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A SAFE-ASSET VIEW

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ABSTRACT

I propose a model of the reserve currency paradigm that centers on liquidity demand for safe assets. In global recessions, the demand for U.S. safe assets increases and raises their convenience yields, giving rise to stronger dollar and countercyclical seigniorage revenues. The seigniorage revenues raise the U.S. wealth and consumption shares in recessions, despite the U.S. suffering portfolio losses from external positions. This asset demand channel also connects exchange rates to bond holdings, which provides new perspectives on exchange rate disconnect and the exchange rate-capital flow relationship. Under this safe-asset view, exorbitant privilege does not require exorbitant duty.

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1 Introduction

Banks play important roles in the economy. By intermediating funds between savers and borrowers, they engage in safety and liquidity transformations. In the global financial system, the U.S. plays a similarly central role as the "world's banker". Under the *insurance-provision view* (Gourinchas and Rey, 2007a, 2022), the U.S. invests in risky assets in foreign countries, and supplies safe liabilities to foreign investors. Through these cross-border asset positions, the U.S. provides insurance to the rest of the world, and, as a result, earns a risk premium in good times as a compensation for its risk-taking, and bears losses in global recessions as the insurance pays off.

While this risk-based view provides important insights about the U.S. exorbitant privilege, its basic form creates a tension: as the insurance arrangement transfers resources from the U.S. to foreign countries in global recessions, the foreigners become relatively wealthier. Given their home bias in consumption demand, they should bid up the price of foreign goods and strengthen the foreign real exchange rate. However, the dollar exchange rate is strongly countercyclical in the data, resulting in what Maggiori (2017) describes as the *reserve currency paradox*.

In this paper, I study a different aspect of this U.S.-as-the-world's-banker metaphor. Just as banks have market power and charge a mark-up on their deposits on top of the compensation for their risk-taking, the U.S. also enjoys a seigniorage revenue from its provision of reserve assets. The liquidity demand for U.S. safe assets gives rise to a convenience yield and introduces a wedge in the international risk-sharing condition, which, in recent literature, has made significant progress in understanding exchange rate puzzles. As such, this *safe-asset view* also has the potential to shed light on quantities, flows, and wealth transfers in the international monetary system. In this paper, I examine this hypothesis in a general equilibrium model of international real business cycles, and report three results.

The first result concerns the U.S. exorbitant privilege. The demand for U.S. safe assets allows the U.S. to fund its liabilities at lower interest rates, which generates a seigniorage revenue to the U.S. This seigniorage revenue is transferred to local households and allows them to run trade deficits. This interpretation of the U.S. exorbitant privilege is different from the insurance-provision view, which regards the U.S. trade deficits as a compensation for providing insurance to the rest of the world and bearing the risk.

Next, I consider the exorbitant privilege's cyclicality. The foreign demand for dollar safe assets increases in global recessions, which makes the seigniorage revenue countercyclical and allows the U.S. households to consume more in relative terms. As a result, the U.S. wealth and consumption shares increase in global recessions. In stark contrast, under the insurance-provision view, global recessions reduce the U.S. wealth and consumption shares because the U.S. suffers portfolio losses from insuring the rest of the world. Gourinchas and Rey (2022) refer to these losses as the *exorbitant duty* of the reserve asset supplier, which transfers its wealth to the rest of the world in bad times. In my model, while the U.S. still suffers portfolio losses from its external asset positions due to dollar appreciation, the increase in its seigniorage revenues more than makes up for its wealth losses. Therefore, under the safe-asset view, the U.S. exorbitant duty could be offset by higher seigniorage revenues.

This safe-asset view also ties together other salient features of the reserve currency paradigm. The dollar appreciates in global recessions, since the foreign demand for U.S. safe assets also bids up the dollar's value (Jiang, Krishnamurthy, and Lustig, 2021a). This exchange rate response is also consistent with goods market clearing: as the U.S. households receive a higher seigniorage revenue, they become relatively wealthier. With a home bias in consumption, the aggregate demand for U.S. goods increases in relative terms and generates countercyclical terms of trade.

Moreover, as the U.S. experiences dollar appreciation and capital inflows, its net foreign assets (NFA) deteriorate in global recessions. In subsequent periods, lower returns on its external liabilities allow the U.S. to reduce its NFA imbalances without having to run trade surpluses, which is consistent with the emphasis on valuation effects in NFA dynamics (Gourinchas and Rey, 2007b). In comparison, if the exchange rate wedge is driven by intermediation frictions as in Itskhoki and Mukhin (2021), NFA imbalances have to be paid off by running future trade surpluses.

Having mapped the U.S. exorbitant privilege and its cyclicality to safe asset demand, I next study the broader safe asset equilibrium in this model and its implications for the exchange rate and capital flows. To set a clear benchmark, I consider two scenarios in the safe asset market as illustrated in Figure (1), which takes the perspective of foreign investors. The x-axis denotes the quantity Q of the dollar bond available to the foreign investors, and the y-axis denotes the price P of the dollar bond, which can be interpreted as either the domestic price of the bond or the currency value of the dollar. The left panel depicts a demand shock, which shifts the foreign investors' dollar bond demand upwards; the right panel depicts a supply shock, which moves the foreign investors along their downward-sloping demand curve.

The second result from this model concerns the exchange rate cyclicality. In consumption-based models with complete markets, the exchange rate movement is determined by the differential in marginal utilities *over consumption*:

$$\Delta e = (\Delta u_c - \Delta u_c^*).$$

As recessions lower the local investors' consumption and raise their marginal utility, the exchange rate is always countercyclical. However, the exchange rate is acyclical or even procyclical in the data, as it tends to depreciate when local consumption declines (Backus and Smith, 1993).

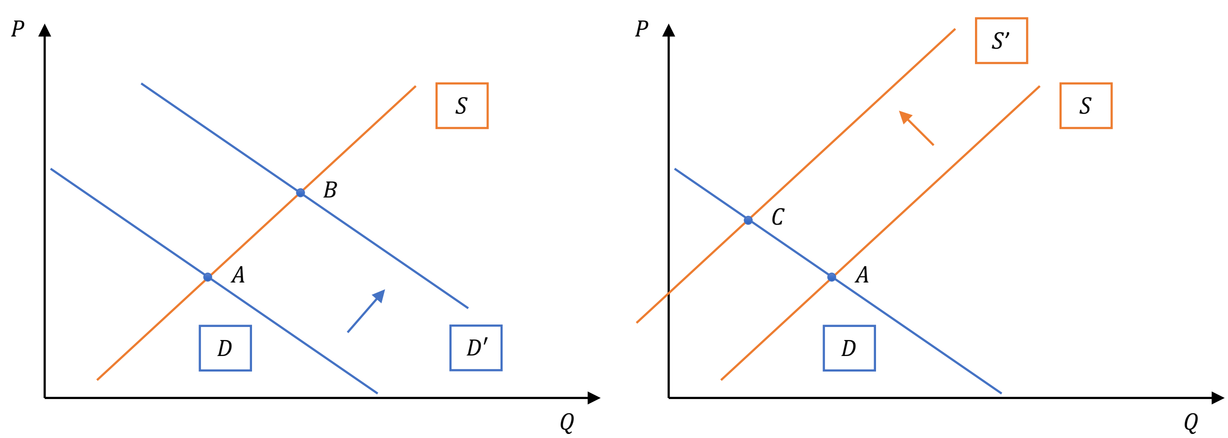


Figure 1: Illustrations of the Demand and Supply in the Safe Asset Equilibrium.

Notes: This figure illustrates two scenarios in the U.S. safe asset market from the foreign investors' perspective. The left panel considers a demand shift by the foreign investors towards the U.S. bond, whereas the right panel considers a supply shift that makes the U.S. bond more scarce to the foreign investors.

The safe-asset equilibrium offers a different perspective. In the presence of non-pecuniary benefits of holding bonds, the exchange rate movement is determined by not only the differential in marginal utilities *over consumption*, but also the differential in marginal utilities *over dollar bond holding*. Heuristically,

$$\Delta e = (\Delta u_c - \Delta u_c^*) + (\Delta u_b^* - \Delta u_b).$$

In the case of an asset demand shock that shifts up the foreign investors' dollar bond demand curve from D to D' in the figure, their marginal utility over dollar bond holding Δu_b^* increases and appreciates the dollar, which is consistent with our analysis of the U.S. exorbitant privilege. As the U.S. relative consumption also rises upon the shock, the exchange rate is procyclical with respect to the U.S. consumption share.

While the asset demand shock has been studied extensively in open economy models, the supply shift in the safe asset market has received less attention. In the case of an asset supply shock that moves the foreign investors along their downward-sloping demand curve from point A to point C in the figure, a reduction in the quantity of the U.S. bond available to the foreign investors also increases their marginal utility over dollar bond holding Δu_b^* and appreciates the dollar. In this way, both demand and supply shocks in the safe asset market impact the exchange rate via the Δu_b^* term.

More precisely, while a decline in the supply of the U.S. bond increases the marginal utilities of the U.S. and foreign investors symmetrically, a shift in the wealth distribution between the U.S. and foreign investors generates asymmetric effects. For example, suppose a wealth shock due to revaluation of cross-border financial claims makes the U.S. investors relatively wealthier than the foreign investors. This shock not only increases the U.S. consumption, but also induces the U.S. investors to purchase more dollar safe assets, which crowds out the foreign investors by shifting the residual supply curve they face from S to S'. As the foreign investors move along their downward-sloping demand curve for dollar safe assets, they impute a higher marginal utility and accept a lower expected return to hold the U.S. bond. To equilibrate their demand with the U.S. investors', the dollar appreciates and lowers its expected return from the foreign perspective.

In this way, while a consumption decline in the foreign country increases the marginal utility Δu_c^* over consumption and *appreciates* the foreign currency in real terms through the standard international risk-sharing channel, a wealth decline increases the marginal utility Δu_b^* over bond holding and *depreciates* the foreign currency through the asset demand channel. In a local recession, if wealth declines more than consumption, the asset demand channel could dominate and generate a procyclical exchange rate.

It is worth noting that this supply shift applies to both home and foreign countries: wealth decline drives the local households out of the safe asset market, which raises their bond convenience yield and depreciates their currency. As such, this mechanism also generates procyclical exchange rates in a symmetric model between two non-U.S. countries. On top of this mechanism, the U.S. dollar is extra special on the demand side: the demand for dollar safe assets tends to shift up in global recessions and drives additional dollar appreciation.

The third result from this model offers a new perspective on the relationship between capital flows and the exchange rate. It is again useful to consider the demand and supply shocks in the dollar bond market. When capital flows are driven by demand shifts towards the dollar safe bond, inflows into the U.S. are associated with dollar appreciation. In this case depicted by the left panel of Figure (1), as the foreign demand curve shifts from D to D', the foreign investors hold more dollar bond and this inflow strengthens the dollar. This result is consistent with the large theoretical literature that emphasizes the flow-driven mechanisms of exchange rate determination (Evans and Lyons, 2002; Froot and Ramadorai, 2005; Hau and Rey, 2006; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021).

When the foreign investors move along their demand curve D, the relationship between net capital flows and the exchange rate is reversed. Consider the wealth shock again: when the U.S. investors become richer and buy more U.S. bonds, the residual supply curve of the U.S. bond faced by the foreign investors shifts from S to S'. As the foreign investors are priced out of the safe asset market, higher scarcity of the U.S. bond overseas increases its convenience yield and appreciates the dollar. In this case depicted by the right panel of Figure (1), we obtain a new prediction: outflows from the U.S. are associated with dollar appreciation.

Empirically, the correlation between the dollar exchange rate and net cross-border flows in the bond market is very close to zero, which has been interpreted as part of the broader exchange rate disconnect puzzle. However, underneath this unconditional lack of correlation, I find that the conditional correlation fluctuates between -0.7 and 0.6 over time, and, using proxies of global financial conditions, net inflows into the U.S. tend to be positively correlated with dollar appreciation during global stress periods, such as the 2007–2012 period as noted by Lilley, Maggiori, Neiman, and Schreger (2022), while the correlation tends to be negative during normal times.

This pattern supports the model's mechanism. If the bond demand shock dominates in global stress periods, the dollar tends to appreciate with inflows into the U.S. If the wealth shock dominates in normal times, the dollar tends to appreciate with outflows from the U.S. In this way, the model obtains a state-dependent relationship between capital flows and the exchange rate, which casts new light on their unconditional disconnect. In particular, the lack of unconditional correlation between capital flows and the exchange rate does not imply that capital flows play no role in exchange rate dynamics.

This discussion also sheds light on the roles that safe asset demand and supply play in exchange rates and real outcomes. On the one hand, both demand and supply shocks in the safe asset market affect the investors' marginal utilities over bond holding, which appreciate the dollar while increasing the U.S. consumption share. In this sense, the safe asset equilibrium provides a resolution of the Backus and Smith (1993) puzzle, which arises in standard models that largely focus on the goods market equilibrium. On the other hand, the demand and supply shocks in the safe asset market have different implications for capital flows. The demand shock generates dollar appreciation when the U.S. receives inflows, while the supply shock generates dollar appreciation when the U.S. experiences outflows. This state-dependent relationship between capital flows and the exchange rate is also a novel feature of the safe-asset view, which requires the presence of both demand and supply shocks to explain the unconditional disconnect.

In summary, these results provide a coherent safe-asset view for understanding exchange rate dynamics, capital flows, and the special status of the U.S. and the dollar. Emphasizing the demand and supply factors in the safe asset market, this view offers a novel way of organizing the empirical facts in the international monetary system, and complements the insurance-provision view that emphasizes the U.S. role as the global insurance provider.

Literature. This paper is related to a large literature on the U.S. exorbitant privilege in the international financial system (Mendoza, Quadrini, and Rios-Rull, 2009; Gourinchas, Rey, and Truempler, 2012; Maggiori, 2017; Gourinchas, Rey, and Sauzet, 2019). The closest paper is Jiang, Krishnamurthy, and Lustig (2020), which studies a dollar liquidity channel through which the dollar cycle drives the global financial cycle. The paper notes the countercyclical nature of the U.S. seigniorage revenue as we discussed in the first result, but the model does not clear foreign goods and bond markets.[1] Building on these works, my paper takes the dollar bond demand as given and introduces this ingredient into an otherwise conventional international business cycle model. The main contribution is to characterize its general equilibrium implications for quantities and flows, such as consumption, wealth share, capital flows, and their relationships with the exchange rate.

