A Portfolio Approach to Global Imbalances and Low Interest Rates*

Preliminary

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Abstract

Recent decades are characterized by large global imbalances in the U.S. external asset position and a steady decline in long-term interest rates. Adopting a portfolio-based approach, we estimate demand curves for international debt and equity assets at the country level, and use the estimated demand curves to quantify various explanations for these trends. We find that in the 2002—2016 period, investor savings, asset issuances, and demand shifts played first-order roles in the dynamics of U.S. imbalances and long-term interest rates. Foreign central banks' reserves had minor contributions to the U.S. imbalances, which are partially offset by the Federal Reserve's quantitative easing.

Key Words: Global Imbalances, Low Interest Rates, Global Savings Glut, Quantitative Easing.

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1 Introduction

Foreign holdings of the U.S. assets have increased dramatically in the past two decades. At the end of 2016, non-U.S. private sector investors held 11.3 trillion dollars' worth of U.S. assets, which accounted for 48% of the wealth in their external portfolio. Non-U.S. central banks held another 2.5 trillion dollars' worth of U.S. long-term debt, accounting for 54% of the long-term debt in their foreign currency reserves. By contrast, U.S. investors held only 6.4 trillion dollars in foreign assets. The sustained net capital flows into the U.S. financial markets have been referred to as "global imbalances" (Gourinchas and Rey 2014), which have led to the U.S. net foreign asset position decreasing from -22 percentage points of GDP in 2002 to -43 percentage points of GDP by the end of 2016.

A related phenomenon is the steady decline in long-term interest rates over the past decades, both in the U.S. and in other developed economies. This trend started from the 1980s, and continued after the Global Financial Crisis. The literature has proposed a number of potential explanations for this decline in interest rates. The Global Savings Glut view, for example, argues that global excess savings, emanating in large part from China, other Asian emerging market economies, and oil producers like Saudi Arabia, were a major driver (Bernanke (2005)). An alternative view focuses on the shortage of safe assets and flight to safety (Caballero et al. (2017)).

The sustained declines in the U.S. net foreign asset position and in long-term interest rates may have substantial impact on U.S. and global economic outcomes going forward. To this end, it is important to understand the key drivers of these two related trends. In this paper, we use a portfolio-based approach to empirically decompose the dual trends of global imbalances and low interest rates into its various drivers.

To begin, we construct bilateral equity and debt portfolio positions between 60 investor countries and 32 issuer countries. We also measure the portfolio holdings of the U.S. Federal Reserve and foreign central bank reserves. We refer to the U.S. external net portfolio debt position as *debt imbalances*, and the U.S. external net portfolio equity position as *equity imbalances*. In equilibrium, investor countries and central banks must hold the total quantity of assets available for purchase. We model and estimate investor countries' demand for assets as a function of observed and unobserved asset characteristics (Koijen and Yogo 2019a,b; Koijen et al. 2019). The estimated demand curves of investor countries, along with the portfolios of central banks and the market clearing condition constitute an asset demand system.

This asset demand system allows us to understand how various forces contributed to global imbalances and changes in long-term interest rates. In particular, the demand system describes how asset prices and investor portfolio holdings change in response to a set of four key components that we take as exogenous: changes in investors' savings, net issuances by governments and corporations, purchases by central banks, and changes in investors' demand for certain assets. Had all of these variables remained constant from the start of our sample period to the end, the U.S. net foreign asset position and long-term yield would have remained constant. Hence, all changes in asset prices and portfolio positions can be attributed to changes in the inputs to the demand system. Using the estimated demand system, we quantify the importance of these four components for global imbalances and low long-term interest rates.

We start from a baseline in which all four components are set to their 2002 values. We then sequentially introduce each component and measure how much the U.S. net foreign asset position changes between 2002 and 2016. This allows us to understand quantitatively what the key drivers of the long-term decrease in the U.S. net foreign asset position are.

The first component that drives changes in the U.S. net foreign asset position and long-term interest rates are changes in private savings by global investors. Increases in private savings, especially from developing economies, has been a key focus in the literature on the global savings glut (Bernanke 2005; Mian et al. 2020). From our baseline of no changes in savings for all investors, we find that the changes in savings behavior over our sample for all investors decreased the total U.S. net asset position as a percent of 2002 GDP by 11 percentage points. Given that the total decline over this period was 39 percentage points, this change in savings behavior accounted for 28% of the total change. In terms of long-term yields, we find that changes in savings alone accounted for 53% of the decline.

The second component that we introduce is net issuances of equity and and debt globally. When we include net issuances, along with savings, we find that an additional 9 percentage points of the decline in the U.S. net foreign asset position from 2002 to 2016 can be explained. That is, jointly, changes in savings behavior and issuances can explain 54% of the total decline in the U.S. net foreign asset position over this period. We further decompose this decrease in the U.S. net foreign asset position due to net asset issuances into changes in U.S. portfolio assets and changes in U.S. portfolio liabilities. From this decomposition, we find that the majority of the decline can be attributed to issuances of U.S. new debt by the U.S., which drives up U.S. liabilities.

The third component we study is the change in central bank portfolios — both the Federal Reserve and other central banks, globally. When we introduce the changes in holdings of central banks along with savings and net issuances, the U.S. net foreign asset position drops an additional 4 percentage points. Jointly these three forces explain 60% of the 39 percentage point decline in the U.S. net foreign asset position over our sample. We further decompose the contribution of changes in reserves into a component derived from the U.S. Federal Reserve and a component from all non-U.S. central banks globally. We find that increases in foreign central banks reserves widened the U.S. external imbalance by 6 percentage points. On the other hand, the Federal Reserve's QE purchases the U.S. debt from the foreigners, which reduces the U.S. external imbalance by 2 percentage points.

The final component which we introduce is changes in investor's demand for assets. When we introduce changes in demand, the U.S. net foreign asset position drops by an additional 14 percentage points, leading to the total decline of 39 percentage points of the U.S. 2002 GDP from 2002 to 2016. As a result, changes in investor demand explains the remaining 39% of the drop in the U.S. net foreign asset position.

Beyond the aggregate patterns in changes in net foreign asset positions, we are able to understand how each of the four components contributed to decreases in long-term yields in the U.S. From 2002 to 2016 long-term yields in the U.S. declined from 4.51 percentage points to 1.82 percentage points. Changes in net savings explain a decrease of 1.43 percentage points (53% of the total decline of 2.68 percentage points). However, the net positive issuances of long-term debt from 2002 to 2016 naturally decreases the equilibrium price of long-term debt, which brings the long-term yields back to a higher value 4.20 percentage points (which is only 0.31 percentage points lower than the starting value). Increases in central bank reserves in addition to savings and net issuances explains 0.56 percentage points of the total 2.68 percentage point decline in U.S. long-term yields. Finally, introducing changes in asset demand explains the remaining 2.12 percentage point decline.

Overall, using a portfolio approach sheds new light on the key drivers of the long-term changes in the U.S. net foreign asset position, as well as long-term yields. We showed that changes in investor's demand for certain assets over others, changes in savings behavior, and net issuances of assets all played prominent roles in driving the decline in the U.S. debt imbalance. Meanwhile, central bank policies played a more secondary role. These results suggest that any theory that seeks to explain the decline in the U.S. debt imbalance with just one channel alone are unlikely to succeed quantitatively. In comparison, the U.S. equity imbalance has a hump-shaped time series which is mainly driven by demand shifts.

Literature Review. Our paper contributes to a large empirical literature studying the drivers of net foreign asset dynamics and the composition of global portfolios (Lane and Milesi-Ferretti 2007; Gourinchas and Rey 2007; Curcuru et al. 2008; Maggiori et al. 2019; Coppola et al. 2020). Drivers of capital flows long and-term yields in the previous literature includes institutional quality (Alfaro et al. 2008), demographic factors (Lane and Milesi-Ferretti 2001; Carvalho et al. 2016), financial development (Caballero et al. 2008), information and transaction cost (Portes et al. 2001; Portes and Rey 2005), abilities to insure against idiosyncratic risk (Mendoza et al. 2009; Angeletos and Panousi 2011), and interactions between financial frictions and international trade (Antras and Caballero 2009). Our paper focuses on the imbalances in the U.S. net foreign asset position and the secular decline in long-term interest rates (Caballero et al. 2008; Gourinchas et al. 2010; Gourinchas and Rey 2014). We take a finance perspective from the portfolio allocation to analyze these phenomena, taking into account both the country-level characteristics as well as investor substitution between assets within each asset class.

The methodology we use in this paper builds upon an empirical literature that explicitly measures asset demand elasticities to understand changes in asset prices (Krishnamurthy and Vissing-Jorgensen 2012; Koijen and Yogo 2019b; Koijen et al. 2019,?).[1] Closely related

[1] A related literature on the asset price dynamics in the bond market also adopts a quantity-centric view (Vayanos and Vila 2009; Greenwood et al. 2010; Greenwood and Vayanos 2014; Malkhozov et al. 2016;

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 is also related to studies of the effects of central banks' unconventional monetary policy (Krishnamurthy et al. 2013; Koijen et al. 2017; Krishnamurthy et al. 2018; Acharya and Krishnamurthy 2018). We provide a structural estimate of its effects on international asset prices and capital flows.

