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EXORBITANT PRIVILEGE:
A SAFE-ASSET VIEW

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ABSTRACT

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

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1 Introduction

Banks and other financial intermediaries play important roles in the economy. By intermediating funds between savers and borrowers, they engage in safety and liquidity transformations. When we think about the international financial system, the U.S. plays a similarly central role as the “world’s banker”. Under the *insurance-provision view* developed by [Gourinchas and Rey \(2007a, 2022\)](#); [Mendoza, Quadrini, and Rios-Rull \(2009\)](#); [Gourinchas, Rey, and Truemptler \(2012\)](#); [Maggiore \(2017\)](#), the U.S. invests in high-return risky assets in foreign countries, and creates low-return safe liabilities held by foreign investors. As a result, the U.S. earns a risk premium in good times as a compensation for its insurance provision, and bears losses in global recessions as the insurance pays off.

While this risk-based view has provided important insights about the U.S. exorbitant privilege, its basic form creates a tension. [Maggiore \(2017\)](#) notes that, as the insurance arrangement transfers resources from the U.S. to foreign countries in global recessions, the foreign households become relatively wealthier. Given their home bias in consumption demand, they bid up the price of the foreign goods and appreciate the foreign currency in real terms. However, the dollar exchange rate is strongly countercyclical in the data, resulting in what [Maggiore \(2017\)](#) 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 the banks have market power and charge mark-up for their deposits on top of the competitive compensation for risk transformation, the U.S. also enjoys a seigniorage revenue from its provision of global reserve assets. The demand for the U.S. safe assets gives rise to a convenience yield and introduces a wedge in the international risk-sharing condition, which, in the recent literature, has made significant progress in understanding the exchange rate puzzles. As such, this *safe-asset view* also has the potential to provide a novel and complementary account of the U.S. exorbitant privilege in the international monetary system. I examine this hypothesis in a general equilibrium model of international real business cycles, and report three main 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 the 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 cyclical. I assume that the foreign demand for dollar safe assets increases in global recessions, which makes the seigniorage revenue countercyclical. As a result, global recessions raise the U.S. wealth share and consumption share. In stark contrast, under the insurance-provision view, global recessions reduce the U.S. wealth and consumption shares, as 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 requires it to transfer wealth to the rest of the world in global recessions. In my model, while the U.S. still suffers portfolio losses from its external asset positions due to dollar appreciation, the increase in its expected seigniorage revenues more than makes up for its wealth loss. Therefore, under my safe-asset view, the U.S. exorbitant duty could be offset by higher seigniorage revenues in global recessions.

This safe-asset view also ties together other salient features of the reserve currency paradigm. The dollar's exchange rate 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 the U.S. goods increases in relative terms and generates a countercyclical dollar exchange rate.

Moreover, as the U.S. experiences dollar appreciation and capital inflows, its net foreign assets (NFA) deteriorate in global recessions. In subsequent periods, the seigniorage revenue it earns from the bond convenience yield allows it to pay off its NFA imbalances without having to run trade surpluses, which is consistent with the emphasis on valuation effects in the NFA decom-

position (Gourinchas and Rey, 2007b). In comparison, if the exchange rate wedge is driven by intermediation frictions as in Itskhoki and Mukhin (2021) instead of the seigniorage revenue, NFA imbalances have to be paid off by future trade surpluses.

Having mapped the U.S. exorbitant privilege and its cyclicalty to safe asset demand, I turn to additional non-targeted moments that are unique to this model. This safe-asset view also has novel implications for exchange rate cyclicalty and capital flow dynamics. The second result from this model concerns the relationship between wealth and exchange rate cyclicalty. In consumption-based models with complete markets, the equilibrium 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 households' consumption and raise their marginal utility, the exchange rate is always countercyclical with respect to local business cycles. However, in the data, exchange rates are acyclical or even procyclical, meaning that currencies tend to depreciate when local consumption declines (Backus and Smith, 1993).

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

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

Take the foreign households as an example. A local recession lowers their wealth and reduces their holdings of the dollar safe assets. As they 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. households, the dollar appreciates on the spot to lower its expected return from the foreign perspective. In this way, while a higher

foreign marginal utility Δu_c^* over consumption appreciates the foreign currency through the standard international risk-sharing condition, a higher foreign marginal utility Δu_b^* over bond holding depreciates the foreign currency through the asset demand channel. If the foreign wealth declines more than foreign consumption in local recessions, the bond demand channel could dominate and generate procyclical exchange rates.