Kekre and Lenel (2021) also propose a model of the dollar and U.S. external imbalances with safe asset demand. They develop a channel through which the dollar appreciates in global downturns because the U.S. suffers a greater recession and a greater consumption decline. Similarly, in Dahlquist, Heyerdahl-Larsen, Pavlova, and Pénasse (2022); Sauzet (2022); Kim (2022); Devereux, Engel, and Wu (2023), the dollar appreciation in global downturns is accompanied by a *higher* U.S. marginal utility over consumption. My model explores a different and complementary channel. Emphasizing the seigniorage revenue earned by the U.S. safe asset issuers, this channel generates dollar appreciation despite the U.S. having higher consumption and *lower* marginal

[1] Moreover, Caballero, Farhi, and Gourinchas (2008) study the U.S. provision of financial assets, and develop a different channel through which the U.S. earns rents that fund trade deficits. Chen (2021) develops a two-country model of financial intermediation in which the U.S. Treasury is a special collateral, and shows that a symmetric tightening of financial constraint could increase the Treasury's convenience yield.

utility over consumption in global downturns.

On the empirical side, Jiang, Krishnamurthy, and Lustig (2020) note the countercyclical nature of the U.S. wealth share and present evidence in the 2008 financial crisis. Dahlquist, Heyerdahl-Larsen, Pavlova, and Pénasse (2022); Kim (2022) present further evidence in favor of countercyclical U.S. wealth and consumption shares, while Sauzet (2022) presents evidence that the U.S. household wealth declines more than the foreign household wealth in global recessions. Future empirical works that shed light on the asset holdings of non-household sectors could help reconcile these findings.

This paper is also related to segmented-market models of exchange rates (Alvarez, Atkeson, and Kehoe, 2002, 2009; Chien and Naknoi, 2015; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021), which emphasize the wedge in the international risk-sharing condition as the key to understanding exchange rate disconnect. The demand for safe assets gives rise to a similar wedge, which generates novel patterns in international transfers and capital flows in addition to the exchange rate. Moreover, the convenience yield interpretation of the wedge provides a direct measurement and an economic interpretation for the cyclicality of the wedge, which tends to move in the direction that appreciates the dollar in flight-to-safety episodes. Valchev (2020); Bianchi, Bigio, and Engel (2021); Jiang (2021); Jiang, Krishnamurthy, Lustig, and Sun (2021b); Engel and Wu (2023) also study the implication of the safe asset demand for exchange rate dynamics.

Finally, this paper takes the foreign investors' countercyclical demand for U.S. safe assets as a given fact, which has deeper theoretical foundations. Farhi and Maggiori (2018); He, Krishnamurthy, and Milbradt (2019); Coppola, Krishnamurthy, and Xu (2023) propose coordination-based explanations for why the U.S. bond is especially valued. Caballero, Farhi, and Gourinchas (2016); Caballero and Farhi (2018) study the general equilibrium effects of safe asset scarcity. This paper studies the global business cycle fluctuations within the current regime in which the U.S. bond is regarded as the safe asset. The possibility of a regime change in its reserve asset status and its implication for exorbitant privilege remains an interesting open question (Chen et al., 2022).

The rest of the paper is organized as follows. Section 2 presents the model and characterizes the equilibrium exchange rate dynamics as determined by the marginal utilities over consumption and bond holding. Section 3 reports the impulse responses to different fundamental and financial shocks, and discusses the implications for the U.S. exorbitant privilege. Section 4 derives further results on the relationship between capital flows and the exchange rate, and presents empirical evidence in favor of the model's predictions. Section 5 presents the quantitative results to evaluate the model's fit of exchange rate, consumption, and capital flow moments. Section 6 concludes. The appendix contains the proof of theoretical results and details of data construction and model extension.

2 Model

2.1 Set-Up

There are two countries, the home (U.S.) and the foreign country. Each country has a unique type of consumption goods. The model abstracts away from the nominal layer: the dollar and the foreign currency refer to the consumption baskets of the home and foreign households, which are combinations of the home and foreign goods. Let p_t denote the price of the home goods in dollar, and let p_t^* denote the price of the foreign goods in the foreign currency. Let e_t denote the dollar-foreign currency exchange rate in log, which is the real exchange rate between the home and foreign consumption baskets. A higher value of e_t means a stronger dollar and a higher price of the home consumption basket relative to the foreign consumption basket. For expositional simplicity, I consider an endowment economy. I discuss a model extension with production and capital accumulation in Section 3.2, which confirms the main results.

Each country is populated by a unit mass of identical households and a government. The government in each country issues one-period, risk-free bond, which is held by the households in both countries. Each unit of the bond pays off one unit of the local consumption basket in the next period. Let $\bar{b}_t$ and $\bar{b}_t^*$ denote the market value of bonds issued by the home and the foreign governments, in the unit of their respective local consumption baskets, and let r_t and r_t^* denote their interest rates. The proceeds from the net issuance, which are

$$g_t = \bar{b}_t - \bar{b}_{t-1} \exp(r_{t-1}), \qquad g_t^* = \bar{b}_t^* - \bar{b}_{t-1}^* \exp(r_{t-1}^*),$$

for the home and foreign governments, are transferred to the local households.

The home households' consumption basket is a CES aggregation of home and foreign goods:

$$c_t = \left[\alpha^{1-\eta} c_{H,t}^{\eta} + (1-\alpha)^{1-\eta} c_{F,t}^{\eta}\right]^{1/\eta},$$

and they hold $b_{H,t}$ dollars' worth of the home bond and $b_{F,t}$ foreign currencies' worth of the foreign bond.

The home households derive utility from consumption and from holding home and foreign bonds. I use the bond-in-utility function as a reduced-form way to capture the non-pecuniary benefits of holding bonds (Krishnamurthy and Vissing-Jorgensen, 2012; Nagel, 2016). The home households' utility function is

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \delta^t \left(\frac{1}{1-\gamma} c_t^{1-\gamma} + \frac{1}{1-\sigma} \omega_H b_{H,t}^{1-\sigma} + \frac{1}{1-\sigma} \omega_F b_{F,t}^{1-\sigma}\right)\right],$$

subject to the budget constraint

$$p_t y_t + \exp(r_{t-1}) b_{H,t-1} + \exp(r_{t-1}^* - e_t) b_{F,t-1} + g_t + \tau_t = c_t + b_{H,t} + \exp(-e_t) b_{F,t}.$$

The budget constraint is expressed in the unit of the home consumption basket. The left-hand side includes the home households' incomes, including their endowment of the home goods, their savings in the home and foreign bonds from the previous period, the government transfer g_t from net debt issuance, and an international wealth transfer τ_t. The right-hand side includes their expenditures, including their consumption and their purchases of the home and foreign bonds. The τ_t term captures international wealth transfer in a reduced-form way, which could result from nonbond portfolio holdings that are not directly modeled in this paper. For example, if the U.S. holds a large amount of foreign equities and derivatives, and the value of these foreign claims rises, then, the U.S. receives a wealth transfer from the foreign country.

Similarly, the foreign households' consumption basket is a CES aggregation of home and foreign goods:

$$c_t^* = \left[\alpha^{1-\eta}(c_{F,t}^*)^\eta + (1-\alpha)^{1-\eta}(c_{H,t}^*)^\eta\right]^{1/\eta},$$

and they maximize utility

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\delta^t\left(\frac{1}{1-\gamma}(c_t^*)^{1-\gamma} + \frac{1}{1-\sigma}\omega_H^*(b_{H,t}^*)^{1-\sigma} + (\bar{c}^*)^{-\gamma}\theta_{H,t}^* b_{H,t}^* + \frac{1}{1-\sigma}\omega_F^*(b_{F,t}^*)^{1-\sigma}\right)\right],$$

subject to the following budget constraint expressed in the unit of the foreign consumption basket:

$$p_t^* y_t^* + \exp(r_{t-1}^*)b_{F,t-1}^* + \exp(r_{t-1}+e_t)b_{H,t-1}^* + g_t^* - \exp(e_t)\tau_t = c_t^* + b_{F,t}^* + \exp(e_t)b_{H,t}^*.$$

This set-up is symmetric to the home households' problem, with the exception that the foreign households' utility contains an exogenous shock to their dollar bond demand captured by $\theta_{H,t}^*$. As we will see next, this shock shifts the foreign households' demand curve for the U.S. bond.

The goods markets and the bond markets clear in the usual way:

$$c_{H,t} + c_{H,t}^* = y_t, \qquad c_{F,t} + c_{F,t}^* = y_t^* \tag{1}$$

$$b_{H,t} + b_{H,t}^* = \bar{b}_t, \qquad b_{F,t} + b_{F,t}^* = \bar{b}_t^*. \tag{2}$$

The exogenous variables are the endowments, foreign households' dollar asset preferences, and the international wealth transfer: $(y_t, y_t^*, \theta_{H,t}^*, \tau_t)_{t=0}^{\infty}$. Appendix A.1 provides the full set of endogenous variables and equilibrium conditions.

2.2 Model Characterization

I define the home and foreign SDFs as the growth rates of their marginal utilities over consumption:

$$\exp(m_{t+1}) \overset{\text{def}}{=} \delta \left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}, \qquad \exp(m^*_{t+1}) \overset{\text{def}}{=} \delta \left(\frac{c^*_{t+1}}{c^*_t}\right)^{-\gamma}.$$

The home and foreign households' optimization problems imply the following Euler equations:

$$\exp(-\lambda_{H,t}) \overset{\text{def}}{=} 1 - \frac{\omega_H b_{H,t}^{-\sigma}}{c_t^{-\gamma}} = \mathbb{E}_t \left[\exp(m_{t+1} + r_t)\right], \tag{3}$$

$$\exp(-\lambda_{F,t}) \overset{\text{def}}{=} 1 - \frac{\omega_F b_{F,t}^{-\sigma}}{c_t^{-\gamma}} \exp(e_t) = \mathbb{E}_t \left[\exp(m_{t+1} - \Delta e_{t+1} + r^*_t)\right],$$

$$\exp(-\lambda^*_{F,t}) \overset{\text{def}}{=} 1 - \frac{\omega^*_F (b^*_{F,t})^{-\sigma}}{(c^*_t)^{-\gamma}} = \mathbb{E}_t \left[\exp(m^*_{t+1} + r^*_t)\right],$$

$$\exp(-\lambda^*_{H,t}) \overset{\text{def}}{=} 1 - \frac{\omega^*_H (b^*_{H,t})^{-\sigma} + (\bar{c}^*)^{-\gamma}\theta^*_{H,t}}{(c^*_t)^{-\gamma}} \exp(-e_t) = \mathbb{E}_t \left[\exp(m^*_{t+1} + \Delta e_{t+1} + r_t)\right]. \tag{4}$$

The right-hand sides of these equations are the risk-neutral expected returns, which are standard in the Euler equations. The left-hand sides deviate from the standard Euler equations because of the non-pecuniary benefits of holding bonds, which lower the bonds' required returns below 1. I use the convenience yields λ to capture these deviations, which are determined by the ratio between the marginal utility over bond holding and the marginal utility over consumption.

I have chosen a parsimonious specification of the safe asset demand. Take the last Euler equation for example, which describes the foreign households' demand for the U.S. bond. The term $\omega^*_H (b^*_{H,t})^{-\sigma}$ captures the downward-sloping demand for the U.S. bond, which helps us pin down the equilibrium quantity of the U.S. bond held by foreign households. The other Euler equations also contain similar terms. The other term $(\bar{c}^*)^{-\gamma}\theta^*_{H,t}$ captures a demand shifter, which reflects the foreign households' time-varying demand for dollar safe assets. For parsimony, I only include this demand shifter in the foreign households' demand for the U.S. bond, because, as I show below, only the differential in the convenience yields matters for the exchange rate dynamics.

Log-linearizing the Euler equations yields the following international risk-sharing condition,

$$-(\lambda_{H,t}^* - \lambda_{H,t}) = \mathbb{E}_t[m_{t+1}^* - m_{t+1} + \Delta e_{t+1}]. \tag{5}$$

Compared to the complete-market case $0 = m_{t+1}^* - m_{t+1} + \Delta e_{t+1}$, market incompleteness reduces international risk-sharing so that the SDF differential is not aligned with the exchange rate movement state by state; instead, the Euler equations for risk-free bond holding only imposes restrictions between the expectation of $m_{t+1}^* - m_{t+1}$ and the expectation of Δe_{t+1}. Convenience yields further introduce a wedge $-(\lambda_{H,t}^* - \lambda_{H,t})$ in this condition, which is related to the marginal utilities over bond holding by both home and foreign households.

Using the definition of the SDFs and letting $\bar{e} \overset{\text{def}}{=} \lim_{t\to\infty} e_t$ denote the long-term exchange rate level, I iterate this equation forward and obtain the following result.

Proposition 1. *The exchange rate level is equal to the sum of the expected consumption growth differential and the expected convenience yield differential:*

$$\begin{aligned} e_t - \bar{e} &= \sum_{j=1}^{\infty} \mathbb{E}_t[\gamma(\Delta \log c_{t+j} - \Delta \log c_{t+j}^*)] + \sum_{j=0}^{\infty} \mathbb{E}_t[\lambda_{H,t+j}^* - \lambda_{H,t+j}] \\ &= -\gamma \left(\log \frac{c_t}{\bar{c}} - \log \frac{c_t^*}{\bar{c}^*} \right) + \sum_{j=0}^{\infty} \mathbb{E}_t[\lambda_{H,t+j}^* - \lambda_{H,t+j}], \end{aligned} \tag{6}$$

where the convenience yield differential on the U.S. bond is approximately

$$\lambda_{H,t}^* - \lambda_{H,t} \approx \frac{\omega_H^* (b_{H,t}^*)^{-\sigma}}{(c_t^*)^{-\gamma}} \exp(-e_t) - \frac{\omega_H b_{H,t}^{-\sigma}}{c_t^{-\gamma}} - \theta_{H,t}^* \exp(-e_t). \tag{7}$$

The proof is in Appendix A.2. This proposition helps us understand how the exchange rate responds to different types of shocks. The right-hand side of Eq. (6) contains two components. The first component is the differential in the marginal utility over consumption. When markets are complete, this is the only driver of the exchange rate. The second component is the sum of expected convenience yield differentials, which drive additional variations in the exchange rate dynamics. Interestingly, it is not the convenience yield per se that affects the exchange rate, but the differential between the foreign investors' perspective and the home investors' perspective. To obtain a stronger dollar (i.e., a higher e_t), the foreign investors' convenience yield on the dollar bond needs to exceed the home investors' convenience yield.

Eq. (7) further connects the convenience yield differential to the households' marginal utilities over bond holding, which are determined by the quantities of the U.S. bond held by foreign and U.S. households, $b^*_{H,t}$ and $b_{H,t}$, and the exogenous demand shifter $\theta^*_{H,t}$. If the foreign households hold more U.S. bonds, their marginal utility from holding the U.S. bond decreases, which reduces their convenience yield $\lambda^*_{H,t}$ and depreciates the dollar, unless the increase in the foreign households' holding is accompanied by a change in the demand shifter $\theta^*_{H,t}$. In this way, this equation connects the exchange rate to bond quantities held by different investors, which provides a flow-based account of the exchange rate dynamics as we explore in Section 4.