This paper proceeds as follows: Section 2 provides a theoretical framework for estimating asset demand and decomposing changes in asset prices and portfolio positions. Section 3 reports data sources and summary statistics, discusses the estimation procedure, and presents the estimation results. Section 4 presents the results from the counterfactual exercises. Section 5 concludes.

2 Model

In this section, we lay out a structural model of international asset markets. Time is discrete and there are N countries in the world. Each country $i = 1, ..., N$ contains a representative investor who allocates her asset under management (AUM) across the asset space. Each country also contains a central bank that holds a portfolio of assets as reserves.

The asset space comprises of $N+1$ assets. Each country issues one asset, which we index by $j = 1, ..., N$. The assets issued by each country can be thought of as a country's debt or equity. That is, we separately model demand for each country's outstanding debt and equity. There also exists an additional "outside" asset indexed by $j = 0$. The outside assets allows the investor to allocate a portion of her AUM outside of the country level assets. We denote the quantity supplied of asset j by $Q_{j,t}$. We assume $Q_{j,t}$ is given exogenously. Over time, we allow for the quantity of assets to change:

$$Q_{j,t+1} = Q_{j,t} + \Delta Q_{j,t+1}, \tag{1}$$

Greenwood et al. 2019).

where $\Delta Q_{j,t+1}$ represents the new quantity of assets issued between period t and $t+1$.

2.1 Investors

The demand for assets is determined by each country's investor and central bank. Following Koijen and Yogo (2019a), we express the country i investor's demand for asset j in period t as a function of the log asset price $p_{j,t}$, asset characteristics $\mathbf{x}_{i,j,t}$, and a residual term $\kappa_{i,j,t}$[2]:

$$\log\left(\frac{w_{i,j,t}}{w_{i,0,t}}\right) = \beta_{i,p}p_{j,t} + \beta_i'\mathbf{x}_{i,j,t} + \kappa_{i,j,t}, \tag{2}$$

where $w_{i,j,t}$ is the share of investor i's AUM invested in the country j asset. $w_{i,0,t}$ is the share of investor i's AUM allocated to the outside asset. Let $A_{i,t}$ denote the country i investor's AUM. Then, the U.S. dollar amount of investor i's holding in asset j is $A_{i,t}w_{i,j,t}$. We assume the supply of the outside asset is perfectly elastic and has a constant price. Hence, the investor's portfolio allocation in the outside asset is determined by the investors' demand for assets in within the demand system.

The total sum of shares invested into each asset must equal 1, $\sum_{j=0}^{N} w_{i,j,t} = 1$. Hence, the share of wealth allocated to asset j is:

$$w_{i,j,t} = \frac{\exp(\beta_{i,p}p_{j,t} + \beta_i'\mathbf{x}_{i,j,t} + \kappa_{i,j,t})}{1 + \sum_{k=1}^{N}\exp(\beta_{i,p}p_{k,t} + \beta_i'\mathbf{x}_{i,k,t} + \kappa_{i,k,t})}. \tag{3}$$

The remaining share of the portfolio is invested in the outside asset.[3] Investor AUM is given by:

$$A_{i,t} = \frac{O_{i,t}}{1 - \sum_{j=1}^{N} w_{i,j,t}}, \tag{4}$$

where $O_{i,t}$ is the total investment in the outside asset, which we take as exogenous.

We expect $\beta_{i,p} < 1$, which implies the demand for assets is downward-sloping. The asset

[2] Koijen and Yogo (2019a) derive this result from an approximation of the portfolio allocation model in Merton (1973).

[3] Formally, the investor's portfolio weight on the outside asset is:

$$w_{i,0,t} = \frac{1}{1 + \sum_j \exp\left(\beta_{i,p}p_{j,t} + \beta_i'\mathbf{x}_{i,j,t} + \kappa_{i,j,t}\right)}.$$

characteristics $\mathbf{x}_{i,j,t}$ can be asset-specific or bilateral in nature. $\kappa_{i,j,t}$ is also called latent demand, which describes additional variation in the demand curve that is not captured by the price or observed asset characteristics.

2.2 Central Banks

In this paper, we view asset purchases and sales by central banks as exogenous. Let $B_{i,j,t}$ denote the quantity of country j assets held in the portfolio of country i's central bank. In practice, central banks can hold assets for several reasons. 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. These holdings are denoted as $B_{i,j,t}$ where the holding country i is different from the issuer country j.

In recent years, central banks have also purchased their 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. These holdings are denoted as $B_{i,i,t}$ where the holding country and the issuer country coincides.

2.3 Market Clearing

At each date t, total value of asset j available for purchase must be held by the investors and the central banks in the world:

$$P_{j,t}Q_{j,t} = \sum_{i=1}^{N} A_{i,t}w_{i,j,t} + \sum_{i=1}^{N} P_{j,t}B_{i,j,t}. \quad (5)$$

The left-hand side is the total market value of asset j, and the right-hand side is the sum of the dollar value of investors' portfolio holdings of asset j, $A_{i,t}w_{i,j,t}$, plus the sum of the dollar value of central banks' reserve holdings, $P_{j,t}B_{i,j,t}$.

Since the market price of each security enters into the asset demand (2), equation (5) describes a fixed-point problem that determines the market values, $p_{j,t}$, of each asset at each date t. Koijen and Yogo (2019a) show this fixed-point has a unique solution if $\beta_{i,p} < 1$. As we shall see when we estimate the demand equation (2), this condition is satisfied. We use the computational algorithm in Koijen and Yogo (2019a) to compute counterfactual equilibrium scenarios.

3 Model Estimation

3.1 Data Sources

In this section, we briefly describe the data we use to decompose international capital flows and prices. We rely on two types of data: (1) cross-country holdings data and (2) the characteristics of the assets being held.

We observe cross-country asset holdings data from the Coordinated Portfolio Investment Survey (CPIS) provided by the IMF. For each country i, we observe year-end holdings of foreign financial assets in US dollars by asset class and issuer country. The asset holders included in the CPIS include government entities, corporations, and individuals. The asset classes we us are long-term debt and equity. We also observe central bank holdings of foreign exchange reserves by asset class through the SEFER survey. However, central bank holdings are aggregated across holding countries for confidentiality, therefore we supplement the SEFER data with data on the US Federal Reserve Balance sheet. Hence, we treat all central banks other than the US Federal Reserve as a single investor unit.

The CPIS does not record domestic holdings of financial assets. Hence, we estimate domestic portfolio holding data. We impute domestic equity holdings by subtracting foreign equity holdings from the total market capitalization of equity assets for each country. We observe country-level stock market capitalization data from the World Bank. For each country, we also observe the aggregate value of outstanding debt securities in both domestic and international markets from the BIS. Unfortunately, domestic debt securities are not always divided by maturity. Whenever the data are unavailable, we assume the share of long-term debt assets in domestic markets is equal to the share of long-term debt assets in international markets.

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 capitalization of equity, the 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.

Ultimately, our sample contains 32 issuer countries and 60 investor countries. Table 1 provides the full list of countries. Issuer countries are countries for which we observe a complete panel of characteristics. The 60 investor countries include the 32 issuer countries plus an additional 28 countries for which we observe holdings data, but do not observe asset characteristics. We also observe the portfolio position of aggregated foreign reserves, and the U.S. Federal Reserve. The sample period ranges from 2002 to 2016.

3.2 Summary Statistics

Table 2 summarizes the total market capitalization of all issuer countries at the end of 2016. By far, the largest issuer of financial assets is the United States. By the end of 2016, the U.S. market capitalization of long-term debt was $34.6 trillion, and market capitalization of equity was an equally large $22.2 trillion. The next largest issuers of financial assets are Japan, the United Kingdom, France and Germany. However, the market capitalization of U.S. securities is larger than the total issuance of these next four countries combined.

Table 3 summarizes the largest investors by asset at the 2016, and reveals the significant share of long-term debt and short-term debt held by central banks. In the long-term debt market, the largest investors are U.S. investors, who primarily hold U.S. long-term debt. These U.S. investors comprise private households, financial institutions and corporations. However, the aggregate foreign reserves position is the fifth largest investor, and the U.S. Federal Reserve alone is the sixth largest investor. The large position of these central banks immediately suggests that central bank policies could have a first order impact in debt markets. On the other hand, central banks are not very active in equity markets. Naturally, the other large investors in Table 3 primarily comprise large economies with well developed financial services.

Table 3 also reveals a drawback to the CPIS data: portfolio allocations are reported on a residency basis, rather than nationality. As a result, portfolio flows to and from offshore financial centers can present a highly distorted view of capital flows, because these portfolio allocations are not associated with their ultimate investor or issuer country (Coppola et al. 2020). This problem is evident in the fact that Luxembourg is in the top 10 investors list for all asset classes. (Coppola et al. 2020) provides evidence that European mutual funds concentrate themselves in Luxembourg and collect investments from the rest of the countries in the European Union.

