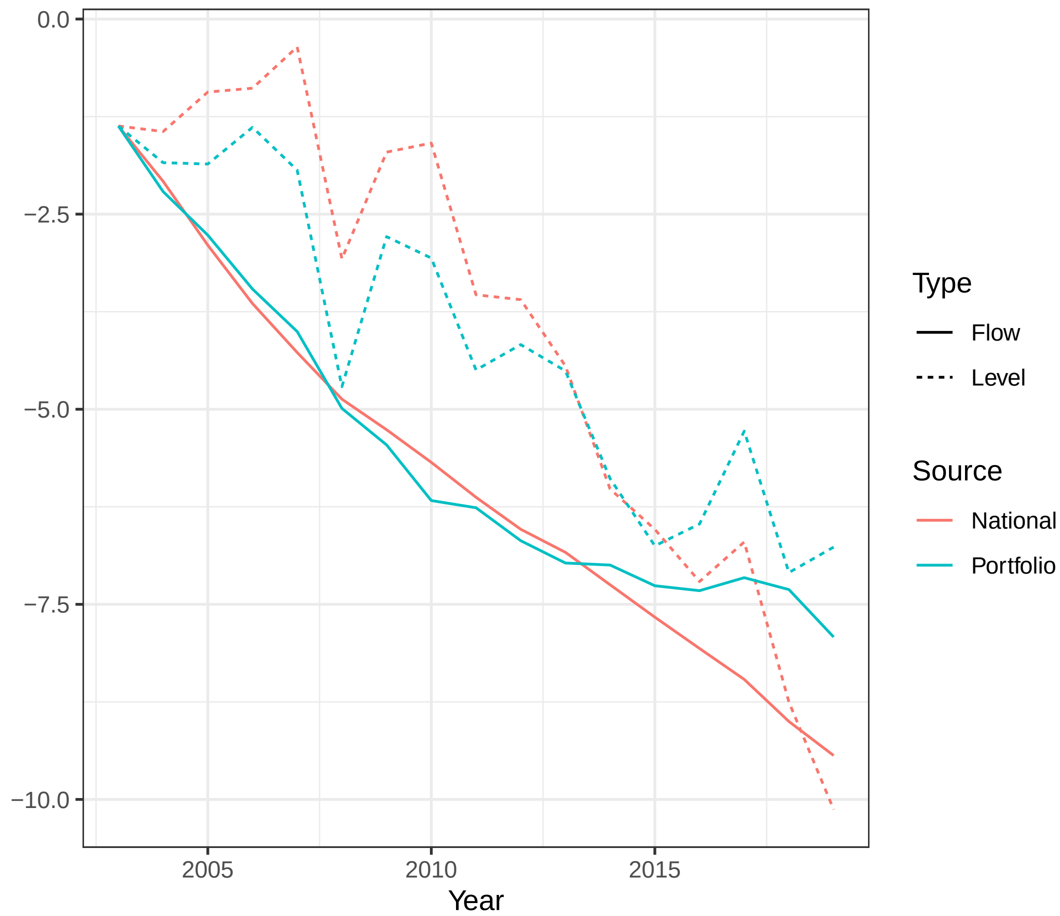
□

B Empirical Appendix

List of investor countries: Australia, Brazil, Canada, Chile, China, Colombia, Czechia, Denmark, Estonia, European Union, Hungary, Iceland, Israel, Japan, Latvia, Lithuania, Malaysia, Mexico, New Zealand, Norway, Poland, Singapore, Slovakia, South Africa, South Korea, Sweden, Switzerland, Thailand, Turkey, United Kingdom, and United States. Investors also include Foreign Reserves and the US Federal Reserve.

List of issuer countries: Australia, Austria, Belgium, Canada, China, Colombia, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, India, Italy, Japan, Malaysia, Mexico, New Zealand, Norway, Philippines, Poland, Portugal, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, United Kingdom, and United States.

Figure A.1. Comparison of U.S. NFA, Portfolio Position, and Cumulative Flows



Notes: The solid lines plot the total Net Foreign Asset position (National) and the portfolio component for the United States. The dashed line plots the cumulative current account (for national) and the cumulative flows to the net portfolio position

Table A.1
Predicting Expected Excess Returns

	Long-term Debt	Short-term Debt	Equity
Log market-to-book	-0.36^{***}	-8.18^{***}	-0.10^{**}
	(0.03)	(0.89)	(0.03)
Log real exchange rate	-0.40^{***}	-0.33^{***}	-0.78^{***}
	(0.04)	(0.03)	(0.09)
Num. obs.	594	594	594
R^2	0.31	0.28	0.16

Notes: This table displays results from estimating equation (6). For debt, the log market-to-book ratio is minus the maturity times the yield. All specifications include country fixed effects. Standard errors are clustered by year.