2.3 Complete-Market Solution

It is useful to compare the results to the complete-market case, in which I maintain the same assumptions about the households' preferences for consumption goods and bonds, but allow the households to trade the complete set of contingent claims. In this case, the model can be solved by considering a social planner who maximizes a weighted sum of home and foreign utilities subject to the market clearing conditions (1) and (2). The equilibrium convenience yields satisfy the following relationships.

Proposition 2. *When the markets are complete, the U.S. and foreign households derive identical convenience yields from holding the U.S. bond:*

$$\lambda_{H,t} = \lambda^*_{H,t},$$

and the exchange rate is determined only by the marginal utility differential:

$$e_t^{cm} - \bar{e}^{cm} = \sum_{j=1}^{\infty} \mathbb{E}_t[\gamma(\Delta \log c_{t+j} - \Delta \log c^*_{t+j})] = -\gamma \left(\log \frac{c_t}{\bar{c}} - \log \frac{c_t^*}{\bar{c}^*} \right).$$

The proof is in Appendix A.3. This proposition shows that, while the convenience yields can be nonzero in complete markets, they do not directly affect the equilibrium exchange rate.[2] More precisely, Eq. (6) in Proposition 1 still holds, but the convenience yields $\lambda_{H,t}$ and $\lambda^*_{H,t}$ are equalized to generate zero differential. Given the definitions of these convenience yields in Eq. (3) and (4), this means that the home and foreign households' marginal utilities derived from holding the dollar bond are equalized (after multiplication with the planner's Pareto weights π and $1-\pi$):

$$\pi v_t'(b_{H,t}) = (1-\pi) v_t^{*'}(b^*_{H,t}),$$

where $v_t'(b_{H,t}) = \omega_H b_{H,t}^{-\sigma}$ and $v_t^{*'}(b^*_{H,t}) = \omega^*_H (b^*_{H,t})^{-\sigma} + (\bar{c}^*)^{-\gamma} \theta^*_{H,t}$ are the home and foreign households' marginal utilities over dollar bond holdings. This result is similar to the equilibrium condition under complete markets that full risk-sharing equalizes the home and foreign households' marginal utilities over consumption (after unit conversion by the exchange rate and multiplication with the Pareto weights):

$$\pi u'(c_t) = (1-\pi) u'(c_t^*) \exp(e_t).$$

As such, incomplete markets are an essential ingredient for the convenience yields to directly impact the exchange rate.

[2] In the complete-market world, convenience yields may still affect exchange rates indirectly via their effect on relative marginal utilities. For example, a higher dollar convenience yield affects the natural rate in the U.S., and, absent responses from the Fed, the U.S. consumption declines and the U.S. marginal utility increases, leading to dollar appreciation (Caballero et al., 2021; Kekre and Lenel, 2021).

2.4 Calibration and the Steady State

I calibrate the model at the quarterly frequency, and pick the following parameter values: risk aversion $\gamma = 1$, time discount $\delta = 0.99$, and average endowment $\bar{y} = \bar{y}^* = 1$. Following Itskhoki and Mukhin (2021), I pick the goods' elasticity of substitution $\eta = 1/3$ and a slightly smaller home bias in consumption $\alpha = 0.9$. I pick the bonds' curvature $\sigma = 3$, so that a 10% reduction in the U.S. bond supply lowers the one-period risk-free rate by 0.4%. This value implies a demand elasticity of $-\partial \log q / \partial \log p = 25$, which is consistent with the empirical estimates in Koijen and Yogo (2019).

I log-linearize the model and solve the forward-looking first-order dynamics around a non-stochastic steady state, which is obtained by setting all variables to be constant over time. I choose $\bar{\theta}^*_H = 0$ so that the demand shifter is neutral in the steady state. I calibrate the bond demand variables $\omega_H, \omega^*_F, \omega^*_H, \omega_F$ so that in the steady state, the quarterly convenience yield on the home bond $\lambda_{H,SS}$ is 1.01% and the convenience yield on the foreign bond $\lambda_{F,SS}$ is 0.50%. These values imply an unconditional dollar Treasury convenience yield of 2% per annum above the foreign bond, which is in line with the empirical estimates in Jiang, Krishnamurthy, and Lustig (2021a). Finally, I calibrate the steady-state bond quantities so that the U.S. debt/output ratio $\bar{b}_{SS}/(p_{SS}y_{SS})$ is 200%, the foreign debt/output ratio $\bar{b}^*_{SS}/(p^*_{SS}y^*_{SS})$ is 100%, $b^*_{H,SS}/\bar{b}_{SS} = 50\%$ of the U.S. bond is held by the foreign households, and $b_{F,SS}/\bar{b}^*_{SS} = 20\%$ of the foreign bond is held by the U.S. households. This set of targets implies that the U.S. net foreign asset is -80.1% of the U.S. output in the steady state.

Table 1 reports more details about the steady-state values. The U.S. consumption is slightly higher than the foreign consumption and on average the U.S. runs an unconditional trade deficit equal to -0.1% of the total output per quarter, which reflects the U.S. exorbitant privilege. However, unlike the insurance-provision view, which interprets this exorbitant privilege as a risk premium that the U.S. earns by insuring the rest of the world, my model interprets this exorbitant privilege as a seigniorage revenue. Specifically, this trade deficit is funded by the fact that the U.S. pays a lower interest rate on its external borrowing than the foreign country due to its convenience

Table 1: Steady-State Values

Variable	Notation	Value
Home consumption	c_{SS}	1.0014
Foreign consumption	c^*_{SS}	0.9986
Home trade balance	$tb_{SS}/(p_{SS}y_{SS})$	-0.1%
Home bond rate	r_{SS}	0.00%
Foreign bond rate	r^*_{SS}	0.50%
Home bond convenience yield	$\lambda_{H,SS}$	1.01%
Foreign bond convenience yield	$\lambda_{F,SS}$	0.50%
Exchange rate	e_{SS}	0.0034
U.S. debt-output ratio	$\bar{b}_{SS}/(p_{SS}y_{SS})$	200%
Foreign debt-output ratio	$\bar{b}^*_{SS}/(p^*_{SS}y^*_{SS})$	100%
Foreign holding of home bond	$b^*_{H,SS}/\bar{b}_{SS}$	50%
Home holding of foreign bond	$b_{F,SS}/\bar{b}^*_{SS}$	20%
Home net foreign asset	$nfa_{H,SS}/(p_{SS}y_{SS})$	-80.1%

yield. Quantitatively, the U.S. borrows 100% of its output from the foreign households at an interest rate of 0%, whereas the foreign country borrows 20% of its output from the U.S. households at an interest rate of 0.5%. In the steady state, the foreign country pays the U.S. a quarterly net interest equal to $20\% \times 0.5\% = 0.1\%$ of the foreign output. In reality, this seigniorage revenue could be greater if the discount rate on the foreign country's liabilities is higher than 0.5% or if the size of the foreign liabilities is greater than 20% of the foreign output in my calibration.

3 Model Mechanism

This section examines impulse response patterns through the lens of Proposition 1 to understand the model's economic mechanism. I show how the variations in the bond convenience yields as driven by the demand and supply shocks in the safe asset market play a central role in both exchange rate dynamics and international transfers.

3.1 Flight to Safety and International Wealth Transfers

In traditional international real business cycle (IRBC) models, a global recession corresponds to a low endowment or productivity. In this model, I highlight a different aspect of the global recession: it coincides with a global flight to safety. In particular, the foreign households' demand for the U.S. risk-free bond, which is captured by $\theta^*_{H,t}$, increases. I first study this shock in isolation to highlight its role in resolving the reserve currency paradox. I consider its correlation with other shocks in Section 5.

Figure (2) reports the impulse responses to a shock to the foreign households' dollar bond demand $\theta^*_{H,t}$. I assume that this shock dissipates gradually with an autocorrelation of 0.9, which implies a half life of 1.6 years. Upon the arrival of the shock, we can see an increase in the

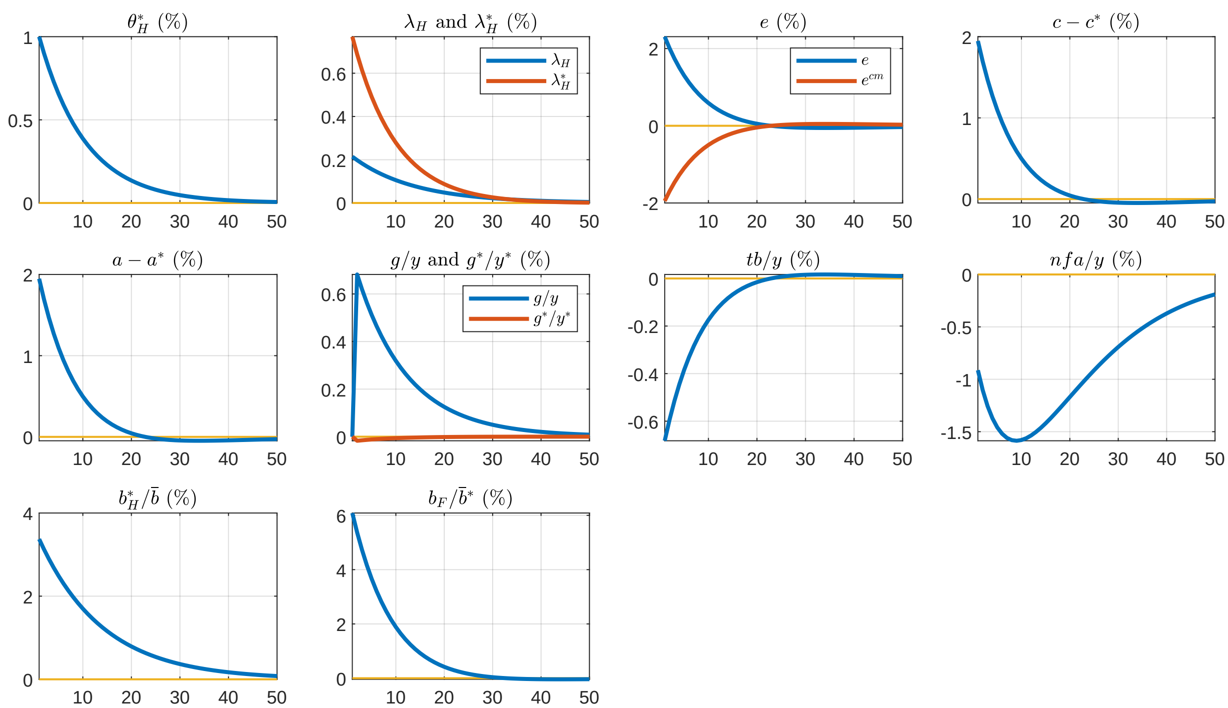


Figure 2: Impulse Responses to Dollar Bond Demand Shock.

Notes: I simulate an exogenous increase in the foreign households' demand for the dollar bond. The figure reports the responses in the convenience yields, the dollar's exchange rate level, the consumption differential, the wealth differential, the government transfers, the trade balance/output ratio, the NFA/output ratio, the fraction of dollar bonds held by foreign households, and the fraction of foreign bonds held by U.S. households.

foreign households' convenience yield $\lambda^*_{H,t}$ on the dollar risk-free bond, and an increase in the foreign households' holding $b^*_{H,t}$ of the U.S. bond. According to the exchange rate formula (6), reproduced below,

$$e_t - \bar{e} = -\gamma \left(\log \frac{c_t}{\bar{c}} - \log \frac{c^*_t}{\bar{c}^*} \right) + \sum_{j=0}^{\infty} \mathbb{E}_t[\lambda^*_{H,t+j} - \lambda_{H,t+j}],$$

the increase in the foreign households' convenience yield $\lambda^*_{H,t+j}$ on the dollar bond appreciates the dollar upon the shock's arrival, as shown by the exchange rate panel e of Figure (2). This dollar appreciation is contrary to what is predicted by complete markets: according to the consumption differential panel $c - c^*$ of Figure (2), the U.S. consumption is relatively higher than the foreign consumption in the flight-to-safety episodes, leading to a lower U.S. households' marginal utility over consumption and hence a weaker dollar under complete markets, as shown by the red curve in the exchange rate panel e.

On the quantity side, the foreign households' purchase of the dollar bond is financed by reductions in their consumption and their holding of the foreign bond. As a result, the transfer of dollar bond from the U.S. to the foreign is accompanied by a transfer of consumption goods and foreign bond from the foreign to the U.S. In the figure, panel $c - c^*$ shows that the U.S. households' consumption increases relative to the foreign households' consumption, and panel $b_F/\bar{b}^*$ shows that the U.S. holding of foreign bond increases.

This increase in U.S. relative consumption reflects a seigniorage revenue that the U.S. earns from issuing bonds that carry convenience yields. By issuing expensive bonds in high convenience yield states, the U.S. receives real resources from the rest of the world. If the convenience yield shock is persistent, expected future seigniorage revenues are also expected to rise. Panel g/y plots the impulse response of the U.S. proceeds from net debt issuance g_t scaled by the U.S. output y_t, which indeed increase as the dollar bond earns a higher convenience yield. This increase in the current and expected future seigniorage revenues raises the U.S. households' wealth a_t, which is defined as the present value of their consumption streams: $a_t = \mathbb{E}_t \left[\sum_{s=t}^{\infty} \delta^s (c_s/c_t)^{-\gamma} c_s \right]$.

This wealth effect is the key distinguishing feature of the safe-asset view, as it disentangles the response in the U.S. wealth a_t from the response in the U.S. net foreign assets nfa_t. On the one hand, the U.S. takes a long position on foreign bonds and a short position on dollar bonds. In a flight-to-dollar episode, the dollar appreciates and the U.S. suffers a loss on its external portfolio, leading to a decline in the U.S. net foreign assets as we see in panel nfa/y. On the other hand, the U.S. receives a higher seigniorage revenue from issuing the dollar bonds, which increases the U.S. wealth share despite the loss on its external portfolio.

Moreover, a higher U.S. wealth relative to the foreign wealth leads to a higher U.S. consumption relative to the foreign consumption. Due to the home bias in the U.S. households' consumption demand, the U.S. spends more on the U.S. goods, which appreciates the dollar in real terms. As such, the goods market clearing is also consistent with a stronger dollar. In this way, a decline in the U.S. NFA does not necessarily imply a relative wealth gain for the foreign households and a stronger demand for the foreign goods. The reserve currency paradox is resolved by engineering countercyclical U.S. wealth and consumption shares from the seigniorage revenue.

3.2 Comparison to Segmented-Market Model

The discussion above emphasizes the role of the safe asset demand in driving the exchange rate dynamics. This mechanism is comparable to the segmented-market model of exchange rates (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021), which also relies on a wedge in the international risk-sharing condition (5) to generate exchange rate disconnect, but offers a different interpretation of the wedge.