The use of offshore financial centers raises two potential concerns for our empirical exercise. First, we are at risk of counting some portfolio positions twice: Once when a country allocates assets to an offshore financial center, and once when the offshore financial center reallocates the capital to some ultimate investment location. In response to this first concern, we drop all observations investments to offshore financial center countries in order to prevent double counting in capital flows. [4] This treats investments from offshore financial centers as a single investor unit, and does not differentiate between potentially heterogeneous demand from the ultimate investors that allocate their. Hence, the second concern is that the estimated demand function does not accurately reflect the substitution patterns of investment from offshore financial centers, which introduces measurement error into our results.

3.3 Demand Estimation and Identification

Next, we use the panel of portfolio shares and characteristics to estimate equation (2). 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

[4] These countries are Bermuda, Cayman Islands, Isle of Man, Ireland, Jersey, Luxembourg and Mauritius.

to an "outside" asset, $w_{i,0,t}$. Specifically, we estimate:

$$\log\left(\frac{\hat{w}_{i,j,t}}{\hat{w}_{i,0,t}}\right) = \hat{\beta}_p p_{j,t} + \hat{\beta}' \mathbf{x}_{i,j,t} + \kappa_{i,j,t}, \tag{6}$$

where $p_{j,t}$ is the dollar asset price and $\mathbf{x}_{i,j,t}$ is a vector of other covariates. The issuer country characteristics on the right-hand side of equation (2) are its log nominal GDP, log GDP per capita, trade centrality, sovereign default risk, the real exchange rate and inflation. We include bilateral trade exposure and distance. Finally, we include an indicator variable for domestic investment, investor country and year fixed effects.

This estimation provides the coefficients $\hat{\beta}$ and the latent demand terms, $\kappa^i_{i,j,t}$, which are given by the regression residuals. The regression describes how the country i investor substitutes towards country j assets when the characteristics of the country j assets become more desirable. However, in regression (6), the asset price $p_{j,t}$ may be correlated with the latent demand $\kappa_{i,j,t}$. Capital flows into country j should drive up the country j asset price.

Hence, the main identification challenge is to consistently estimate the coefficient on log price, β_p. Ideally, we want to isolate exogenous shocks to supply of assets. We follow the identification strategy of Koijen and Yogo (2019b) and use issuer country monetary policy shocks to identify the coefficients in regression model (6). For each issuer country j, we observe monetary policy rate from the BIS, and we use these monetary policy rates to instrument for log price. Let $\hat{\pi}_{j,t}$ denote the instrumented log price. Formally, our identification assumption is:

$$\mathbb{E}\left[\kappa_{i,j,t} | \hat{\pi}_{j,t}, \mathbf{x}_{j,t}\right] = 0.$$

Intuitively, we assume each country's policy rate is exogenous to latent demand after controlling for observed characteristics. We take the viewpoint that each country's central bank sets the monetary policy rate according to some Taylor rule. The observed characteristics control for the expected component of monetary policy. We use the variation in the unexpected component of monetary policy, i.e. the monetary policy shock, to consistently estimate β_p. The exclusion restriction is that the country j monetary policy shocks only affects demand for the country j asset through their effects on the price index $\pi_{j,t}$.

The main threat to identification is that the country j policy rate contains some source of residual variation that affects the demand for the country j asset that is not fully captured by the asset price. For example, we may be concerned that we have not appropriately extracted the monetary policy shock by controlling for the anticipated component of monetary policy. Alternatively, we may be concerned the monetary policy shocks contain information that impacts investor demand through expectations of future macroeconomic conditions. Appendix A.1 studies an alternate set of instruments to address this concern. We follow the industrial organization literature and construct instruments based on asset characteristic (Berry et al. 1995; Gandhi and Houde 2019). Overall, however, we show our the estimate of β_p does not vary much across the use of these various instruments.

Table 4 presents the results from estimating the demand curve for each asset type. The coefficient on log price for both equity and long-term debt is less than 1, which indicates that demand is downward sloping. The regression results show that demand is more price elastic short-term debt markets than in equity markets.

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 4 shows there is strong home bias in all asset classes. Both the overall R-squared and projected R-squared are high in each of these regressions. In this sense, the set of characteristics can explains a large share of the cross-sectional variation in asset holdings across countries.

4 Decomposing the U.S. External Imbalance

In the following section, we use our estimated demand system to run counterfactual exercises to decompose trends in the U.S. debt and equity imbalance as well as asset price movements. To re-iterate, our demand system can be summarized by three sets of equations: the investor demand functions (2), the equations determining investor AUM (4), and the asset market clearing conditions (5):

$$
\begin{aligned}
w_{i,j,t}^{cf} &= \frac{\exp(\beta_{i,p} p_{j,t}^{cf} + \beta_i' \mathbf{x}_{i,j,t} + \kappa_{i,j,t})}{1 + \sum_{k=1}^{N} \exp(\beta_{i,p} p_{k,t}^{cf} + \beta_i' \mathbf{x}_{i,k,t} + \kappa_{i,k,t})} \\
A_{i,t}^{cf} &= O_{i,t} \left(1 + \sum_{k=1}^{N} \exp(\beta_{i,p} p_{k,t}^{cf} + \beta_i' \mathbf{x}_{i,k,t} + \kappa_{i,k,t}) \right) \\
P_{j,t}^{cf} Q_{j,t} &= \sum_{i=1}^{N} A_{i,t}^{cf} w_{i,j,t}^{cf} + P_{j,t}^{cf} \sum_{i=1}^{N} B_{i,j,t}
\end{aligned}
$$

The superscripts cf denote the endogenous variables in our demand system that respond to counterfactual changes in the primitive parameters that we describe below. These endogenous variables are the asset prices $p_{j,t}^{cf}$, the portfolio weights $w_{j,t}^{cf}$, and investor AUM, $A_{i,t}^{cf}$.

We now describe the primitive variables in our demand system along with our counterfactual exercises. We conduct our counterfactual exercises cumulatively such that we explain 100% of the changes in the U.S. debt and equity imbalances and U.S. asset prices. We start by setting start by setting investors' outside asset holdings ($O_{i,t}$), asset quantities ($Q_{j,t}$), central bank reserves as a share of assets issued ($B_{i,j,t}/Q_{j,t}$), and investor demand curves ($\beta_i' \mathbf{x}_{i,j,t} + \kappa_{i,j,t}$) to their 2002 values. This exercise produces the baseline exercise in which the endogenous portfolio quantities and asset prices are fixed at their 2002 levels. Next, we iteratively allow each of the primitive variables to vary according to their observed time series, solving for equilibrium prices at each step.

We start by allowing investors' savings to vary according to the data. This exercise isolates the effects of narratives driven by changes in private savings behavior across countries (Bernanke 2005; Mian et al. 2020). Within our demand system framework, we set each investor's outside asset holding in dollars, $O_{i,t}$, to their observed values in each year.

Next, we allow for the supply of assets, $Q_{j,t}$, to vary according to the data on top of the variation in investor savings. Specifically, this counterfactual accounts for variation in the face value of outstanding debt, and for variation in the book value of equity. In doing so, we account for the changes in imbalances due to both investors' savings and changes in the quantities of assets available for purchase.

Third, we account for the variation in central bank reserves holdings. We allow the quantity of assets held by central bank reserves to vary according to the data. Crucially, in this step, we are able to differentiate between changes in foreign central bank currency reserves and changes in the Federal Reserve balance sheet as a result of quantitative easing. Thus, we are able to differentiate between the precautionary savings motives of foreign central banks, and domestic policy actions.

Finally, we account for changes in the relative desirability of assets over time captured by changes in asset characteristics, $\mathbf{x}_{i,j,t}$, and the latent demand term, $\kappa_{i,j,t}$. Ultimately, accounting for changes in investor demand for specific assets on top of the other counterfactual exercises returns us to the observed data series.

4.1 Aggregate Dynamics of U.S. Portfolio Imbalances

From 2002 to 2016, the U.S. net portfolio imbalance declined dramatically from -1.3 trillion dollars to -5.5 trillion dollars. This decline in the overall portfolio position was primarily driven by a decline in the U.S. portfolio position from -1.6 trillion dollars to -5.9 trillion dollars. On the other hand, the U.S. maintained a positive external imbalance in its portfolio equity position, which partially cancelled out its debt liabilities. The U.S. equity imbalance displayed a hump-shaped dynamic during our sample period – increasing from 0.3 trillion dollars in 2002 to 1.8 trillion dollars in 2010, and then declining 0.4 trillion dollars by 2016.

Figure 1 displays the decomposition of U.S. portfolio imbalances in the four counterfactual scenarios described in the previous section. Each line represents the counterfactual U.S. portfolio imbalance as a share of 2002 GDP. Figure 2 shows the decomposition of U.S. asset prices. The left-hand panel of Figure 2 decomposes the change in long-term yields, and the right-hand panel decomposes changes in the log market-to-book ratio of U.S. equity. Tables 5 and 6 show the change in U.S. external imbalances and asset prices with each iterative counterfactual.

As mentioned above, these counterfactual scenarios are cumulative. In each figure, the baseline is simply a flat line reflecting the 2002 level of each variable. The line accounting for demand shifts ultimately accounts for changes in all other primitive variables and therefore matches the observed data. Similarly, Columns (2) and (4) of Tables 5 and 6 show 100%

of the change in external imbalances and asset prices are explained by the “Demand Shifts” counterfactual. In the following subsection, we discuss and quantify the drivers of the U.S. external imbalance between 2002 and 2016.