Table A.2
Demand Estimation Within Asset Class

	(1) Short-term Debt	(2) Long-term Debt	(3) Equity
E[Excess Return]	47.10^{***}	4.43^{**}	8.82^{***}
	(13.19)	(1.56)	(1.10)
Log GDP	1.83^{***}	1.30^{***}	1.72^{***}
	(0.14)	(0.04)	(0.05)
Log GDP per capita	0.26	0.36^{***}	0.39^{***}
	(0.14)	(0.04)	(0.06)
Centrality	−0.09	-0.05^{*}	−0.03
	(0.10)	(0.03)	(0.04)
Default	0.04	-0.17^{**}	−0.08
	(0.10)	(0.06)	(0.04)
Distance	-1.00^{***}	-1.05^{***}	-1.16^{***}
	(0.12)	(0.03)	(0.04)
Import Exposure	0.07	0.11^{*}	0.00
	(0.12)	(0.04)	(0.05)
Export Exposure	0.07	0.06	0.26^{***}
	(0.12)	(0.04)	(0.05)
Inflation	-0.33^{**}	0.13^{***}	-0.17^{***}
	(0.12)	(0.03)	(0.03)
Volatility	-0.23^{**}	-0.24^{***}	-0.17^{***}
	(0.07)	(0.03)	(0.03)
Indicator: Own Country	6.91^{***}	5.64^{***}	4.70^{***}
	(0.59)	(0.17)	(0.21)
Indicator: USA Issuance	1.75^{***}	2.73^{***}	1.01^{***}
	(0.42)	(0.16)	(0.18)
Num. obs.	15966	18414	18414
R^2 (full model)	−1.21	0.71	0.64
R^2 (proj model)	−2.71	0.35	0.25

Notes: This table estimates equation (10) separately for each asset class. The sample comprises annual data from 2002 to 2016. Default is the 5-year default probability for the sovereign debt category imputed by S&P. All specifications include investor country, year and issuer country MSCI market fixed effects. Heteroskedasticy-robust standard errors are reported in parentheses. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table A.3
Demand Estimation Across Asset Classes

Variable	Symbol	Estimate
Log outside asset weight:		
Short-term Debt	λ_{st}	0.11^{*}
		(0.05)
Long-term Debt	λ_{lt}	0.07
		(0.06)
Equity	λ_{eq}	0.35^{***}
		(0.09)
Asset class fixed effects:		
Short-term Debt	α_{st}	-0.50^{*}
		(0.22)
Long-term Debt	α_{lt}	2.02^{***}
		(0.24)
Num. obs.		1084
R^2		0.37

Notes: This table estimates equation (11) $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

B.1 Calculating Counterfactual Asset Prices

In the following appendix, we apply an approximation of Newton's Method to calculate the equilibrium price in the counterfactual analysis. Our algorithm closely follows Koijen and Yogo (2019a). For each asset j in sector l at time t, we want to find the zero of the following function:

$$H\left(\mathcal{P}\right) = p^{l}_{j,t} + q_{j,t} - \log\left[\sum_{i=1}^{N} A_{i,t} w^{l}_{i,t} w^{l}_{i,j,t}\right],$$

where the vector of parameters:

$$\mathcal{P} = \left[e_{j,t}, q_{j,t}, p^{lt}_{j,t}, p^{eq}_{j,t}\right]$$

comprises nominal exchange rates, short-term debt quantities for issuers in fixed exchange rate regimes, prices of long-term debt, and prices of equity. To re-iterate, the share of investor i assets within asset type l that are allocated to country j at time t is:

$$w^{l}_{i,j,t} = \frac{\exp\left(\beta^{l}\mu^{l}_{i,j,t} + \Theta^{l}_{i,j,t}\mathbf{x}_{i,j,t} + \kappa_{i,j,t}\right)}{1 + \sum_{n=1}^{N}\exp\left(\beta^{l}\mu^{l}_{i,n,t} + \Theta^{l}_{i,n,t}\mathbf{x}_{i,n,t} + \kappa_{i,n,t}\right)}$$