We can obtain a deeper understanding of our model by comparing it to the segmented-market model. I consider the quantitative model in Itskhoki and Mukhin (2021), which has production and capital investment. I also extend the real side of the safe-asset model to include these features, and present the details in Appendix A.4.

Figure (3) reports the impulse responses to the noise trader shock in the segmented-market model and to the dollar bond demand shock in the safe-asset model. A period represents a quarter, and I plot the responses in the first 25 years. I calibrate the magnitude of the shocks such that they generate the same amount of dollar appreciation in the first period.

The first row of Figure (3) reports the responses in the exchange rate and interest rates. In the segmented-market model, the noise trader shock increases the amount of foreign bond that the financiers have to hold. As the financiers require a higher compensation to hold the foreign currency, the dollar appreciates and the dollar's expected excess return decreases. The U.S. bond also becomes relatively more expensive, which lowers its yield relative to the foreign yield. In the convenience yield model, the dollar bond demand shock from the foreign households also appreciates the dollar and lowers the dollar's expected excess return.

This is good news for the U.S. households. The second row of Figure (3) reports the im-

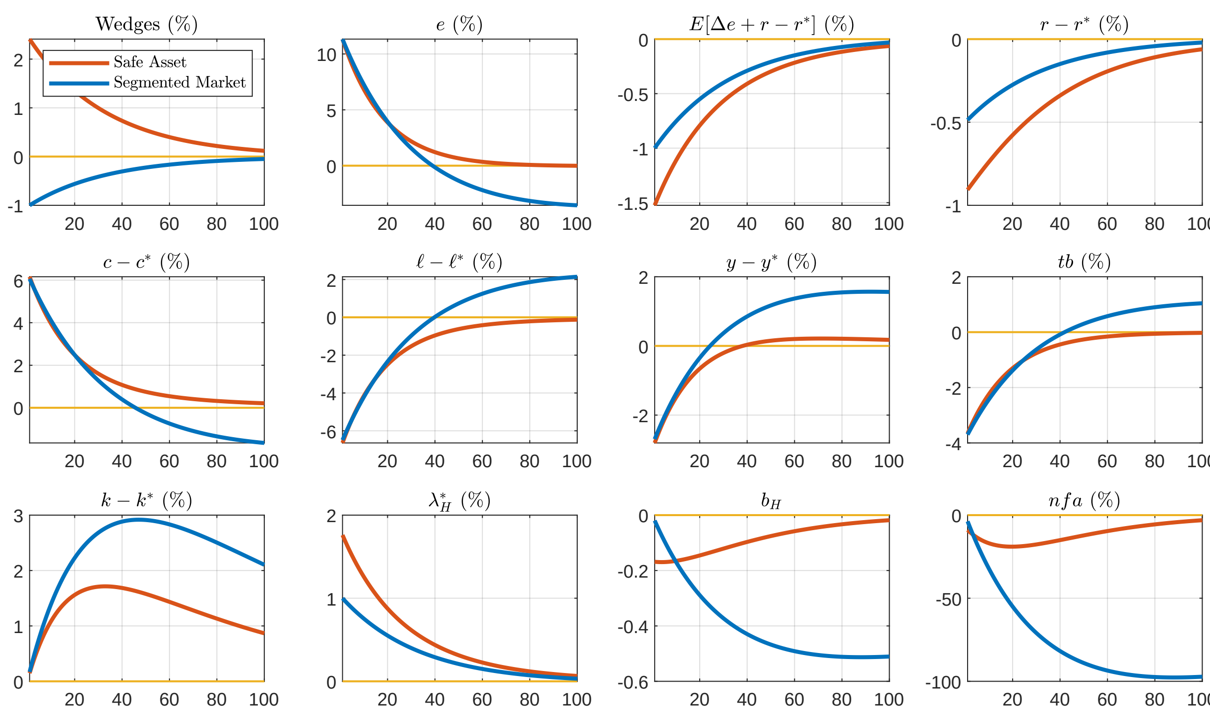


Figure 3: Comparing Segmented-Market and Safe-Asset Models.

Notes: I compare the impulse response to the noise trader shock in the segmented-market model and the impulse response to the dollar bond demand shock in the safe-asset model. The figure reports the responses in the exchange rate, the dollar's expected excess return, the interest rate differential, the consumption differential, the labor differential, the output differential, the U.S. trade balance, the investment differential, the exchange rate wedge, the U.S. bond holdings, and the NFA.

pulse responses in consumption and production. Real dollar appreciation increases the U.S. households' purchasing power, which increases their relative consumption while incentivizing the foreign households to supply more labor and produce more. As a result, the U.S. relative consumption increases, while the U.S. relative labor and production decline. The U.S. trade balance tb also declines as a result.

Both shocks increase the U.S. capital stock relative to the foreign, as shown in the first panel in the third row of Figure (3). These patterns are driven by a discount rate channel: as the U.S. households experience higher consumption upon the shock's arrival, they expect a lower consumption growth rate in future periods, which lowers their discount rate and makes investment more attractive. As a result, investment and consumption move in tandem.

Finally, I can back out the implied convenience yields from the segmented-market model that satisfy the households' Euler equations. Specifically, define $\lambda_{H,t}^{SM,*}$ as the wedge that satisfies the following Euler equation:

$$\exp(-\lambda_{H,t}^{SM,*}) = \mathbb{E}_t\left[\exp(m_{t+1}^* + \Delta e_{t+1} + r_t)\right],$$

which, as panel λ_H^* of Figure (3) shows, increases upon the noise trader shock. This is because the foreign households must act as if they find it highly desirable to hold the U.S. bond in order to justify why the equilibrium excess return on the dollar is so low.

In sum, the segmented-market model and the safe-asset model generate very similar impulse responses in the exchange rate, interest rate, consumption, production, trade balance, and investment. They both offer a wedge-based account of the exchange rate disconnect from consumption dynamics. That said, there are two important differences which distinguish these two models.

The first difference is obvious in the long-run dynamics. While the dollar exchange rate and the U.S.-foreign consumption differential increase immediately upon the shock's arrival in both models, their long-term responses are different. In the segmented-market model, they eventually decline below the steady-state level and have an "overshoot" in the opposite direction; in the safe-asset model, they simply converge to the steady-state level. To understand this difference, let us recall that the net foreign assets (NFA) have the following law of motion:

$$nfa_t - nfa_{t-1} = tb_t + ft_t,$$

where tb denotes the trade balance and ft denotes the financial transfer, which includes dividend payments and capital gains. In both models, the NFA deteriorates upon the shock's arrival, and it needs to revert to the steady-state level in the long run, which requires adjustments in either the trade balances tb or the financial transfers ft in subsequent periods. Formally, let $\overline{nfa} \stackrel{\text{def}}{=} \lim_{k\to\infty} \mathbb{E}_t[nfa_{t+k}]$ denote the steady-state level, we can iterate the NFA dynamics and obtain

$$nfa_t = \overline{nfa} - \sum_{k=1}^{\infty}[tb_{t+k} + ft_{t+k}],$$

which means that if the U.S. runs a negative NFA today, it has to be offset by either positive trade balances or by positive financial gains relative to the foreign country (Gourinchas and Rey, 2007b).

In the segmented-market model, this is achieved by the trade channel alone: the negative U.S. trade balance in the near term is offset by a positive trade balance in the long term.[3] As a result, as the last two panels of Figure (3) show, the U.S. first accumulates a negative NFA by building up a negative position in the home bond b_H, which is repaid by trade surpluses in the long-term future.

In the safe-asset model, the valuation effects are the dominant force: the negative U.S. NFA is repaid by higher financial gains that the U.S. earns from holding the foreign bond relative to what the foreign country earns from holding the U.S. bond, which is precisely the seigniorage revenue characterized in the previous section. In this case, a negative NFA does not require subsequent trade surpluses, because the trade deficits are funded by the seigniorage revenue. As such, the safe-asset model echoes Gourinchas and Rey (2007b) by emphasizing the valuation effects over trade surpluses as the primary driving force of the U.S. NFA dynamics.

[3]More precisely, in Itskhoki and Mukhin (2021), the model is linearized around a steady state with zero bond positions, which means that the valuation effects ft are equal to zero in the first order. In extensions with non-zero NFA or non-zero gross positions in the steady state, the valuation effects can matter in the first order.

The second difference between the two models is in their implications for cross-border capital flows. For example, panel b_H in Figure (3) shows that the U.S. households accumulate a persistently large short position on the home bond in the segmented-market model, which is offset by a persistently large long position by the noise traders. In the safe-asset model, the U.S. households' bond position is quickly reverting to the steady-state level as the bond demand shock dissipates. More broadly speaking, the safe-asset model makes unique predictions about the capital flows, which I study in detail in Section 4.[4]

3.3 Endowment Shocks

Next, let us compare the safe asset demand shock with an endowment shock. I consider an asymmetric shock, which lowers the U.S. endowment by 2.5% and raises the foreign endowment by 2.5%. Figure (4) reports the impulse responses to this shock. Following the shock, the U.S. consumption declines while the foreign consumption rises.

This endowment shock also leads to a dollar appreciation, but the mechanism is different. In this case, the exchange rate is driven predominantly by the marginal utility over consumption, just like the case of complete markets. According to Eq. (6) in Proposition 1, reproduced below,

$$e_t - \bar{e} = -\gamma \left(\log \frac{c_t}{\bar{c}} - \log \frac{c_t^*}{\bar{c}^*} \right) + \sum_{j=0}^{\infty} \mathbb{E}_t[\lambda_{H,t+j}^* - \lambda_{H,t+j}],$$

a reduction in the U.S. consumption relative to the foreign increases the U.S. marginal utility over consumption and appreciates the dollar.

That said, if only the consumption channel were operative, we would have observed an even stronger dollar appreciation, as shown in the red curve in the exchange rate panel e. To understand this effect, note that the persistent decline in the U.S. endowment also lowers the U.S. wealth share and reduces the U.S. households' holdings of the U.S. bond. In the figure, the share of foreign

[4]Different microfoundations of the exchange rate wedge also have different policy implications. In the segmented-market model, governments can stabilize exchange rates by adjusting the financiers' balance sheets or their expectation of currency risk (Itskhoki and Mukhin, 2023). In the safe-asset model, exchange rate intervention can take the form of regulating the supply of safe assets, which can be done by fiscal or monetary policies (Jiang et al., 2020).

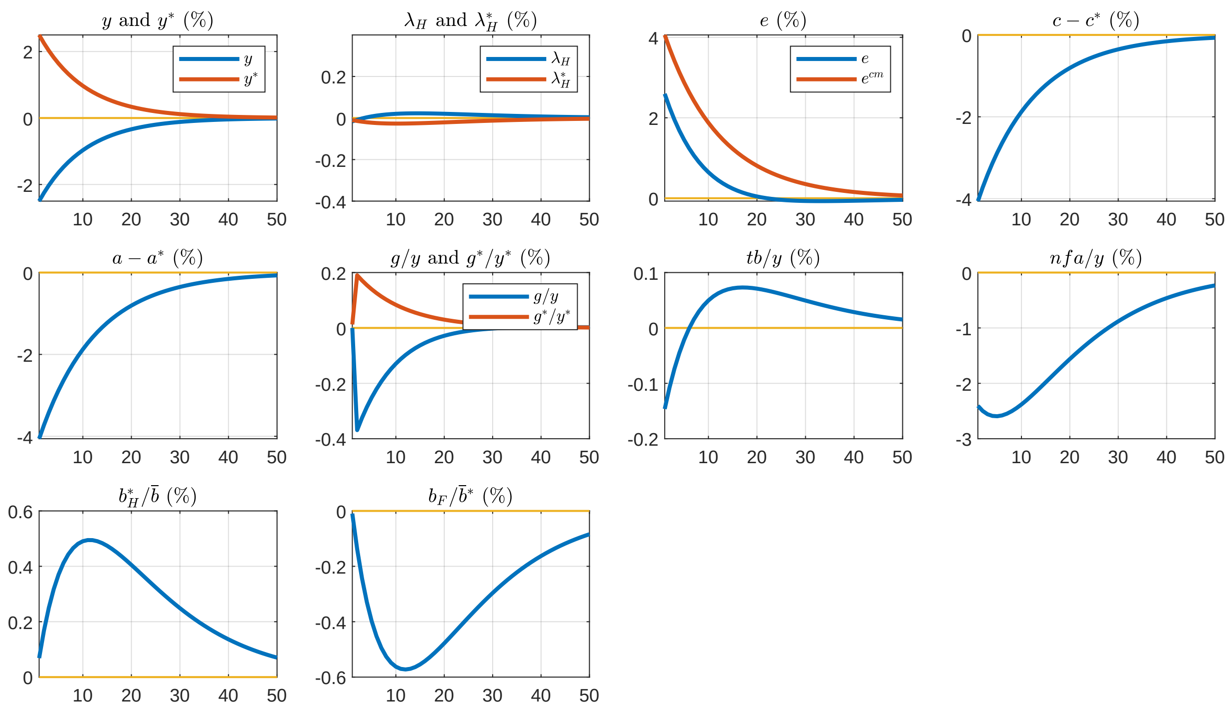


Figure 4: Impulse Responses to Endowment Shock.

Notes: I simulate a shock that raises the foreign endowment and lowers the U.S. endowment. The figure reports the responses in the convenience yields, the dollar's exchange rate level, the consumption differential, the wealth differential, the government transfers, the trade balance/output ratio, the NFA/output ratio, the fraction of dollar bonds held by foreign households, and the fraction of foreign bonds held by U.S. households.

holdings $b_H^*/\bar{b}$ increases. Due to the downward-sloping bond demand curve, the U.S. households derive a higher convenience yield $\lambda_{H,t}$ on the U.S. bond, while the foreign households derive a lower convenience yield $\lambda_{H,t}^*$. This convenience yield adjustment lowers the bond convenience yield term in the dollar's exchange rate formula (6), which partially mitigates the countercyclical exchange rate driven by the consumption channel.

3.4 Wealth Transfer Shocks

Our discussion of the endowment shock shows that shocks affecting the wealth distribution between countries have direct implications for bond demand and hence the exchange rate. The endowment shock simultaneously impacts the supply of consumption goods and the wealth distribution. To isolate the latter effect, I next consider a pure wealth transfer shock that holds the supply of consumption goods fixed. Specifically, in period $t = 1$, τ_t dollars are transferred from the foreign households to the U.S. households. The households are allowed to re-trade, which leads to endogenous consumption and asset holding decisions.