It is worth noting that this argument works for both home and foreign countries: a decline in wealth drives the local households out of the safe asset market, which raises their bond convenience yield and depreciates their currency. As such, this new resolution of the [Backus and Smith \(1993\)](#) puzzle also works in a symmetric model between two non-U.S. countries. As we discussed in the first result, on top of this mechanism, the U.S. dollar is extra special: 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. On the one hand, when capital flows are driven by demand shifts towards the dollar safe bond, the model predicts that inflows into the U.S. are associated with dollar appreciation. The left panel of [Figure \(1\)](#) illustrates the market clearing of the dollar bond market in this case. As the foreign households' demand curve for dollar bond shifts from D to D' , the foreign households hold more dollar bond and this inflow into the U.S. strengthens the dollar. This result is consistent with a large theoretical literature that emphasizes the flow-driven mechanisms of exchange rate movements ([Evans and Lyons, 2002](#); [Hau and Rey, 2006](#); [Gabaix and Maggiori, 2015](#); [Itskhoki and Mukhin, 2021](#)).

On the other hand, when the foreign households move along their downward-sloping demand curve D , the relationship between net capital flows and exchange rate movements is reversed. This happens in response to the wealth shock we considered in the second result: when the U.S. households become richer and buy more U.S. and foreign bonds, the residual supply curve of the U.S. bond for the foreign households shifts from S to S' . As a result, the foreign households are priced out of the safe asset market, and higher scarcity of the U.S. bond overseas increases its convenience yield and appreciates the dollar. In this case, as shown in the right panel of [Figure \(1\)](#),

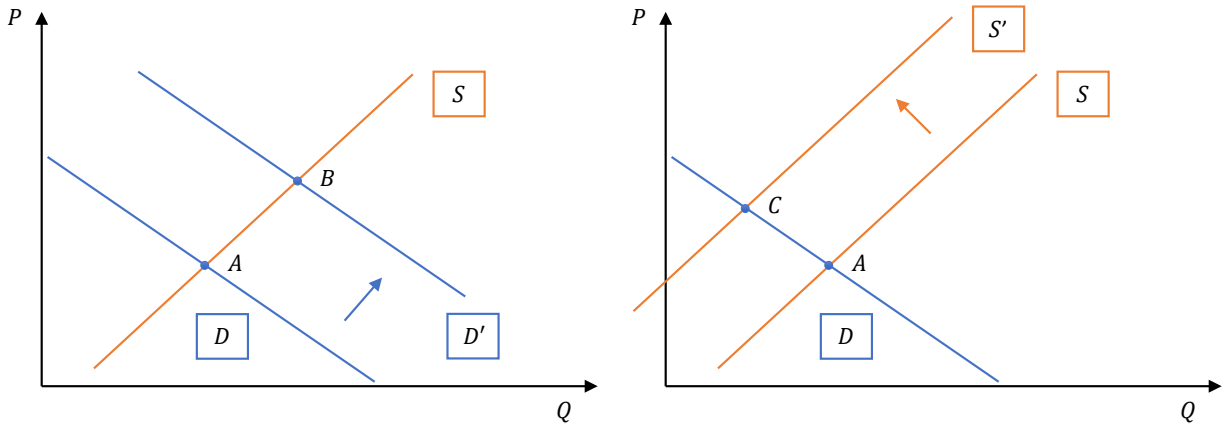


Figure 1: Illustrations of the Capital Flow-Exchange Rate Relationship.

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.

outflows from the U.S. are associated with dollar appreciation. While this association is intuitive in light of the demand-supply diagram, I believe it is surprising given its departure from the standard flow-driven narrative of exchange rate movements.

These two scenarios show that the relationship between capital flows and the exchange rate can go both ways. Empirically, the correlation between the dollar exchange rate and cross-border net capital 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 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 et al. \(2022\)](#), while the correlation tends to be negative during normal times.

This result supports the model's mechanism. When the bond demand shock dominates during global stress periods, the dollar tends to appreciate with inflows into the U.S. When the wealth shock dominates during normal times, the dollar tends to appreciate with outflows from the U.S. In this way, the model generates 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 determination.

In summary, these results provide a coherent safe-asset view for understanding capital flows and exchange rate dynamics, and the special status of the U.S. and the dollar. Emphasizing the downward-sloping demand for the safe dollar bond, 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. Besides the papers cited above under the insurance-provision view, [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. [Jiang, Krishnamurthy, and Lustig \(2020\)](#) study a dollar liquidity channel through which the U.S. monetary policy drives the global financial cycle; they also note the countercyclical nature of the U.S. seigniorage revenue, although foreign goods and bond markets are not cleared. My paper derives general equilibrium outcomes of a two-country exchange economy, which provide new insights on the implications of the U.S. exorbitant privilege for consumption, wealth, capital flows, and their relationships with the exchange rate.