Investor Savings From 2002 to 2016, the total assets under management from our sample of 60 investor countries increased from 62.2 trillion dollars to 164.0 trillion dollars. Out of this 101.8 trillion dollar increase, 56.3 trillion dollars flowed into debt markets and 45.5 trillion flowed into equity markets. Both of these flows represent significant increases in the size of investor portfolios since 2002. Our demand system framework captures an overwhelming share of investor savings during this period. In 2016, the 60 investor countries allocated 84% of their wealth among the assets of the 32 issuer countries.

When we account for investors' savings, the U.S. aggregate external imbalance declines from -12% of 2002 GDP to -23%. This decline of 11 percentage points captures 28% of the total decline in the U.S. external position between 2002 and 2016. Moreover, the effect of investor savings on the U.S. portfolio imbalance primarily captures the change in the U.S. portfolio debt position, which declined from an initial position of -15% of 2002 GDP to -25% of 2002 GDP in the investor savings counterfactual.

Increases in investor savings explains 11% of the change in U.S. portfolio equity imbalance. However, Figure 1 shows that over the entire period from 2002 to 2016, investor savings explains very little of the hump shaped dynamics of the U.S. portfolio equity imbalance. Column (1) and (2) from Table 5 show that changes in savings explain only 5% of in increase in the U.S. portfolio equity position from 2002 to 2009.

Figure 2 and Table 6 show that changes in investor savings alone explain 53% of the 2.68 percentage point decline in U.S. long-term yields. Naturally, increases in investor savings drives up the price of assets and drives down yields. The right-hand panel of Figure 2 similarly shows that accounting for investor savings increases the log market-to-book ratio of U.S. equities. However, the data show the log market-to-book ratio of U.S. equities actually declined from 2002 to 2016. Thus, our counterfactual exercise suggests that models that account for investor savings alone would do a poor job of explain changes in U.S. equity valuations.

Net Issuances From 2002 to 2016, the shares of debt outstanding increased by 81%, and the total book value of equity increased by 195%. Both of these changes indicate significant increases in the quantity of assets available for investors purchase. Naturally, we should then expect increases in the quantities of assets issued to depress asset prices overall. However, changes in the holdings of specific assets and changes in the prices of specific assets still depend on relative issuances across countries.

When we additionally allow asset issuances to vary according to the data, the overall U.S. portfolio imbalance drops by an additional 20 percentage points of 2002 GDP, roughly doubling the effect of investor savings alone. Thus, together, increases in investor savings and net issuances explain 50% of the decline in the U.S. portfolio position. Similar to the investor savings counterfactual, an inspection of Figure 1 shows that the bulk of this explanatory power originates from the debt market. In contrast, accounting for net issuances actually decreases the model's explanatory power for the U.S. equity position from 2002 to 2016.

From a pricing standpoint, the net issuances offset some of the price changes attributed to investor savings. For example, Panel A of Table 6 shows that accounting for increases in investor savings and net issuances together only imply a 0.31 percentage point decrease in the U.S. long-term debt yield from 2002 to 2016, which decreases the amount of variation in the price of U.S. debt explained by the model.

On the other hand, Figure 2 shows that accounting for net issuances, on top of investor savings, decreases the counterfactual log market-to-book ratio such that it almost matches the data. That is to say, models that explain changes in investor savings and net issuances in the equity market alone will get us most of the way towards explaining the dynamics of the U.S. equity market-to-book ratio.

Central Bank Reserves Central banks have long played an active role in global financial markets. After the Asian Financial Crisis of 1997, emerging market central banks increased their foreign currency reserves in preparation for potential future turmoil. In more recent years, many central banks engaged in quantitative easing to control credit conditions during a period where policy rates were stuck at the zero lower bound. Our data captures the aggregate portfolio of central bank reserves, as well as the portfolio of U.S. domestic assets purchased by the Federal Reserve through quantitative easing. Crucially for the U.S. portfolio position, both data series show a significant increase in the share of U.S. assets held in central bank portfolios.

Naturally, this increase in central bank holdings of U.S. debt assets further drops the U.S. portfolio debt position. However the overall effect of central bank policy on U.S. portfolio imbalances is small compared to the effects of investor savings and asset issuances. Quantitatively, changes in reserve assets only accounts for an additional 6% of the total decline in the U.S. portfolio debt position — thus bringing the total explained share of the decline in the U.S. portfolio debt position to 60%. Central bank purchases of U.S. debt assets also depressed U.S. long-term yields. However, accounting for central bank reserves on top of investor savings and net issuances only explains 21% of the decline in U.S. long-term yields from 2002 to 2016.

Moreover, changes in central bank reserves had an almost negligible effect on equity markets. This is primarily because central banks are most active in debt markets, and hold minimal amounts of equity in their portfolio.

Shifts in Investor Demand All remaining variation in external imbalances and asset prices result from shifts in investors' demand functions. These demand shifts reflect changes in observed country characteristics such as economic growth, as well as changes in unobserved characteristics captured by the latent demand. Intuitively, the changes in investor demand reflect changes in the relative desirability of assets over time, such as recent narratives describing an increased demand for safe assets (Krishnamurthy and Vissing-Jorgensen 2012).

Shifts in investor demand curves explain a sizable portion of the overall decline in the U.S. portfolio position. This decline in the U.S. portfolio position implies that, on net, foreign investor demand for U.S. assets increased more than U.S. investor demand for foreign assets. These shifts in demand largely reflect the debt market, in which the shifts in demand curves explain 40% of the decline in the U.S. portfolio debt position, as well as 79% of the decline in the U.S. long-term yield from 2002 to 2016.

Surprisingly, shifts in investor demand drive an even larger share of the variation in the U.S. portfolio equity position. Figure 1 clearly shows the first three counterfactual components explain almost none of the variation in the portfolio equity position from 2002 to 2009. Instead, the large hump-shaped pattern in the U.S. equity position was entirely driven entirely by shifts in demand, which we explore in greater detail below. While, demand shifts resulted in large changes in the U.S. equity imbalance, they had a much smaller effect on the price of equity. As stated previously, the vast majority of the change in equity prices is already explained by investor savings and net issuances.

Summarizing the Long-term Trends In summary, our decomposition exercise allows us to quantify the relative impacts of investor savings, net issuances, central bank policies, and shifts in investor demand on the U.S. portfolio position. First and foremost, we showed the U.S. external imbalance is mainly driven by its external debt imbalance — both of which widened significantly over our sample period. The observed decline in the U.S. debt imbalance is explained almost equally by increases in investor savings, by net issuances, and by changes in investor demand. We also showed that increases in central bank holdings of U.S. debt assets playing a more minor role. Ultimately, these results suggest that any model of external imbalances that relies on any one of these channels alone will likely fail to realistically account for the total change in the U.S. portfolio position.

By comparison, investor savings, net issuances, and central bank reserves play almost no role in determining the U.S. portfolio equity position. Figure 1 clearly shows the overwhelming majority of the variation in the U.S. portfolio equity position is explained by shifts in investor demand. These results suggest two additional channels for models seeking to explain global imbalances. First, a model that can realistically capture the shift in the U.S. portfolio equity position should seek to understand changes in investor demand curves over time. Second, and more crucially, the key economic mechanisms driving equity markets likely differ from the key mechanisms operating in debt markets.

4.2 Trends in Assets and Liabilities

Using a demand system framework allows us to further decompose changes in the U.S. external imbalance into changes in assets and changes in liabilities. Assets capture what

U.S. private investors hold in terms of foreign securities, and liabilities capture what foreign investors hold in terms of U.S. securities. Figures 3 and 4 show the results of these counterfactual exercises. Our analysis yields three additional observations.

First, the U.S. external assets and liabilities have different cyclicalities. In the data, the U.S. external assets declined tremendously during the 2008 financial crisis, whereas the U.S. external liabilities changed much less. The reason is that the U.S. assets are predominantly foreign equity, whose valuation is cyclical, whereas the U.S. liabilities are predominantly U.S. debt, whose valuation is much less cyclical (Gourinchas and Rey (2007); Gourinchas et al. (2010); Maggiori (2017)). Our counterfactual scenarios allow us to further attribute the asset and liabilities cyclicalities to each channel. On the asset side, we find that the savings alone can generate large decline in U.S. external equity assets in 2008 — the U.S. investors pulled savings from the equity markets across the world. On the liability side, all four channels contribute to the steady decline in the U.S. external debt liabilities. The demand shifts also drive a reduction in the U.S. holdings of foreign debt assets in 2008, which creates greater U.S. net debt liabilities.

Second, in the aggregate Figure 1, the issuances channel further widens the U.S. external debt imbalance. However, when we separate U.S. external assets from liabilities, we find that asset issuances increase both the U.S. holdings of foreign debt and the foreign holdings of U.S. debt. However, the latter is greater in magnitude, resulting in a net decline in the U.S. external debt imbalance.

Third, the demand shifts channel suggests there has been a persistent increase in the willingness of the U.S. investors to hold foreign equity and debt assets, as well as in the willingness of the foreign investors to hold U.S. equity and debt assets. This pattern is consistent with increased willingness to invest abroad (for a review of the literature on globalization see Kose et al. 2009).