Figure (5) reports the impulse responses to this shock. This one-time wealth transfer persistently increases the U.S. wealth a relative to the foreign wealth a^*, which raises the U.S. consumption share. The wealthier U.S. households also buy more U.S. bond and crowd out the foreign households in this market. In this sense, the wealth transfer shock shifts the residual supply curve of the U.S. bond faced by the foreign households, who have to pay a higher price for a given quantity of the U.S. bond. As a result, the foreign households hold less U.S. bond and impute a higher

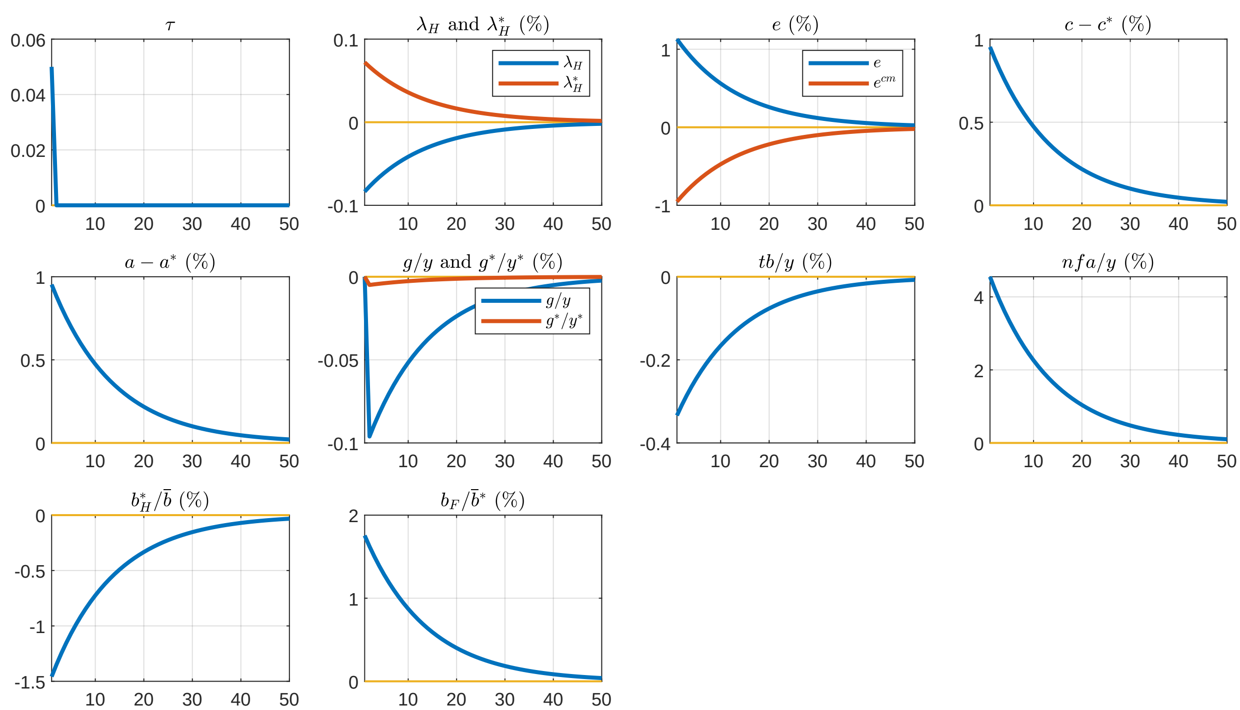


Figure 5: Impulse Responses to Wealth Transfer Shock.

Notes: I simulate a shock that transfers wealth from the foreign households to the U.S. households. The figure reports the responses in the convenience yields, the dollar's exchange rate level, the consumption differential, the wealth differential, the government transfers, the trade balance/output ratio, the NFA/output ratio, the fraction of dollar bonds held by foreign households, and the fraction of foreign bonds held by U.S. households.

convenience yield $\lambda^*_{H,t}$. Through Eq. (6), reproduced below again,

$$e_t - \bar{e} = -\gamma \left(\log \frac{c_t}{\bar{c}} - \log \frac{c^*_t}{\bar{c}^*} \right) + \sum_{j=0}^{\infty} \mathbb{E}_t[\lambda^*_{H,t+j} - \lambda_{H,t+j}],$$

the dollar's exchange rate is determined by the relative magnitude of the convenience yields from the foreign and U.S. perspectives. Since $\lambda_{H,t}$ declines while $\lambda^*_{H,t}$ increases, the dollar appreciates despite the fact that the U.S. consumption rises relative to the foreign consumption and would have led to dollar depreciation if markets were complete.

In this way, the bond demand channel connects the wealth distribution between countries to exchange rate dynamics. When a country experiences a recession, both consumption and wealth decline. The consumption decline raises the local marginal utility over consumption and appreciates the local currency, whereas the wealth decline drives the local households out of the bond market, which raises their marginal utility over bond holdings and depreciates the local currency. If the wealth declines more than consumption, the wealth channel could dominate and provide a novel way for understanding the Backus and Smith (1993) puzzle that currency tends to depreciate when local consumption declines.

It is worth noting that both the bond demand shock $\theta^*_{H,t}$ and the wealth transfer shock τ_t generate a weaker foreign currency, a lower foreign consumption, and a higher U.S. wealth share. However, the mechanisms are different. The bond demand shock shifts the foreign households' demand curve for the U.S. bond, which directly raises the foreign households' convenience yield on the U.S. bond for a given quantity. In comparison, the wealth transfer shock moves the foreign households along their bond demand curve, and settles at a new equilibrium with a lower quantity held and a higher convenience yield imputed. These two mechanisms lead to different implications for capital flows, as we next explore.

In prior works, Corsetti et al. (2008) also note countervailing substitution and wealth effects that terms of trade have on the equilibrium consumption and exchange rate. When the endowment shock is highly persistent, the wealth effect dominates and appreciates the local currency while raising the local consumption. The international transfer shock considered here is another way of generating shifts in the cross-country wealth distribution. The marginal utility over bond holding in our model further magnifies the wealth effect on the exchange rate, which is absent in the analysis of Corsetti et al. (2008).

4 Capital Flows and the Exchange Rate

This model connects exchange rate movements to bond holdings, which allows us to explore the relationship between capital flows and the exchange rate under different shocks. Let np_t denote the U.S. households' net purchases of the foreign bond:

$$np_t \stackrel{\text{def}}{=} \exp(-e_t)(b_{F,t} - b_{F,t-1}\exp(r_t^*)),$$

and let np_t^* denote the foreign households' net purchases of the U.S. bond:

$$np_t^* \stackrel{\text{def}}{=} b_{H,t}^* - b_{H,t-1}^*\exp(r_t).$$

Both flows are in dollar units. A positive np_t^* means that the foreign households purchase more U.S. bond, and a positive np_t means that the U.S. households purchase more foreign bond. I define the net flows from the foreign country to the U.S. as their difference:

$$f_t \stackrel{\text{def}}{=} np_t^* - np_t,$$

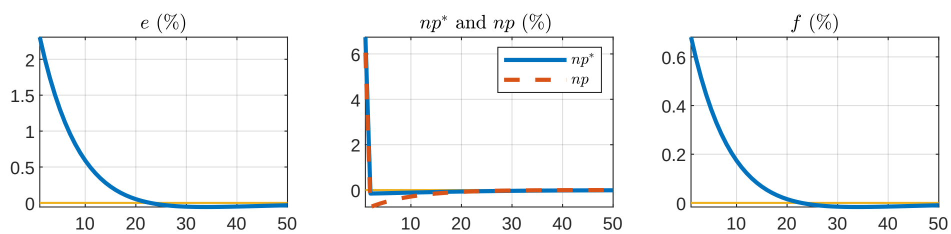
which is positive when the foreign households buy some U.S. bond (i.e., a higher np^*) or the U.S. households sell some foreign bond (i.e., a lower np).

4.1 Demand Shocks: Inflows and Currency Appreciation

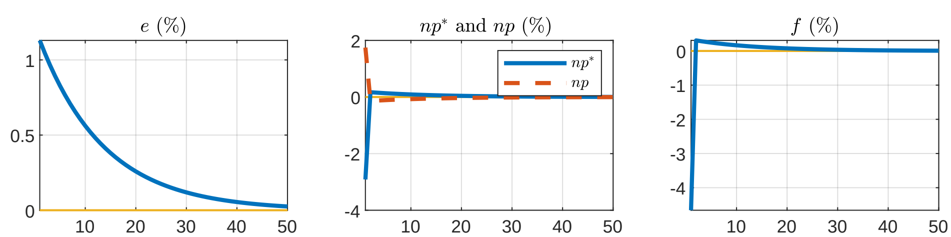
The safe asset demand shock and the wealth transfer shock offer two complementary ways for thinking about the relationship between capital flows and the exchange rate. First, let us revisit the safe asset demand shock in Figure (2). As the foreign households' demand for the U.S. debt increases, they purchase more U.S. bond (i.e., np^* increases), while selling some foreign bond to the U.S. households (i.e., np increases).

Figure 6(a) reports the exchange rate's and capital flows' responses to the demand shock. As more funds flow from the foreign country into the U.S. than the other way around, we obtain a positive net flow f to the U.S. As the dollar appreciates, this demand shock produces a positive correlation between the dollar's exchange rate e and the net inflow f, which is consistent with a large literature that emphasizes the flow-driven mechanism of exchange rate movements.

If we return to the demand-supply diagram Figure (1) in the introduction, it is useful to regard



(a) Flow Responses to Dollar Bond Demand Shock.



(b) Flow Responses to Wealth Transfer Shock.

Figure 6: Flow Responses.

Notes: The figure reports the responses in the dollar's exchange rate level and in capital flows. A positive net flow means an inflow into the U.S.

this shock as a shift in the foreign households' demand curve for the U.S. bond, which increases the foreign households' holding of the U.S. bond while making it more expensive via dollar appreciation.

4.2 Supply Shocks: Outflows and Currency Appreciation

Next, let us revisit the wealth shock in Figure (5). When the U.S. households receive a wealth transfer, they not only consume more, but also hold more U.S. and foreign bonds. As a result, the U.S. households buy more foreign bond (i.e., $np > 0$), while the foreign households sell some of their U.S. bond holdings (i.e., $np^* < 0$). As shown in Figure (6)(b), both of these flows are in the same direction from the U.S. to the foreign country, which leads to a negative f. Since the dollar also appreciates in this case, we obtain a negative correlation between the dollar's exchange rate e and the net inflow f.

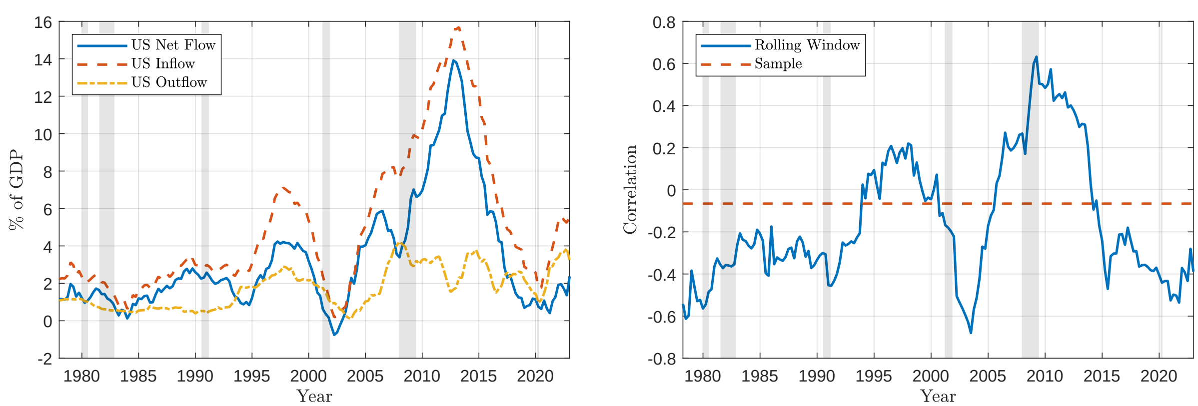
In the demand-supply diagram Figure (1), it is useful to regard this shock as a supply shock in the bond market. As the wealthier U.S. households buy more U.S. bond and reduce the quantity of the U.S. bond available to the foreign households, this shock shifts the residual supply curve faced by the foreign households. As the foreign households move along their demand curve, they hold a smaller amount of the U.S. bond while imputing a higher convenience yield on the U.S. bond. In this case, while the shock also increases the convenience yield on the U.S. bond from the foreign perspective and appreciates the dollar, the accompanying capital flows are in the opposite direction compared to the case of the demand shock.

This result shows that the flow-exchange rate relation can go both ways, depending on which shock dominates. In the case of the safe asset demand shock, the dollar appreciation is accompanied by capital flows from the foreign country to the U.S. In the case of the wealth transfer shock, the dollar appreciation is accompanied by capital flows from the U.S. to the foreign country.

4.3 Empirical Implications

Demand and supply shocks in the safe asset market predict opposite relationships between exchange rate and capital flows. In this subsection, I discuss its empirical implications. I construct the empirical counterpart of the net flows f_t and scale them by the U.S. GDP. The inflows are the foreign net purchases of U.S. Treasurys. The outflows are the U.S. net purchases of foreign bonds. The data are quarterly. Appendix B provides the details.

Figure (7)(a) reports the U.S. inflows, outflows, and net flows from 1973Q1 to 2022Q4. To better see the lower-frequency variations, I average these flows in 5-year rolling windows. Each value in the x axis represents the last date in the 5-year window. This figure shows that the U.S. inflows have greater variations than the U.S. outflows, which leads to a strong comovement between the inflows and the net flows. The 2008 Global Financial Crisis stands out as a period of large inflows and net flows, which is consistent with the model's assumption that the U.S. attracts capital inflows during global stress periods. The inflows remained high until 2013, which is possibly due to the financial turmoil amid the Eurozone sovereign debt crisis.



(a) Flows. (b) Flow-FX Correlation.

Figure 7: Bond Flows and Flow-FX Correlation.

Notes: Panel (a) reports the mean U.S. inflows, outflows and net flows in 5-year rolling windows. Panel (b) reports the sample correlation and the rolling-window correlation between the net flow and the dollar's real appreciation against advanced economies.

Figure (7)(b) reports the correlation between the net flows and the dollar's real appreciation against advanced economies. I first consider the full-sample estimate, which is represented by the dashed red line.

Observation 1. *Unconditionally, the correlation between the dollar appreciation and the net capital flow is close to zero.*

More specifically, the correlation is -0.07 and is statistically insignificant. In the prior literature, this lack of correlation is interpreted as evidence consistent with the broader exchange rate disconnect from economic quantities.

Next, I compute the correlation in 5-year rolling windows, which is represented by the solid blue line in Figure (7)(b).