The share of investor i assets allocated to asset type l is:

$$w_{i,t}^{l}=\frac{\left(1+\sum_{n=1}^{N}\exp\left(\beta^{l}\mu_{i,n,t}^{l}+\Theta_{i,n,t}^{l}\mathbf{x}_{i,n,t}+\kappa_{i,n,t}\right)\right)^{\lambda^{l}}\exp\left(\alpha^{l}+\xi_{i,t}^{l}\right)}{\sum_{m=\{st,lt,eq\}}\left[\left(1+\sum_{n=1}^{N}\exp\left(\beta^{m}\mu_{i,n,t}^{m}+\Theta_{i,n,t}^{m}\mathbf{x}_{i,n,t}+\kappa_{i,n,t}\right)\right)^{\lambda^{m}}\exp\left(\alpha^{m}+\xi_{i,t}^{m}\right)\right]},$$

and the expected return of asset j of type l for investor i at time t is defined:

$$\mu_{i,j,t}^{l}=\gamma_{p}^{l}p_{j,t}^{l}+\gamma_{e}^{l}\left(e_{j,t}-\pi_{j,t}\right)-\left(\gamma_{p}^{st}p_{j,t}^{st}+\gamma_{e}^{st}\left(e_{i,t}-\pi_{j,t}\right)\right)$$

Given any initial parameter vector $\mathcal{P}$, Newton's Method would update the price vector with:

$$\mathcal{P}'=\mathcal{P}-\mathcal{J}_{H}^{-1}H\left(\mathcal{P}\right)$$

where $\mathcal{J}_H$ represents the Jacobian of the multivariate function H. However, rather than calculate the full Jacobian, we approximate $\mathcal{J}_H$ with its diagonal. Let $H_{j,t}^{l}$ denote the row of H that corresponds to the market clearing condition for asset j of asset type l in period t.

For an asset j in the short-term debt market with floating exchange rates, the diagonal element of $\mathcal{J}_H$ is:

$$\frac{\partial H_{j,t}^{st}}{\partial e_{j,t}}=-\frac{\sum_{i=1}^{N}A_{i,t}\left(\frac{\partial w_{i,t}^{st}}{\partial e_{j,t}}\times w_{i,j,t}^{st}+\frac{\partial w_{i,j,t}^{st}}{\partial e_{j,t}}\times w_{i,t}^{st}\right)}{\sum_{i=1}^{N}\left(A_{i,t}w_{i,t}^{st}w_{i,j,t}^{st}\right)} \tag{A.4}$$

where

$$\frac{\partial w_{i,t}^{st}}{\partial e_{j,t}}=\begin{cases}\lambda^{st}\beta^{st}\gamma_{e}^{st}w_{i,t}^{st}w_{i,j,t}^{st}-w_{i,t}^{st}\left(\sum_{m=st,lt,eq}\lambda^{m}\beta^{m}\gamma_{e}^{m}w_{i,t}^{m}w_{i,j,t}^{m}\right) & \text{if } i\neq j\\ -\lambda^{st}\beta^{st}\gamma_{e}^{st}w_{i,t}^{st}\left(\sum_{k\neq i}w_{i,k,t}^{st}\right)+w_{i,t}^{st}\left(\sum_{m=st,lt,eq}\lambda^{m}\beta^{m}\gamma_{e}^{m}w_{i,t}^{m}\left(\sum_{k\neq i}w_{i,k,t}^{m}\right)\right) & \text{if } i=j\end{cases}$$

and

$$\frac{\partial w_{i,j,t}^{st}}{\partial e_{j,t}}=\begin{cases}\beta^{st}\gamma_{e}^{st}w_{i,j,t}^{st}\left(1-w_{i,j,t}^{st}\right), & \text{if } i\neq j\\ -\beta^{st}\gamma_{e}^{st}w_{i,j,t}^{st}\left(\sum_{k\neq i}w_{i,k,t}^{st}\right), & \text{if } i=j\end{cases} \tag{A.5}$$

For an asset j in the short-term debt market that is part of a currency union, the diagonal element of $\mathcal{J}_H$ is:

$$\frac{\partial H_{j,t}^{st}}{\partial q_{j,t}}=1, \tag{A.6}$$

where we update the quantity $q_{j,t}$ of short-term debt outstanding.