4.3 Foreign Reserves and the U.S. Quantitative Easing

In recent years, there has been much interest in the role of central banks policy in determining long-term yields (Koijen et al. 2017, 2019). We turn specifically towards this phenomenon here, and quantify the effects of central bank policies on U.S. external imbalances in more detail. To do so, we further break down the contribution of the central bank reserves into two sub-components: Changes in the non-U.S. central bank foreign reserves, and changes in the Federal Reserve holdings due to quantitative easing. More precisely, in the reserves counterfactual, we add an intermediate step in which we set the foreign reserve ratio $B_{i,j,t}/Q_{j,t}$ to the actual value in each year only for the aggregate currency reserves of foreign central banks.

Figure 5 and Figure 6 report the counterfactual movements in the U.S. external portfolio imbalances and asset prices in this scenario. On top of the net issuances counterfactual, updating the foreign central banks' reserve positions further widens the U.S. external portfolio imbalance by 7% of the GDP over the sample period. This effect is consistent with our observation that foreign central bank holdings of U.S. long-term assets significantly increased between 2002 and 2016. Between 2002 and 2016, foreign central banks increased their holdings of U.S. long-term debt outstanding from 3.45% of the total quantity outstanding to 5.84%, which amounted to an increase in holdings of 1.41 trillion dollars.

In comparison, the U.S. quantitative easing reduces the U.S. external portfolio imbalance by 3% of the GDP over the sample period. The Federal Reserve engaged in three rounds of quantitative easing between 2008 and 2014. During this period, the Federal Reserve held $372 billion worth of U.S. long-term Treasury and mortgage backed securities. The Federal Reserve balance sheet ballooned to $2.1 trillion by June of 2010. In November of 2010, the Federal Reserve announced a second round of quantitative easing, and bought up an addition $600 billion of U.S. government debt by mid-2011. A third round of quantitative easing began in September, 2012, which involved purchases of long maturity assets of $40 to $85 billion a month. As a result, by the end of 2016, the Federal Reserve had increased held $4.0 trillion dollars worth of assets. This dramatic increase in the Federal Reserve balance sheet was specifically intended to decrease interest rates for longer maturity assets. As the Fed buys the U.S. long-term debt, the foreigners and the U.S. private investors sell some of the debt in equilibrium, leading to a reduction in the overall U.S. external portfolio imbalance.

In terms of the price response, both the foreign central banks' purchase and the U.S. quantitative easing lower the interest rate on the U.S. debt. The effect of the U.S. quantitative easing on the bond prices is much greater than that of the foreign central bank purchases. After all, the \$3.7 trillion of the U.S. long-term debt purchased through QE was a much larger quantity than the \$1.5 trillion we attribute to the foreign central banks' purchases. This result suggests that the Fed unwinding the holdings of long-term debt assets purchased through QE would increase long-term yields by about 20 bps.

5 Conclusion

This paper uses a portfolio approach to evaluate the impact of savings, asset net issuances, central bank reserves, and demand shifts on the decline of long-term interest rates and the evolution of the U.S. net foreign asset position. We find that all four components contribute to the U.S. external imbalances, while the savings and demand shifts are the major drivers of the U.S. long-term interest rates. This approach allows us to quantitatively assess the contributions of different explanations of these key macro trends.

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Tables and Figures

Table 1
List of Issuer and Investor Countries

Issuer Countries	Investor Countries
Developed Markets:	*All Markets:*
Australia	Argentina
Austria	Bahrain
Belgium	Bermuda
Canada	Brazil
Denmark	Bulgaria
Finland	Cayman Islands
France	Chile
Germany	China
Hong Kong	Colombia
Italy	Egypt
Japan	Estonia
Netherlands	Indonesia
New Zealand	Ireland
Norway	Israel
Portugal	Kazakhstan
Singapore	Kuwait
Spain	Lebanon
Sweden	Lithuania
Switzerland	Luxembourg
United Kingdom	Pakistan
United States	Peru
	Romania
Emerging Markets:	Russia
Czech Republic	Saudi Arabia
Greece	Slovenia
Hungary	Turkey
India	Ukraine
Malaysia	
Mexico	
Philippines	
Poland	
South Africa	
South Korea	
Thailand	

Notes: All issuer countries are also investor countries.

Table 2
Market Capitalization of Issuer Countries (USD Billions)

Issuer Country	Debt	Equity
Developed market:		
Australia	1,867.5	1,268.2
Austria	477.8	119.9
Belgium	650.9	377.9
Canada	2,842.1	1,992.9
Denmark	709.5	330.2
Finland	252	199.2
France	3,943.5	2,157.8
Germany	3,232.8	1,715.3
Hong Kong	401.7	3,182
Italy	2,887.3	551.4
Japan	11,263.7	4,954.8
Netherlands	2,104.1	805.2
New Zealand	76	80
Norway	438.9	231
Portugal	264.3	57.2
Singapore	193.2	637.1
Spain	1,731.9	704.4
Sweden	816.9	634.7
Switzerland	397.4	1,400.9
United Kingdom	5,423	2,780.6
United States	36,702.6	27,342.4
Emerging market:		
Czech Republic	118.4	26.5
Greece	89.7	36.2
Hungary	102.9	22.5
India	792.1	1,487.8
Malaysia	320.8	359.8
Mexico	697.5	352
Philippines	125.9	239.7
Poland	274.3	138.7
South Africa	234.7	950.6
South Korea	1,596.5	1,254.4
Thailand	318.1	432.5

Notes: This table displays the total market capitalization of debt and equity held by the investor countries at the end of 2016. All values are in U.S. dollars.

Table 3
Top Ten Investors by Asset Class

Debt		Equity	
Investor	Billion USD	Investor	Billion USD
United States	26,583	United States	27,716
Japan	12,582	China	6,928
China	9,193	Japan	4,295
United Kingdom	5,034	Hong Kong	3,150
Foreign Reserves	5,013	Canada	2,349
U.S. FRB	4,205	United Kingdom	2,317
France	3,364	France	1,568
Germany	3,034	Luxembourg	1,488
Italy	2,353	Australia	1,271
Canada	2,209	India	1,216

Notes: This table displays the largest 10 investors of debt and equity at the end of 2016. All values are in billion U.S. dollars. Foreign Reserves is the aggregated portfolio of central bank foreign currency reserves.

Table 4
Demand System, 2SLS

	(1) Equity	(2) Debt
Log Price	0.40***	−1.36***
	(0.03)	(0.10)
Log GDP	1.26***	1.23***
	(0.02)	(0.01)
Log GDP per capita	0.33***	0.44***
	(0.02)	(0.02)
Centrality	0.17***	0.10***
	(0.02)	(0.02)
Default	−0.05**	−0.20***
	(0.02)	(0.02)
Distance	−1.17***	−1.60***
	(0.03)	(0.03)
Trade Exposure	0.27***	0.19***
	(0.01)	(0.01)
RER	0.08***	0.16***
	(0.01)	(0.01)
Inflation	0.09***	0.11***
	(0.02)	(0.02)
Indicator: Own Country	5.48***	4.37***
	(0.11)	(0.11)
Num. obs.	22,192	22,484
R^2 (full model)	0.77	0.78
R^2 (proj model)	0.46	0.48

Notes: This table estimates equation (6) separately for each asset class. The sample comprises annual data from 2002 to 2016. Log price is the market to book ratio for equities. Default is the 5-year default probability for the sovereign debt category imputed by S&P. All specifications include investor country and year fixed effects. Heteroskedasticy-robust standard errors are reported in parentheses. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 5
Decomposing Long-Run Variation in Portfolio Imbalances

	2002 - 2009		2002 - 2016	
	(1) Change in Pos.	(2) Pct of Total	(3) Change in Pos.	(4) Pct of Total
Panel A: Debt and Equity				
Savings	-8.47	93	-10.69	28
Net Issuances	-16.36	179	-20.13	52
Reserves	-19.44	213	-23.56	61
Foreign Res.	-19.89	218	-25.62	66
incl. FRB QE	-19.44	213	-23.56	61
Demand Shifts	-9.12	100	-38.68	100
Panel B: Debt				
Savings	-9.05	45	-10.77	27
Net Issuances	-16.41	82	-21.41	54
Reserves	-19.30	97	-23.77	60
Foreign Res.	-19.75	99	-25.83	65
incl. FRB QE	-19.30	97	-23.77	60
Demand Shifts	-19.92	100	-39.47	100
Panel C: Equity				
Savings	0.58	5	0.08	11
Net Issuances	0.05	0	1.28	162
Reserves	-0.14	-1	0.21	26
Foreign Res.	-0.14	-1	0.21	26
incl. FRB QE	-0.14	-1	0.21	26
Demand Shifts	10.80	100	0.79	100