Observation 2. *There is significant variation in the relationship between the dollar appreciation and the net capital flow across different periods of time.*

Quantitatively, the correlation is as high as 0.6 in 2003–2008, and as low as -0.7 in 1999–2004. This variation in the rolling-window correlation is potentially consistent with the model: if different types of shocks dominate in different periods, then, their implied correlation patterns can vary over time even when the unconditional correlation is close to zero.

Moreover, the two episodes in which the correlation is positive correspond to the time windows ending with 1997–1998 and with 2008–2009, which might not be a coincidence. The Russian and Asian Financial Crises occurred in the first episode, and the Global Financial Crisis occurred in the second episode. Both episodes are characterized by a global flight to safety, which, in the model, appreciates the dollar while driving capital flows into the U.S. This implication is consistent with the positive correlation between the dollar appreciation and the net capital flow in the data.[5]

Conversely, for the periods outside these two global stress periods, the correlation between the exchange rate and capital inflow is mostly negative. In the model, a negative correlation can be

[5]Interestingly, the Covid-19 crisis in 2020 does not stand out in the correlation pattern. Perhaps the disturbance in the financial market was too short-lived to be captured by the quarterly data. Or, the U.S. Treasury did not enjoy as much of a safe-haven status as it did in the prior crises (Haddad et al., 2021; He et al., 2022; Jiang et al., 2023).

driven by the wealth transfer shock: a higher U.S. wealth appreciates the dollar while driving net capital outflows from the U.S. to the foreign country. If this shock dominates, then, we should expect to see a negative flow-exchange rate correlation in the periods outside global crises.

We can formally test the relationship between the flow-exchange rate correlation and variables proxying for the global financial condition. My first proxy is the U.S. net flows, which, as shown in Figure (7), appear to comove with the flow-exchange rate correlation. Intuitively, given the U.S. safe-haven status, we should expect capital inflows into the U.S. during global stress periods as investors seek safety, and capital outflows from the U.S. when investors are willing to take on more risk. My second proxy is the financial crisis indicator from Jordà et al. (2017), averaged across countries weighted by their nominal GDP. My third proxy is the change in the U.S. Treasury's cross-country currency basis (Du et al., 2018; Jiang et al., 2021a), which captures the global demand for U.S. Treasurys. For each variable, I take the average in each 5-year rolling window, and regress the flow-exchange rate correlation in the same window on it.

Table (2) reports the regression results: a positive flow-exchange rate correlation tends to coincide with positive net bond flows into the U.S., financial crises, and more negative Treasury

Table 2: Flow-FX Correlation and Global Financial Condition.

	Dependent variable: Flow-FX Correlation		
	(1)	(2)	(3)
Mean Net Flow	6.68^{***}		
	(0.70)		
Mean Crisis		3.78^{***}	
		(1.23)	
Change in Treasury Basis			-5.53^{*}
			(3.18)
Observations	180	172	98
R^2	0.47	0.35	0.10
Adjusted R^2	0.47	0.34	0.09

Notes: I regress the rolling-window correlation between the net flow and the dollar appreciation on the variables proxying for the global financial condition. The Newey-West standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

basis, all of which are consistent with the following characterization.

Observation 3. *The correlation between dollar appreciation and the net capital flow tends to be positive during global stress periods, and negative during global expansion periods.*

If the bond demand shock dominates in global stress periods, and the wealth shock dominates in global expansion periods, then, this observation is consistent with the model's prediction that the bond demand shock generates a positive flow-exchange rate correlation, while the wealth shock generates a negative flow-exchange rate correlation. This result reconciles the prior literature that emphasizes the demand-driven channel with the close-to-zero unconditional correlation observed in the data. This result also broadens the "exchange rate reconnect" observation that the flow-exchange rate correlation strengthens after the Global Financial Crisis (Lilley et al., 2022). The model implies that the correlation is time-varying and is driven by the relative importance of different types of shocks in different periods.

5 Simulation Analysis

In this section, I combine the shocks we studied in previous sections and simulate the model to study its quantitative properties. The goal is two-fold: to ensure that the combination of multiple shocks generates a reasonable fit to the exchange rate, consumption, and capital flow moments in the data, and to understand the roles played by different shocks in driving these moments. To tease out the effects of different shocks, I consider three model specifications.

5.1 Model Specification

In Model 1, I only turn on the endowment shocks, which are positively correlated between the U.S. and the foreign country. Specifically, I assume that the U.S. and foreign endowment shocks have a global component $u_{G,t}$ and a country-specific component $u_{H,t}$ or $u_{F,t}$:

$$\log y_t = (1-\rho)\bar{y} + \rho \log y_{t-1} + \sigma_G u_{G,t} + \sigma_I u_{H,t},$$

$$\log y_t^* = (1-\rho)\bar{y}^* + \rho \log y_{t-1}^* + \sigma_G u_{G,t} + \sigma_I u_{F,t},$$

where $u_{G,t}$, $u_{H,t}$, and $u_{F,t}$ are independent and standard normal variables.

In Model 2, I additionally turn on the foreign households' bond demand shock:

$$\theta_{H,t}^* = (1-\rho)\bar{\theta}_H^* + \rho \theta_{H,t-1}^* - \nu_G u_{G,t} + \nu_\theta u_{\theta,t};$$

to capture the countercyclicality in dollar bond demand, I assume that the innovation to the bond demand loads on the global endowment shock $u_{G,t}$. In addition, it also loads on an independent and standard normal demand shock $u_{\theta,t}$.

In Model 3, I additionally turn on the wealth transfer shock:

$$\tau_t = \psi_\tau u_{\tau,t},$$

where $u_{\tau,t}$ is an independent and standard normal variable. As discussed earlier, this shock captures zero-sum wealth gains and losses between the two countries in a reduced-form way. It is not correlated with the global endowment shock or the bond demand shock.

5.2 Moments

Before I report the simulation results, I first discuss the moments considered in this exercise. The first column of Table (3) lists these moments, which cover the exchange rate, interest rates, as well as consumption quantities and portfolio flows. The second column reports their values in the data, based on the time series of the U.S. against the equal-weighted average of 10 developed countries from 1985Q1 to 2022Q4. Appendix B provides the details.

The Exchange Rate panel reports the dollar exchange rate movement's autocorrelation and volatility. To measure the dollar's cyclicality, the panel also reports the correlation between the exchange rate movement and the global consumption growth, and the correlation between the exchange rate movement and the change in the convenience yield differential as proxied by the Treasury basis. In the data, the dollar's exchange rate is close to a random walk, has a volatility of 4% per quarter, and tends to appreciate when global consumption declines or the bond convenience yield differential widens.

The correlation between the dollar exchange rate movement and the global consumption growth is only -0.09 in the full sample. This correlation is -0.25 in the pre-Covid sample before 2020Q1,

Table 3: Simulation Results

Shocks	Data	Model 1 (y, y^*)	Model 2 (y, y^*, θ_H^*)	Model 3 $(y, y^*, \theta_H^*, \tau)$
	data	Model 1	Model 2	Model 3
Exchange Rate				
$autocorr(\Delta e)$	0.09	-0.05	-0.06	-0.06
$\sigma(\Delta e)(\%)$	3.79	1.84	3.75	3.79
$corr(\Delta e, \Delta \bar{c})$	-0.25	0.29	-0.25	-0.25
$corr(\Delta e, \Delta(\lambda_h^* - \lambda_h))$	0.22	-0.19	0.87	0.87
Interest Rate				
$autocorr(r - r^*)$	0.94	0.89	0.91	0.91
$\sigma(r - r^*)/\sigma(\Delta e)$	0.11	0.28	0.36	0.35
$Fama\ \beta$	1.73	-0.47	0.42	0.42
Consumption				
$corr(\Delta c, \Delta c^*)$	0.78	0.86	0.75	0.74
$corr(\Delta c - \Delta c^*, \Delta \bar{c})$	-0.19	0.17	-0.20	-0.20
$corr(\Delta c - \Delta c^*, \Delta e)$	0.16	-0.89	0.31	0.32
Net Foreign Assets and Capital Flows				
$corr(\Delta nfa, \Delta \bar{c})$	0.46	0.91	0.89	0.79
$corr(\Delta nfa, \Delta e)$	-0.32	-0.09	-0.56	-0.42
$corr(f, \Delta e)$	-0.03	0.15	0.25	0.02

Notes: This table reports the exchange rate, interest rate, consumption, NFA, and capital flow moments in the data and in different model specifications. Model 1 has the endowment shocks only. Model 2 has both the endowment shocks and the bond demand shock. Model 3 has endowment, bond demand, and wealth transfer shocks. The model is at quarterly frequency.

which means that the dollar has been more countercyclical until recently. In the post-Covid sample, the dollar strengthened to a record high as the global economy recovered from the pandemic, which was possibly attributable to rising U.S. rates and an increase in foreign demand for U.S. risky assets (Jiang et al., 2022; Atkeson et al., 2022). In this exercise, I focus on the pre-Covid sample correlation which captures the dollar's countercyclical behavior as emphasized by the prior literature.

The Interest Rate panel reports the autocorrelation of the interest rate differential, the volatility of the interest rate differential scaled by the volatility of the exchange rate movement, and the Fama beta, defined as the slope coefficient in the regression of the exchange rate movement on the interest rate differential:

$$\Delta e_{t+1} = \alpha + \beta(r_t - r_t^*) + \varepsilon_t.$$

In the data, the U.S.-foreign interest rate differential is very persistent, less volatile than the exchange rate movement, and is positively associated with the dollar's expected appreciation in the next period.

The Consumption panel reports the correlation between the U.S. and foreign consumption growth, and the correlation between the U.S.-foreign log consumption growth differential $\Delta c - \Delta c^*$ and the average consumption growth $\Delta \bar{c}$. The panel also reports the correlation between the U.S.-foreign log consumption growth differential and the dollar exchange rate movement. In the data, the U.S. and foreign consumption growth rates are positively correlated. The U.S. consumption share tends to increase when the global consumption growth is low. Moreover, consistent with Backus and Smith (1993), the consumption growth differential is weakly correlated with the exchange rate movement.

Finally, the Net Foreign Assets and Capital Flows panel reports the U.S. NFA's correlations with the global consumption growth and with the dollar exchange rate movement. In the data, the U.S. NFA tends to decline when global consumption drops and when the dollar appreciates, which is consistent with the fact that the U.S. takes a large position on foreign currency-denominated risky assets and suffers portfolio losses when the dollar appreciates. This panel also reports the correlation between the net capital flow f and the exchange rate movement, which, as we discussed in the previous section, is close to zero.

I rely on some of these moments to calibrate the shock processes. I pick the volatilities σ_G and σ_I of the endowment shocks to match the exchange rate volatility and the U.S.-foreign consumption growth correlation in the full model. I pick the volatilities ν_G and ν_θ of the bond demand shock to match the U.S. consumption share's cyclicality and the dollar's cyclicality with respect to the global consumption growth. I pick the volatility ψ_τ of the wealth transfer shock to match the correlation between net capital flows and the exchange rate. Based on these targets, I set $\sigma_G = 0.046$, $\sigma_I = 0.023$, $\nu_G = -0.0065$, $\nu_\theta = 0.013$, and $\psi_\tau = 0.026$.

5.3 Endowment Shocks Only

Let us begin with Model 1 which only has endowment shocks. With persistent endowment shocks, the exchange rate movement is close to a random walk, and its volatility is in the same order of magnitude as in the data. In terms of exchange rate cyclicality, the dollar is stronger when the global consumption is high, which is counterfactual.[6] Moreover, the bond demand does not play a major role in the exchange rate dynamics, and the bond convenience yield is not strongly correlated with the exchange rate movement.

The interest rate differential is highly persistent, and its volatility is lower than the exchange rate volatility. The endowment shocks alone generate a negative Fama beta, which is inconsistent with the data but close to the Uncovered Interest Rate Parity (UIP) benchmark, which predicts a coefficient of -1.

The correlated endowment shocks generate a positive correlation between the U.S. and foreign

[6]This is a result of the calibration choice. High endowment implies lower expected growth and lower discount rates. Since the U.S. borrows more debt under my calibration, the lower rates reduce the financing cost and increase consumption more in the U.S., which leads to a stronger demand for the U.S. goods. This mechanism is unrelated to changes in the convenience yields. Under a different specification in which the U.S. and foreign debt issuances are symmetric, the global endowment shock has no effect on the dollar.

consumption. With endowment shocks alone, the U.S. consumption share is positively correlated with the average consumption growth, and negatively correlated with the dollar exchange rate. Both features are inconsistent with the data, and the latter is a manifestation of the Backus and Smith (1993) puzzle.

Finally, because the U.S. external portfolio consists of a long position on the foreign bond and a short position on the dollar bond, and rising dollar depreciates the value of the foreign bond, the U.S. NFA is decreasing in the dollar's strength. The net capital flow is positively correlated with the currency strength in the country to which the flow is going.

In summary, this model with only endowment shocks is similar to a standard international real business cycle model, which fails to generate key features of the international monetary system and exchange rate data.

5.4 Introducing the Bond Demand Shock

Introducing the bond demand shock makes the exchange rate more volatile. It also overturns the cyclicality of the dollar: as the demand for U.S. safe assets increases in low endowment states, the dollar is stronger when the global consumption is low, which is consistent with its countercyclical behavior in the data. Moreover, the bond demand shock generates large variations in the bond convenience yield, which becomes a significant driver of the exchange rate movement. Consistent with Proposition 1, a higher convenience yield differential is associated with a stronger dollar.

Notably, the correlation between the exchange rate movement and the bond convenience yield differential is 0.87, which is much higher than the empirical moment. This is because our model is set up to focus on the convenience yield channel in exchange rate determination. If we additionally introduce monetary shocks that affect the interest rate differential, or richer preferences that give rise to variations in currency risk premia, then, the exchange rate vary through other channels as well.

The bond demand shock also overturns the sign of the Fama regression coefficient. In particular, a higher convenience yield on the U.S. bond simultaneously lowers the U.S. bond yield and appreciates the dollar, which also creates an expected dollar depreciation. In this way, the bond convenience yield generates a positive Fama coefficient in a way similar to currency risk premium, which is absent in this model. If we further introduce time-varying currency risk premia, we can generate a quantitatively greater Fama beta.

Moreover, the bond demand shock also alters consumption dynamics. While the U.S. and foreign consumption growth rates are still positively correlated, the U.S. seigniorage revenue increases in global recessions when the demand for the dollar safe bond is high, which generates a countercyclical U.S. consumption share with respect to the global consumption growth. The safe asset demand shock also appreciates the dollar while increasing the U.S. consumption, leading to a positive correlation between consumption and exchange rate which resolves the Backus and Smith (1993) puzzle. In this way, the seigniorage revenue generated by safe-asset demand plays a central role in the model's ability to match the two key consumption moments $corr(\Delta c - \Delta c^{*}, \Delta\bar{c})$ and $corr(\Delta c - \Delta c^{*}, \Delta\bar{e})$.