For long-term debt and equity assets, the diagonal element of $\mathcal{J}_H$ is:

$$\frac{\partial H_{j,t}^{l}}{\partial p_{j,t}^{l}}=1-\frac{\sum_{i=1}^{N}A_{i,t}\left(\frac{\partial w_{i,t}^{l}}{\partial p_{j,t}^{l}}\times w_{i,j,t}^{l}+\frac{\partial w_{i,j,t}^{l}}{\partial p_{j,t}^{l}}\times w_{i,t}^{l}\right)}{\sum_{i=1}^{N}\left(A_{i,t}w_{i,t}^{l}w_{i,j,t}^{l}\right)} \tag{A.7}$$

where

$$\frac{\partial w_{i,t}^{l}}{\partial p_{j,t}^{l}} = \lambda^{l}\beta^{l}\gamma_{p}^{l} w_{i,j,t}^{l} w_{i,t}^{l}\left(1 - w_{i,t}^{l}\right) \tag{A.8}$$

and

$$\frac{\partial w_{i,j,t}^{l}}{\partial p_{j,t}^{l}} = \beta^{l}\gamma_{p}^{l} w_{i,j,t}^{l}\left(1 - w_{i,j,t}^{l}\right) \tag{A.9}$$

We start with an initial parameter vector $\mathcal{P}$ equal to the observed market prices and quantities, and we update the parameter vector according to:

$$\mathcal{P}' = \mathcal{P} - \left(\text{diag}\left[\mathcal{J}_H\right]\right)^{-1} H\left(\mathcal{P}\right).$$

We continue to iterate until convergence.

C Data Appendix

Our estimation exercise and NFA decomposition requires three types of data. These are cross-country holdings data, data on country characteristics, data on realized returns in each asset class.

C.1 Cross-Country Holdings

We observe cross-country asset holdings data from the Coordinated Portfolio Investment Survey (CPIS) provided by the IMF and for the US from the Treasury International Capital System (TIC). The TIC data reports U.S. external assets and U.S. external liabilities only. Thus, for the U.S., we use all available data from TIC, and then we supplement with any additional holdings from CPIS. For all other countries, we use CPIS data.

After merging the CPIS and TIC data, we apply the reallocation matrices from Coppola, Magiori, Neiman, and Schreger (2020) to reattribute proftolio holdings to their investor nationality as much as possible. These reallocation matrices are provided from 2007 to 2017, and we extend these matrices forwards and backwards in time to cover the full sample period from 2002 to 2019. Following Coppola, Magiori, Neiman, and Schreger (2020), we also aggregate all investment holdings by Euro Area countries into a single European Monetary Union (EMU) investor entity. After applying the reallocation matrices there remain some funds held by tax haven countries. We redistribute these remaining holdings proportionally to the countries which have inward investment into the tax havens.

The CPIS does not contain reserve holdings of central banks. We thus supplement the CPIS with central bank holdings data from three sources. First, the TIC data report U.S. liabilities to both private and official foreigners together for privacy reasons. Thus, foreign central bank holdings of U.S. liabilities are already accounted for. We use the SEFER survey to fill in central bank reserve holdings of all other countries. For confidentiality reasons, the SEFER survey aggregates holdings across all central banks. Finally, we account for U.S. FRB holdings of U.S. long-term debt, short-term debt and equity as a result of its quantitative easing programs. These holdings can be found on the Federal Reserve balance sheet.

The portfolio holdings data do not record domestic holdings of financial assets. Thus, we estimate domestic portfolio holdings by subtracting foreign holdings from total market capitalization data. We observe the country-level stock market capitalization from the World Bank, and we observe the aggregate value of outstanding short-term and long-term debt securities from the BIS.

C.2 Country Characteristics

We observe country level market-to-book values of equity, yields on short-term debt, and yields on long-term debt from Datastream. We observe GDP and GDP per capita from the World Bank. We obtain trade network centrality measures from Richmond (2016). We observe S&P sovereign debt ratings impute sovereign default probabilities using S&P 5-year default rates. We obtain dollar exchange rates from Datastream, inflation rates from the IMF, and trade and distance variables from CEPII.

C.3 Realized Returns

For all countries other than the U.S., we impute realized returns on equity by computing changes in country-level equity total return indicies obtained through Datastream, and we impute realized returns on debt using 3-month and 10-year yields. For short-term debt, the realized return is computed by compounding the four 3-month yields within each year. For long-term debt, the realized return is the annualized 10-year yield from the previous year.

For the U.S. we are able to impute the realized yield earned by foreign investors using TIC data, because the TIC data provide both the U.S. liability positions as well as the observed net flows of capital by each asset class. Thus, we can more accurately match the patterns in U.S. NFA positions and U.S. net capital flows. For each asset class, we compute the realized returns between year $t-1$ and t such that the U.S. liability position in period t equals the observed capital flow plus the U.S. liability position in period $t-1$ multiplied by the realized return.