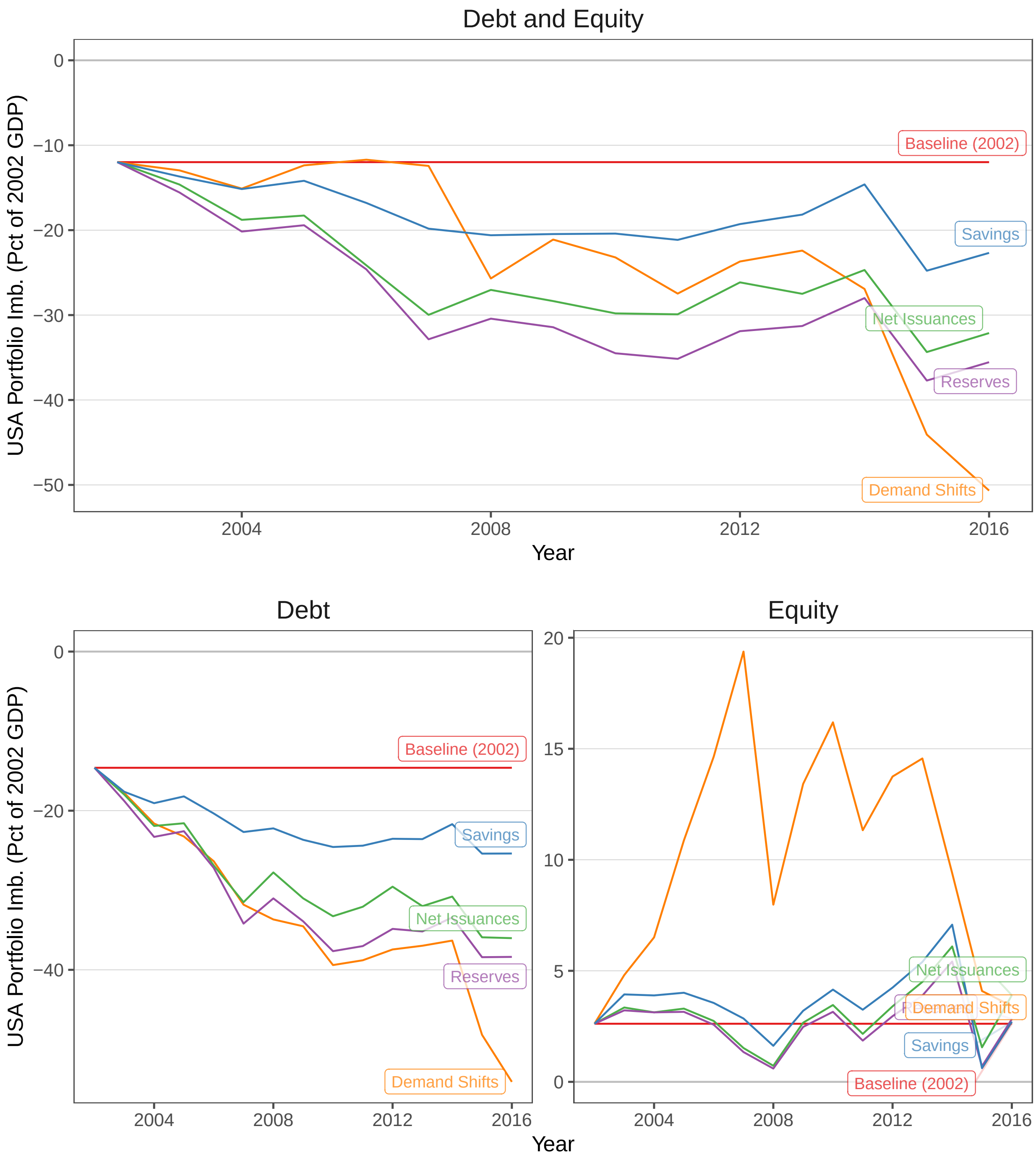
Notes: This table presents the changes in the U.S. portfolio imbalance under each counterfactual exercise. The counterfactual exercises are cumulative. Portfolio imbalances normalized by U.S. GDP in 2002. Columns (1) and (3) provide changes in portfolio position between the counterfactual exercise and the 2002 portolio position. Columns (2) and (4) provide changes in portfolio as a share of the total position change between 2002 and the final year indicated by the column headings (either 2009 or 2016). Panel A presents results for the sum of the U.S. debt and equity portfolio position. Panel B and Panel C provide results for the debt and equity portfolio positions, respectively.

Table 6
Decomposing Long-Run Variation in Asset Prices

	2002 - 2009		2002 - 2016	
	(1) Change in Value	(2) Pct of Total	(3) Change in Value	(4) Pct of Total
Panel A: Long-term Debt Yield (%)				
Savings	-1.14	87	-1.43	53
Net Issuances	-0.23	18	-0.31	12
Reserves	-0.33	25	-0.56	21
Foreign Res.	-0.27	21	-0.36	13
incl. FRB QE	-0.33	25	-0.56	21
Demand Shifts	-1.30	100	-2.68	100
Panel B: Equity Log Market-to-Book				
Savings	0.52	-124	1.22	-963
Net Issuances	-0.47	111	-0.18	140
Reserves	-0.46	110	-0.17	135
Foreign Res.	-0.46	110	-0.17	135
incl. FRB QE	-0.46	110	-0.17	135
Demand Shifts	-0.42	100	-0.13	100

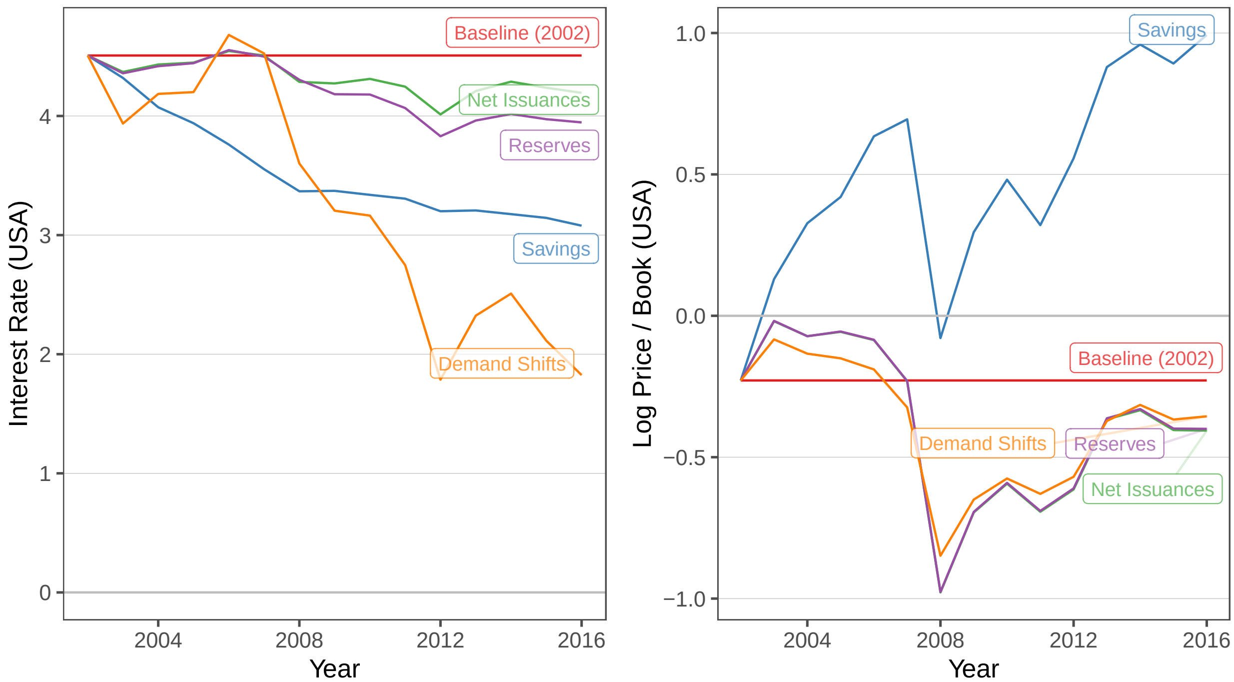
Notes: This table presents the changes in U.S. asset prices under each counterfactual exercise. The counterfactual exercises are cumulative. Columns (1) and (3) provide changes in asset prices between the counterfactual exercise and their 2002 values. Columns (2) and (4) provide changes in asset prices as a share of the total price change between 2002 and the final year indicated by the column headings (either 2009 or 2016). Panel A presents results for the yield on U.S. long-term debt in percentage points. Panel B presents results for the log market-to-book ratio for U.S. equities.