Finally, the bond demand shock creates an inflow into the U.S. which further lowers the U.S. NFA. As this shock strengthens the dollar, it makes the correlation between the U.S. NFA and the dollar exchange rate more negative. Because the bond demand shock is also negatively correlated with the global consumption growth, the U.S. NFA remains positively correlated with the global consumption growth. As we discussed in Section 4, the bond demand shock also generates a positive correlation between capital inflows into the U.S. and dollar appreciation, which increases $corr(f, e)$.

In summary, the bond demand shock delivers a significant improvement in the model's ability to match the dollar exchange rate's cyclicality, the Fama regression beta, the U.S. consumption share's cyclicality, and the Backus and Smith (1993) puzzle. It still generates a strong correlation between net capital flows and the exchange rate, which, as we will see next, can be reversed by the wealth transfer shock.

5.5 Introducing the Wealth Transfer Shock

In the last model specification, I introduce the wealth transfer shock. The exchange rate movement remains close to a random walk, as the wealth transfer shock creates a persistent shift in the wealth distribution between countries.

While it seems that introducing the wealth transfer shock does not alter the exchange rate, interest rate, and consumption moments, it does give rise to a separate mechanism to reverse the Backus and Smith (1993) correlation. As we discussed in Section 3.4, the wealth transfer shock moves the U.S. consumption and the dollar's currency value in the same direction, even in the absence of the countercyclical demand shock in the safe asset market.

Moreover, the NFA has different properties in the presence of the wealth transfer shock. Different from the bond demand shock, the wealth transfer shock generates a positive correlation between the U.S. NFA and the dollar exchange rate. This is because, while the U.S. still suffers losses on external portfolios when the dollar appreciates, the wealth transfer replenishes the U.S. wealth and NFA. Similarly, the wealth transfer shock also reduces the correlation between the U.S. NFA and the global consumption growth, as it only shifts the relative consumption and the NFA position without affecting the global endowment level.

Finally, following our discussion in Section 4, while the safe asset demand shock appreciates the dollar as the U.S. experiences net inflows, the wealth transfer shock appreciates the dollar as the U.S. experiences net outflows. These countervailing forces brought by the demand and supply shocks in the safe asset market generate the close-to-zero unconditional correlation between the net capital flow and the exchange rate observed in the data.

6 Conclusion

In this paper, I develop a general equilibrium model of the international monetary system with one key ingredient: the liquidity demand for U.S. safe assets. Compared to the standard view of the U.S. exorbitant privilege, which emphasizes the U.S.' role as the global insurer who has to bear an exorbitant duty in global downturns, my model emphasizes the seigniorage revenue that the U.S. earns as the global safe asset issuer, which allows it to have a stronger currency and higher consumption and wealth shares in global downturns despite the losses on its external portfolio. In reality, it is plausible that the U.S. play both roles, just like banks which simultaneously engage in risk and liquidity transformations. These results shed new light on the nature of the U.S. exorbitant privilege, exchange rate disconnect, and the relationship between exchange rate movements and cross-border capital flows.

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A Model Appendix

A.1 Macro Synthesis

There are 15 endogenous variables in each period t:

$$(c_t, c_{H,t}, c_{F,t}, b_{H,t}, b_{F,t}, p_t, c_t^*, c_{H,t}^*, c_{F,t}^*, b_{H,t}^*, b_{F,t}^*, p_t^*, r_t, r_t^*, e_t)_{t=0}^{\infty}.$$

The model implies the following 16 equations in each period, one of which is redundant. These 16 equations include 2 consumption aggregation equations,

$$c_t = \left[\alpha^{1-\eta} c_{H,t}^{\eta} + (1-\alpha)^{1-\eta} c_{F,t}^{\eta}\right]^{1/\eta},$$

$$c_t^* = \left[\alpha^{1-\eta} (c_{F,t}^*)^{\eta} + (1-\alpha)^{1-\eta} (c_{H,t}^*)^{\eta}\right]^{1/\eta},$$

2 household budget conditions are

$$p_t y_t + \exp(r_{t-1}) b_{H,t-1} + \exp(r_{t-1}^* - e_t) b_{F,t-1} + g_t + \tau_t = c_t + b_{H,t} + \exp(-e_t) b_{F,t},$$

$$p_t^* y_t^* + \exp(r_{t-1}^*) b_{F,t-1}^* + \exp(r_{t-1} + e_t) b_{H,t-1}^* + g_t^* - \exp(e_t)\tau_t = c_t^* + b_{F,t}^* + \exp(e_t) b_{H,t}^*,$$

2 goods market clearing conditions

$$c_{H,t} + c_{H,t}^* = y_t,$$

$$c_{F,t} + c_{F,t}^* = y_t^*,$$

2 bond market clearing conditions

$$\bar{b}_t = b_{H,t} + b_{H,t}^*,$$

$$\bar{b}_t^* = b_{F,t} + b_{F,t}^*,$$

4 within-period consumption choices

$$\left[\alpha^{1-\eta}c_{H,t}^{\eta}+(1-\alpha)^{1-\eta}c_{F,t}^{\eta}\right]^{1/\eta-1}\alpha^{1-\eta}c_{H,t}^{\eta-1}=p_t,$$
$$\left[\alpha^{1-\eta}c_{H,t}^{\eta}+(1-\alpha)^{1-\eta}c_{F,t}^{\eta}\right]^{1/\eta-1}(1-\alpha)^{1-\eta}c_{F,t}^{\eta-1}=p_t^*\exp(-e_t),$$
$$\left[\alpha^{1-\eta}(c_{F,t}^*)^{\eta}+(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta}\right]^{1/\eta-1}\alpha^{1-\eta}(c_{F,t}^*)^{\eta-1}=p_t^*,$$
$$\left[\alpha^{1-\eta}(c_{F,t}^*)^{\eta}+(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta}\right]^{1/\eta-1}(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta-1}=p_t\exp(e_t),$$

and 4 Euler equations

$$1-\frac{\omega_H b_{H,t}^{-\sigma}}{c_t^{-\gamma}}=\mathbb{E}_t\left[\delta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\exp(r_t)\right],$$
$$1-\frac{\omega_F b_{F,t}^{-\sigma}}{c_t^{-\gamma}}\exp(e_t)=\mathbb{E}_t\left[\delta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\exp(-\Delta e_{t+1}+r_t^*)\right],$$
$$1-\frac{\omega_F^*(b_{F,t}^*)^{-\sigma}}{(c_t^*)^{-\gamma}}=\mathbb{E}_t\left[\delta\left(\frac{c_{t+1}^*}{c_t^*}\right)^{-\gamma}\exp(r_t^*)\right],$$
$$1-\frac{\omega_H^*(b_{H,t}^*)^{-\sigma}-(\bar{c}^*)^{-\gamma}\theta_{H,t}^*}{(c_t^*)^{-\gamma}}\exp(-e_t)=\mathbb{E}_t\left[\delta\left(\frac{c_{t+1}^*}{c_t^*}\right)^{-\gamma}\exp(\Delta e_{t+1}+r_t)\right].$$

A.2 Proof of Proposition 1

Proof. Linearize the Euler equation to get

$$\exp(-\bar{\lambda}_{H,t})(-\lambda_{H,t}+\bar{\lambda}_H+1)=\mathbb{E}_t\left[\delta\left(\frac{\bar{c}}{\bar{c}}\right)^{-\gamma}\exp(\bar{r})(1-\gamma\Delta\log c_{t+1}+r_t-\bar{r})\right]$$
$$\Rightarrow -\lambda_{H,t}+\bar{\lambda}_H=\mathbb{E}_t[-\gamma\Delta\log c_{t+1}+r_t-\bar{r}],$$

where $-\bar{\lambda}_H=\log\delta+\bar{r}$, which implies

$$-\lambda_{H,t}=\mathbb{E}_t[-\gamma\Delta\log c_{t+1}+r_t+\log\delta].$$

Similarly,

$$-\lambda^*_{H,t} = \mathbb{E}_t[-\gamma \Delta \log c^*_{t+1} + \Delta e_{t+1} + r_t + \log \delta],$$

which implies

$$\begin{aligned}
-(\lambda^*_{H,t} - \lambda_{H,t}) &= \mathbb{E}_t[m^*_{t+1} - m_{t+1}] + \mathbb{E}_t[\Delta e_{t+1}] = \mathbb{E}_t[\gamma(\Delta \log c_{t+1} - \Delta \log c^*_{t+1})] + \mathbb{E}_t[\Delta e_{t+1}] \\
\Rightarrow e_t &= (\lambda^*_{H,t} - \lambda_{H,t}) + \mathbb{E}_t[\gamma(\Delta \log c_{t+1} - \Delta \log c^*_{t+1})] + e_{t+1}.
\end{aligned}$$

Iterate forward to get

$$e_t = \sum_{j=0}^{\infty} (\lambda^*_{H,t+j} - \lambda_{H,t+j}) + \sum_{j=0}^{\infty} \mathbb{E}_t[\gamma(\Delta \log c_{t+j+1} - \Delta \log c^*_{t+j+1})] + \lim_{j \to \infty} e_{t+j+1}.$$

Let $\lim_{j \to \infty} e_{t+j+1} = \bar{e}$. Plugging $\Delta c_{t+1} = \log c_{t+1} - \log c_t$ yields

$$\begin{aligned}
e_t - \bar{e} &= \sum_{j=0}^{\infty} (\lambda^*_{H,t+j} - \lambda_{H,t+j}) + \sum_{j=0}^{\infty} \mathbb{E}_t[\gamma(\log c_{t+j+1} - \log c_{t+j} - \log c^*_{t+j+1} + \log c^*_{t+j})] \\
&= \sum_{j=0}^{\infty} (\lambda^*_{H,t+j} - \lambda_{H,t+j}) - \gamma(\log c_t - \log c^*_t) + \gamma(\log \bar{c} - \log \bar{c}^*)
\end{aligned}$$

where we let $\bar{c} = \lim_{j \to \infty} c_{t+j+1}$, $\bar{c}^* = \lim_{j \to \infty} c^*_{t+j+1}$. This yields Eq. (6). Finally, recall that

$$\begin{aligned}
\exp(-\lambda^*_{H,t}) &= 1 - \frac{\omega^*_H (b^*_{H,t})^{-\sigma} - (\bar{c}^*)^{-\gamma} \theta^*_{H,t}}{(c^*_t)^{-\gamma}} \exp(-e_t) \\
\exp(-\lambda_{H,t}) &= 1 - \frac{\omega_H (b_{H,t})^{-\sigma}}{c_t^{-\gamma}}
\end{aligned}$$

Plug in $\exp(-\lambda_{H,t}) \approx 1 - \lambda_{H,t}$ and $\exp(-\lambda^*_{H,t}) \approx 1 - \lambda^*_{H,t}$ yields Eq. (7). □

A.3 Proof of Proposition 2

Proof. The within-period solutions are given by

$$
\begin{aligned}
\left[\alpha^{1-\eta} c_{H,t}^{\eta} + (1-\alpha)^{1-\eta} c_{F,t}^{\eta}\right]^{1/\eta - 1} \alpha^{1-\eta} c_{H,t}^{\eta-1} &= p_t, \\
\left[\alpha^{1-\eta} c_{H,t}^{\eta} + (1-\alpha)^{1-\eta} c_{F,t}^{\eta}\right]^{1/\eta - 1} (1-\alpha)^{1-\eta} c_{F,t}^{\eta-1} &= p_t^* \exp(-e_t), \\
\left[\alpha^{1-\eta} (c_{F,t}^*)^{\eta} + (1-\alpha)^{1-\eta} (c_{H,t}^*)^{\eta}\right]^{1/\eta - 1} \alpha^{1-\eta} (c_{F,t}^*)^{\eta-1} &= p_t^*, \\
\left[\alpha^{1-\eta} (c_{F,t}^*)^{\eta} + (1-\alpha)^{1-\eta} (c_{H,t}^*)^{\eta}\right]^{1/\eta - 1} (1-\alpha)^{1-\eta} (c_{H,t}^*)^{\eta-1} &= p_t \exp(e_t),
\end{aligned}
$$

which combined characterize the exchange rate as

$$
\exp(e_t) = \left(\frac{(1-\alpha) c_t^* / c_{H,t}^*}{\alpha c_t / c_{H,t}}\right)^{1-\eta} = \left(\frac{\alpha c_t^* / c_{F,t}}{(1-\alpha) c_t / c_{F,t}^*}\right)^{1-\eta}.
$$

Write the Lagrangian of social planner's problem as follows

$$
\begin{aligned}
\mathcal{L} = {} & \pi \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \delta^t \left(\frac{1}{1-\gamma} c_t^{1-\gamma} + \frac{1}{1-\sigma} \omega_H b_{H,t}^{1-\sigma} + \frac{1}{1-\sigma} \omega_F b_{F,t}^{1-\sigma}\right)\right] \\
& + (1-\pi) \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \delta^t \left(\frac{1}{1-\gamma} (c_t^*)^{1-\gamma} + \frac{1}{1-\sigma} \omega_H^* (b_{H,t}^*)^{1-\sigma} + (\bar{c}^*)^{-\gamma} \theta_{H,t}^* b_{H,t}^* + \frac{1}{1-\sigma} \omega_F^* (b_{F,t}^*)^{1-\sigma}\right)\right] \\
& + \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \zeta_{H,t} \left(y_t - c_{H,t} - c_{H,t}^*\right) + \zeta_{F,t} \left(y_t^* - c_{F,t} - c_{F,t}^*\right)\right] \\
& + \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \xi_{H,t} \left(\bar{b}_t - b_{H,t} - b_{H,t}^*\right) + \xi_{F,t} \left(\bar{b}_t^* - b_{F,t} - b_{F,t}^*\right)\right].
\end{aligned}
$$

The first order conditions w.r.t. 8 endogenous variables are

$$\text{w.r.t. } c_{H,t}: \quad \pi\delta^t c_t^{-\gamma}\left[\alpha^{1-\eta}c_{H,t}^{\eta}+(1-\alpha)^{1-\eta}c_{F,t}^{\eta}\right]^{1/\eta-1}\alpha^{1-\eta}c_{H,t}^{\eta-1}=\zeta_{H,t}$$
$$\text{w.r.t. } c_{H,t}^*: \quad (1-\pi)\delta^t(c_t^*)^{-\gamma}\left[\alpha^{1-\eta}(c_{F,t}^*)^{\eta}+(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta}\right]^{1/\eta-1}(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta-1}=\zeta_{H,t}$$
$$\text{w.r.t. } c_{F,t}: \quad \pi\delta^t(c_t^*)^{-\gamma}\left[\alpha^{1-\eta}(c_{F,t}^*)^{\eta}+(1-\alpha)^{1-\eta}(c_{H,t}^*)^{\eta}\right]^{1/\eta-1}\alpha^{1-\eta}(c_{F,t}^*)^{\eta-1}=\zeta_{F,t}$$
$$\text{w.r.t. } c_{F,t}^*: \quad (1-\pi)\delta^t(c_t^*)^{-\gamma}\left[\alpha^{1-\eta}c_{H,t}^{\eta}+(1-\alpha)^{1-\eta}c_{F,t}^{\eta}\right]^{1/\eta-1}(1-\alpha)^{1-\eta}c_{F,t}^{\eta-1}=\zeta_{F,t}$$
$$\text{w.r.t. } b_{H,t}: \quad \pi\delta^t\omega_H b_{H,t}^{-\sigma}=\xi_{H,t}$$
$$\text{w.r.t. } b_{H,t}^*: \quad (1-\pi)\delta^t\left(\omega_H^*(b_{H,t}^*)^{-\sigma}+(\bar{c}^*)^{-\gamma}\theta_{H,t}^*\right)=\xi_{H,t}$$
$$\text{w.r.t. } b_{F,t}: \quad \pi\delta^t\omega_F b_{F,t}^{-\sigma}=\xi_{F,t}$$
$$\text{w.r.t. } b_{F,t}^*: \quad (1-\pi)\delta^t\omega_F^*(b_{F,t}^*)^{-\sigma}=\xi_{F,t}$$

with 4 budget constraint conditions, we can solve the 8 endogenous variables and the 4 lagrangian multiplers. Divide the first foc condition by the second one and plug in the within-period solution to obtain the exchange rate as follows

$$\exp(e_t)=\frac{\pi c_t^{-\gamma}}{(1-\pi)(c_t^*)^{-\gamma}}.$$

Besides, we are typically interested in the convenience yields, which are given by

$$\begin{aligned}\exp(-\lambda_{H,t})&=1-\frac{\omega_H b_{H,t}^{-\sigma}}{c_t^{-\gamma}}=1-\frac{\xi_{H,t}}{\pi\delta^t c_t^{-\gamma}}\\ \exp(-\lambda_{H,t}^*)&=1-\frac{\omega_H^*(b_{H,t}^*)^{-\sigma}+(\bar{c}^*)^{-\gamma}\theta_{H,t}^*}{(c_t^*)^{-\gamma}}\exp(-e_t)\\ &=1-\frac{\xi_{H,t}}{(1-\pi)\delta^t(c_t^*)^{-\gamma}}\exp(-e_t)\\ &=1-\frac{\xi_{H,t}}{(1-\pi)\delta^t(c_t^*)^{-\gamma}}\frac{(1-\pi)(c_t^*)^{-\gamma}}{\pi c_t^{-\gamma}}\\ &=1-\frac{\xi_{H,t}}{\pi\delta^t c_t^{-\gamma}}\end{aligned}$$

Hence, $\lambda_{H,t}=\lambda_{H,t}^*$, and similarly $\lambda_{F,t}=\lambda_{F,t}^*$. □

A.4 Specification of the Segmented-Market Model

We abstract from price stickiness in this model as it is not central to the exchange rate disconnect mechanism in either this model or the safe-asset model.

We follow the specification in Itskhoki and Mukhin (2021). The exogenous variables are the productivity shocks and the noise traders' demand shocks:

$$(a_t, a_t^*, \psi_t)_{t=0}^{\infty}.$$

The model contains 27 endogenous variables in each period t:

$$(y_t, y_{H,t}, y_{F,t}, c_t, k_t, z_t, x_t, \ell_t, b_{H,t}, q_t, w_t, r_t, p_t, y_t^*, y_{H,t}^*, y_{F,t}^*, c_t^*, k_t^*, z_t^*, x_t^*, \ell_t^*, b_{F,t}^*, q_t^*, w_t^*, r_t^*, p_t^*, e_t)_{t=0}^{\infty},$$

plus two auxiliary variables $\exp(m_{t+1})$ and $\exp(m_{t+1}^*)$ that denote the home and foreign SDFs/marginal utility growth:

$$\exp(m_{t+1}) = \delta \frac{u'(c_{t+1})}{u'(c_t)},$$
$$\exp(m_{t+1}^*) = \delta \frac{u'(c_{t+1}^*)}{u'(c_t^*)}.$$

The model implies the following equations in each period, one of which is redundant because the market clearing adds up to the sum of households' budget constraints. These 28 equations include 2 consumption aggregation equations,

$$c_t + z_t + x_t = \left[\alpha^{1-\eta} y_{H,t}^{\eta} + (1-\alpha)^{1-\eta} y_{F,t}^{\eta}\right]^{1/\eta},$$
$$c_t^* + z_t^* + x_t^* = \left[\alpha^{1-\eta} (y_{F,t}^*)^{\eta} + (1-\alpha)^{1-\eta} (y_{H,t}^*)^{\eta}\right]^{1/\eta},$$

2 goods market clearing conditions,

$$y_t = y_{H,t} + y^*_{H,t},$$
$$y^*_t = y_{F,t} + y^*_{F,t},$$

6 optimality conditions for within-period consumption and labor choices,

$$\begin{aligned}
\left[\alpha^{1-\eta} y_{H,t}^{\eta} + (1-\alpha)^{1-\eta} y_{F,t}^{\eta}\right]^{1/\eta-1} \alpha^{1-\eta} y_{H,t}^{\eta-1} &= p_t, \\
\left[\alpha^{1-\eta} y_{H,t}^{\eta} + (1-\alpha)^{1-\eta} y_{F,t}^{\eta}\right]^{1/\eta-1} (1-\alpha)^{1-\eta} y_{F,t}^{\eta-1} &= p^*_t \exp(-e_t), \\
\ell_t^{1/\nu} &= c_t^{-\gamma} w_t, \\
\left[\alpha^{1-\eta} (y^*_{F,t})^{\eta} + (1-\alpha)^{1-\eta} (y^*_{H,t})^{\eta}\right]^{1/\eta-1} \alpha^{1-\eta} (y^*_{F,t})^{\eta-1} &= p^*_t, \\
\left[\alpha^{1-\eta} (y^*_{F,t})^{\eta} + (1-\alpha)^{1-\eta} (y^*_{H,t})^{\eta}\right]^{1/\eta-1} (1-\alpha)^{1-\eta} (y^*_{H,t})^{\eta-1} &= p_t \exp(e_t), \\
(\ell^*_t)^{1/\nu} &= (c^*_t)^{-\gamma} w^*_t,
\end{aligned}$$

8 equations that govern firm production and factor prices,

$$\begin{aligned}
y_t &= (\exp(a_t) k_t^{\vartheta} \ell_t^{(1-\vartheta)})^{1-\phi} x_t^{\phi}, \\
\ell_t w_t &= p_t (1-\vartheta)(1-\phi) y_t, \\
k_t q_t &= p_t \vartheta (1-\phi) y_t, \\
x_t &= p_t \phi y_t, \\
y^*_t &= (\exp(a^*_t)(k^*_t)^{\vartheta} (\ell^*_t)^{(1-\vartheta)})^{1-\phi} (x^*_t)^{\phi}, \\
\ell^*_t w^*_t &= p^*_t (1-\vartheta)(1-\phi) y^*_t, \\
k^*_t q^*_t &= p^*_t \vartheta (1-\phi) y^*_t, \\
x^*_t &= p^*_t \phi y^*_t,
\end{aligned}$$

4 equations that govern capital accumulation,

$$
\begin{aligned}
z_t &= k_{t+1} - (1-d)k_t + \frac{\kappa}{2}\frac{(\Delta k_{t+1})^2}{k_t}, \\
1 + \kappa\frac{\Delta k_{t+1}}{k_t} &= \mathbb{E}_t\left[\delta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\left(q_{t+1} + 1 - d + \kappa\frac{\Delta k_{t+2}}{k_{t+1}} + \frac{\kappa}{2}\left(\frac{\Delta k_{t+2}}{k_{t+1}}\right)^2\right)\right], \\
z_t^* &= k_{t+1}^* - (1-d)^* k_t + \frac{\kappa}{2}\frac{(\Delta k_{t+1}^*)^2}{k_t^*}, \\
1 + \kappa\frac{\Delta k_{t+1}^*}{k_t^*} &= \mathbb{E}_t\left[\delta\left(\frac{c_{t+1}^*}{c_t^*}\right)^{-\gamma}\left(q_{t+1}^* + 1 - d + \kappa\frac{\Delta k_{t+2}^*}{k_{t+1}^*} + \frac{\kappa}{2}\left(\frac{\Delta k_{t+2}^*}{k_{t+1}^*}\right)^2\right)\right],
\end{aligned}
$$

3 Euler equations for households and the intermediary,

$$1 = \mathbb{E}_t\left[\delta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\exp(r_t)\right], \tag{A.1}$$

$$1 = \mathbb{E}_t\left[\delta\left(\frac{c_{t+1}^*}{c_t^*}\right)^{-\gamma}\exp(r_t^*)\right], \tag{A.2}$$

$$\mathbb{E}_t[\Delta e_{t+1} + r_t - r_t^*] = \chi_1\psi_t - \chi_2\frac{b_{H,t}\exp(r_t)}{\bar{Y}}, \tag{A.3}$$

2 budget constraints for households,

$$
\begin{aligned}
(w_t\ell_t + q_tk_t) + \exp(r_{t-1})b_{H,t-1} &= c_t + z_t + b_{H,t}, \\
(w_t^*\ell_t^* + q_t^*k_t^*) + \exp(r_{t-1}^*)b_{F,t-1}^* &= c_t^* + z_t^* + b_{F,t}^*,
\end{aligned}
$$

and 1 bond market clearing condition,

$$b_{H,t} = -\exp(-e_t)b_{F,t}^*. \tag{A.4}$$

In Section 3.2 where we compare the segmented-market model with the safe-asset model, we also embed our safe-asset demand in the same real economy with production and investments. We only need to replace the Euler equations (A.1) to (A.3) with the following Euler equations from the safe-asset model:

$$\exp(-\lambda_{H,t}) = \mathbb{E}_t\left[\exp(m_{t+1} + r_t)\right],$$

$$\exp(-\lambda_{F,t}) = \mathbb{E}_t\left[\exp(m_{t+1} - \Delta e_{t+1} + r_t^*)\right],$$

$$\exp(-\lambda_{F,t}^*) = \mathbb{E}_t\left[\exp(m_{t+1}^* + r_t^*)\right],$$

$$\exp(-\lambda_{H,t}^*) = \mathbb{E}_t\left[\exp(m_{t+1}^* + \Delta e_{t+1} + r_t)\right],$$

change the bond market clearing condition (A.4) to include the government's supply:

$$\bar{b}_t = b_{H,t} + b_{H,t}^*,$$

$$\bar{b}_t^* = b_{F,t} + b_{F,t}^*,$$

and modify the households' budget conditions accordingly to include both home and foreign bonds.

Table (A.1) reports our parameter choices in the two models. The common parameters describe the real economy which is common to both models. The segmented market parameters describe the parameters related to the intermediated bond market in the segmented-market model. These parameters follow from Itskhoki and Mukhin (2021). The convenience yield parameters describe the parameters related to the bond demand in the safe-asset model which follow from this paper.

Table A.1: Parameter Values.

Parameter	Notation	Value
Common parameters		
Subjective discount factor	δ	0.99
Relative risk averse	γ	2.0
Frisch elasticity	ν	1
Intermediate goods share	ϕ	0.5
Capital share in value added	ϑ	0.3
Depreciation rate	d	0.02
Capital adjustment cost	κ	50
Trade home bias	α	0.93
Trade elasticity of substitution	η	0.33
segmented market parameters		
Transmission from shock to UIP	χ_1	1
Coefficient of NFA on UIP	χ_2	0.001
Volatility of financial shock	σ_ψ	0.01
Persistence of financial shock	ρ_ψ	0.97
Convenience yield parameters		
Bond demand curvature	σ	3
Home investor's utility from home bond	ω_H	0.0658
Home investor's utility from foreign bond	ω_F	0.000264
Foreign investor's utility from home bond	ω_H^*	0.0667
Foreign investor's utility from foreign bond	ω_F^*	0.0171
Persistence of bond demand shock	$\rho_{\theta_H^*}$	0.97
Volatility of bond demand shock	$\sigma_{\theta_H^*}$	0.024

B Data Appendix

The exchange rate data are from Datastream. We construct quarterly nominal exchange rate series between the U.S. and 10 developed countries: Australia, Canada, Germany, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. The log U.S. dollar exchange rate is the equal-weighted average of the log exchange rates against these 10 countries. Unless otherwise specified, the sample is 1988Q1 to 2022Q4.

B.1 Data Used in Section 4

U.S. capital flows and NFA are from Bureau of Economic Analysis (BEA), Table S9. The inflows are the foreign net purchases of U.S. Treasury securities, and the outflows are the U.S. net purchases of foreign bond securities. The flow data are scaled by the U.S. GDP in the same year. The annualized flow/GDP ratio is equal to the quarterly flow times 4 divided by the annual GDP.

The financial crisis indicator is from Jordà et al. (2017). The data are annual and cover 18 developed countries: AUS, BEL, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, JPN, NLD, NOR, PRT, SWE, USA. The indicator is at annual frequency, which is merged with the quarterly data by assuming that the crisis indicator in a given country is constant within a year. The worldwide financial crisis indicator is constructed as the average of the crisis indicators across countries weighted by their nominal dollar GDP.

The cross-currency Treasury basis data are from Jiang et al. (2021a). A more negative basis means that the 1-year dollar Treasury yield is lower than the 1-year synthetic dollar yield constructed from the foreign Treasury yield and the currency forward which hedges the exchange rate risk. The basis is averaged across the 9 major currencies: AUD, CAD, CHF, DEM/EUR, GBP, JPY, NOK, NZD, SEK. The Treasury basis sample is 1988Q1 to 2017Q2.

B.2 Data Used in Section 5, Table 3

The dollar exchange rate movement is again the equal-weighted average of the nominal exchange rate movements across 10 developed countries. The U.S.-foreign log interest rate differential is implied from the 3-month log forward premium, equal-weighted across the same 10 developed countries.

The real consumption data is from Oxford Economics, available at quarterly frequency and seasonally adjusted. At the level of individual countries, the real consumption growth is the year-on-year growth rate of the quarterly real consumption. When we compute the correlation between consumption growth and the exchange rate movement, we also use the year-on-year growth rate of the exchange rate. The world consumption growth is equal-weighted average of the log real consumption growth across 11 countries: Australia, Canada, Germany, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The foreign consumption growth is the average without the United States.

The capital flows np, np^*, and f are constructed in the same way as in Section B.1. The U.S. nfa is the ratio between the U.S. NFA in nominal dollar units and the U.S. GDP in nominal dollar units.