Figure 1. Decomposing Long-Run Variation in Portfolio Imbalances (Cumulative Counterfactuals)



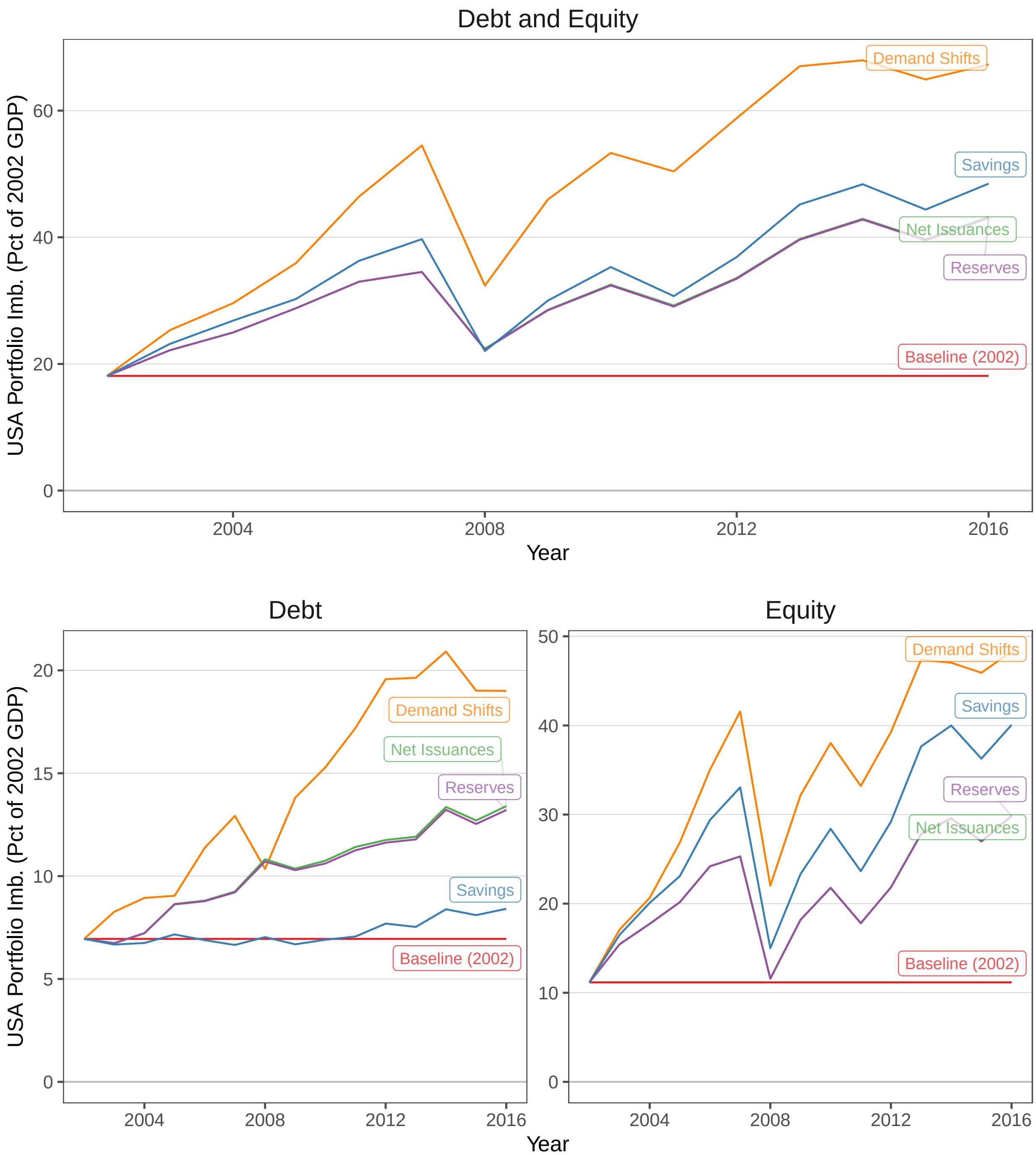
Notes: These figures present the U.S. portfolio position under different counterfactual exercises. The counterfactual exercises are cumulative and start with a "Baseline" position from 2002. The order of the counterfactuals continues with "Savings", "Net Issuances", "Reserves" and finally "Demand Shift". The "Demand Shifts" exercise corresponds with the data. Portfolio positions are normalized by U.S. GDP in 2002. The top panel presents the overall U.S. portfolio position. The bottom two panels present the U.S. debt position and U.S. equity position separately.

Figure 2. Decomposing Long-Run Variation in Aggregate Asset Prices (Cumulative Counterfactuals)



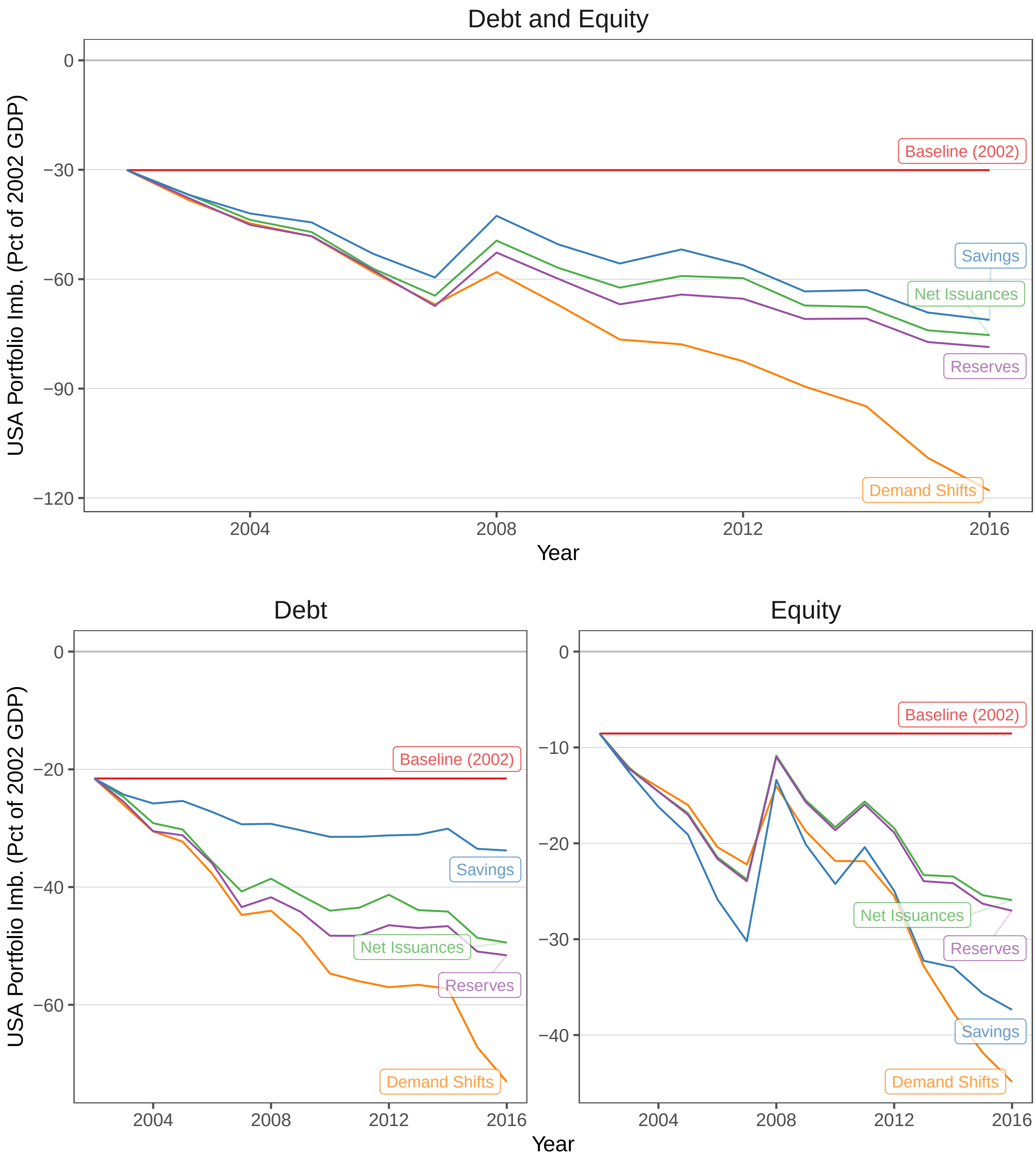
Notes: These figures present U.S. asset prices under different counterfactual exercises. The counterfactual exercises are cumulative and start with the "Baseline" prices from 2002. The order of the counterfactuals continues with "Savings", "Net Issuances", "Reserves" and finally "Demand Shift". The "Demand Shifts" exercise corresponds with the data. The left panel presents the yield on U.S. long-term debt, and the right panel presents the log market-to-book ratio on U.S. equity.

Figure 3. Decomposing Long-Run Variation in Portfolio Assets (Cumulative Counterfactuals)



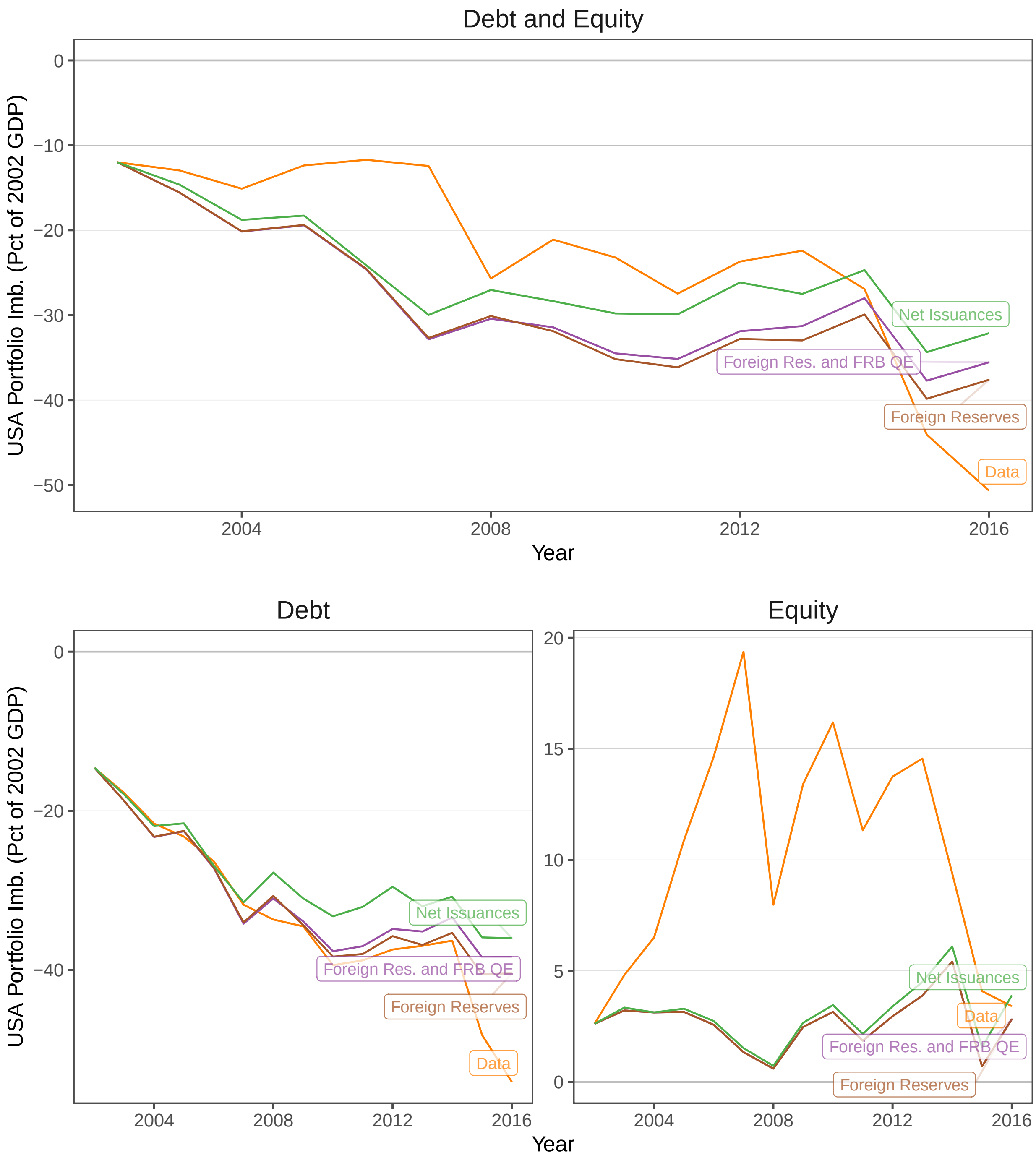
Notes: These figures present the U.S. asset position under different counterfactual exercises. The counterfactual exercises are cumulative and start with a "Baseline" position from 2002. The order of the counterfactuals continues with "Savings", "Net Issuances", "Reserves" and finally "Demand Shift". The "Demand Shifts" exercise corresponds with the data. Asset positions are normalized by U.S. GDP in 2002. The top panel presents the overall U.S. asset position. The bottom two panels present the U.S. debt holdings and U.S. equity holdings separately.

Figure 4. Decomposing Long-Run Variation in Portfolio Liabilities (Cumulative Counterfactuals)



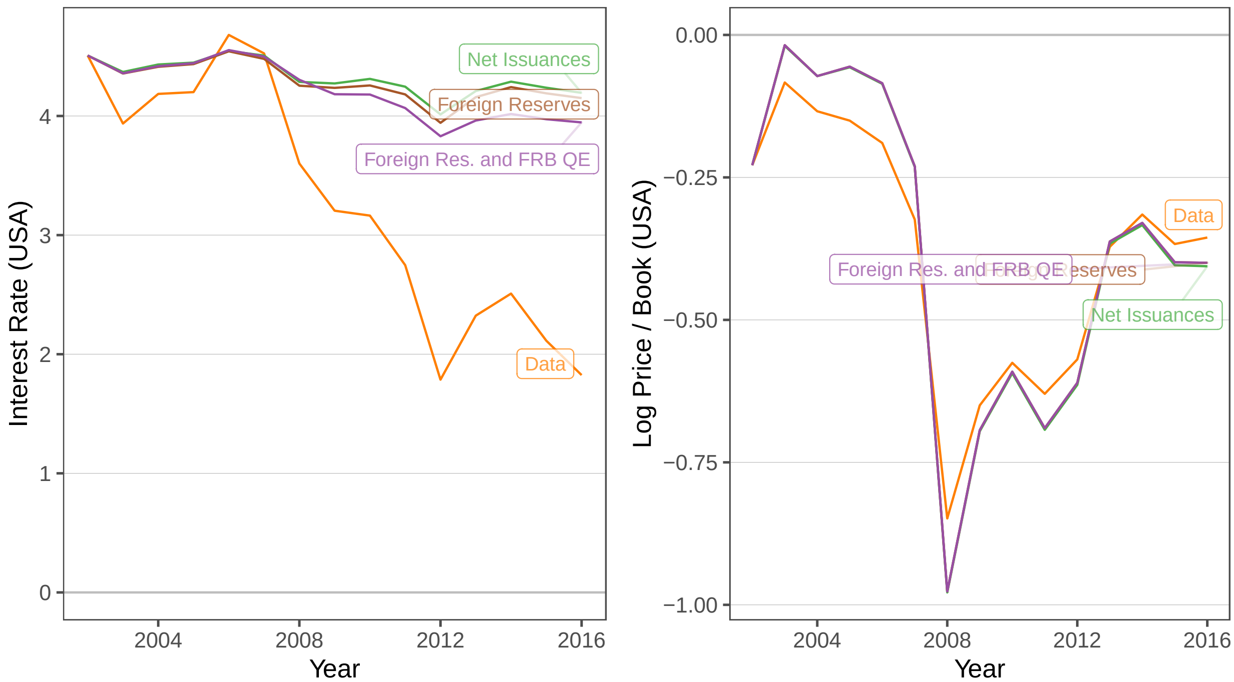
Notes: These figures present the U.S. liabilities position under different counterfactual exercises. The counterfactual exercises are cumulative and start with a "Baseline" position from 2002. The order of the counterfactuals continues with "Savings", "Net Issuances", "Reserves" and finally "Demand Shift". The "Demand Shifts" exercise corresponds with the data. Asset positions are normalized by U.S. GDP in 2002. The top panel presents the overall U.S. asset position. The bottom two panels present the U.S. debt holdings and U.S. equity holdings separately.

Figure 5. Decomposing Quantity Effects of Central Bank Reserves (Cumulative Counterfactuals)



Notes: These figures present the U.S. portfolio position under different counterfactual exercises. The counterfactual exercises are cumulative and start with the position from the "Net Issuances" counterfactual. The "Foreign Reserves" counterfactual accounts for changes in assets held in central banks' foreign currency reserves. The "Foreign Res. and FRB QE" exercise also account for FRB debt purchases made under quantitative easing. Portfolio positions are normalized by U.S. GDP in 2002. The top panel presents the overall U.S. portfolio position. The bottom two panels present the U.S. debt position and U.S. equity position separately.

Figure 6. Decomposing Price Effects of Central Bank Reserves (Cumulative Counterfactuals)



Notes: These figures present the U.S. asset prices under different counterfactual exercises. The counterfactual exercises are cumulative and start with the prices from the "Net Issuances" counterfactual. The "Foreign Reserves" counterfactual accounts for changes in assets held in central banks' foreign currency reserves. The "Foreign Res. and FRB QE" exercise also account for FRB debt purchases made under quantitative easing. The left panel presents the yield on U.S. long-term debt, and the right panel presents the log market-to-book ratio on U.S. equity.

Appendix
-For online publication only-

A Empirical Appendix

A.1 Alternative Instruments

The following appendix provides estimates of the coefficient on price in (6) using an alternative instrument constructed using asset characteristics. Within Section 3, we used the central bank policy rate of country j to instrument for the price of the country j asset.

Alternatively, we follow the industrial organization literature and construct variables based on the characteristics of "competing assets". Economic theory suggests that products that are more unique, may be able to charge higher markups Berry et al. (1995). In the finance literature, these markups correspond to convenience yields, where assets with uniquely more desirable characteristics may be able to charge higher convenience yields. For each asset j, we calculate the instrument $z_{j,t}$ as the sum of differences between asset j's log per capital GDP and the log per capita GDP of all other assets within the same market classification:

$$z_{j,t} = \sum_{k \in \Omega_j} (pcap\_gdp_{j,t} - pcap\_gdp_{k,t})^2$$

where Ω_j denotes the set of countries in the same MSCI asset market classification as country j.

Table 7 presents the estimate of the coefficient on log price using the policy rate and an additional sets of instruments for each asset class. The coefficient on log price is relatively stable across both instruments. The demand for equity is less price elastic than the demand for debt.

Table 7
Alternative Instruments for Log Price

	Equity	Long-term Debt
Policy Rate	0.26	-3.45
	(0.21)	(0.20)
Log per Capita GDP	0.12	-5.97
	(0.38)	(0.74)