[Kekre and Lenel \(2021\)](#) also develop a model of the dollar and U.S. external imbalances with safe asset demand. In their model, to generate dollar appreciation during global downturns, the U.S. suffers a greater recession and a greater decline in consumption. Similarly, in [Dahlquist, Heyerdahl-Larsen, Pavlova, and Pénasse \(2022\)](#); [Sauzet \(2022\)](#); [Devereux, Engel, and Wu \(2023\)](#); [Kim \(2022\)](#), dollar appreciation during global downturns is accompanied by a *higher* U.S. marginal utility over consumption. In comparison, my model explores a different but complementary channel, which emphasizes the seigniorage revenue earned by the U.S. safe asset issuers and generates dollar appreciation despite the U.S. having higher consumption and *lower* marginal utility over consumption during 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 cyclicity 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 the U.S. safe assets as a given fact, which has deeper theoretical foundations. [Farhi and Maggiori \(2018\)](#); [He et al. \(2019\)](#); [Coppola et al. \(2023\)](#) propose coordination-based explanations for why the U.S. bond is especially valued. [Caballero et al. \(2016\)](#); [Caballero and Farhi \(2018\)](#) study the general equilibrium effects of safe asset scarcity. This paper studies the global business cycle variations within the current regime in which the U.S. bond is regarded as the safe asset. It remains silent about the possibility of a regime change in its reserve asset status.

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. I consider a real model: 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.

Each country is populated by a unit mass of identical households and a government. The government in each country issues an exogenously specified amount of 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. 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

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

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

The home households' consumption basket is a Cobb-Douglas aggregation of home and foreign goods:

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

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 non-bond portfolio holdings that are not directly modeled in this paper. For example, if the U.S. holds a large amount of foreign equity and the foreign equity value rises, then, the U.S. receives a wealth transfer from the foreign country.

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

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

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:

$$c_{H,t} + c_{H,t}^* = y_t, \quad c_{F,t} + c_{F,t}^* = y_t^* \quad (1)$$

$$b_{H,t} + b_{H,t}^* = \bar{b}_t, \quad b_{F,t} + b_{F,t}^* = \bar{b}_t^*. \quad (2)$$

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 their marginal utility growth:

$$\exp(m_{t+1}) \stackrel{\text{def}}{=} \delta \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma}, \quad \exp(m_{t+1}^*) \stackrel{\text{def}}{=} \delta \left(\frac{c_{t+1}^*}{c_t^*} \right)^{-\gamma}.$$

Then, the home and foreign households' utility maximization problems imply the following equations:

$$\begin{aligned}
\exp(-\lambda_{H,t}) &\stackrel{\text{def}}{=} 1 - \frac{\omega_H b_{H,t}^{-\sigma}}{c_t^{-\gamma}} && = \mathbb{E}_t [\exp(m_{t+1} + r_t)], && (3) \\
\exp(-\lambda_{F,t}) &\stackrel{\text{def}}{=} 1 - \frac{\omega_F b_{F,t}^{-\sigma}}{c_t^{-\gamma}} \exp(e_t) && = \mathbb{E}_t [\exp(m_{t+1} - \Delta e_{t+1} + r_t^*)], \\
\exp(-\lambda_{F,t}^*) &\stackrel{\text{def}}{=} 1 - \frac{\omega_F^* (b_{F,t}^*)^{-\sigma}}{(c_t^*)^{-\gamma}} && = \mathbb{E}_t [\exp(m_{t+1}^* + r_t^*)], \\
\exp(-\lambda_{H,t}^*) &\stackrel{\text{def}}{=} 1 - \frac{\omega_H^* (b_{H,t}^*)^{-\sigma} + (\bar{c}^*)^{-\gamma} \theta_{H,t}^*}{(c_t^*)^{-\gamma}} \exp(-e_t) && = \mathbb{E}_t [\exp(m_{t+1}^* + \Delta e_{t+1} + r_t)]. && (4)
\end{aligned}$$

The right-hand sides of these equations are the risk-neutral expected returns common 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 λ variables to capture these deviations, which are commonly referred to as the convenience yields.

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,

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

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 $m_{t+1}^* - m_{t+1} = \gamma(\Delta \log c_{t+1} - \Delta \log c_{t+1}^*)$ and letting $\bar{e} \stackrel{\text{def}}{=} \lim_{t \rightarrow \infty} e_t$ 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 expected consumption growth differential and the expected convenience yield differential:*

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

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

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

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 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 is lower, 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 additionally allow the households to trade the complete set of contingent claims. In this case, I can solve the model 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.¹ More

¹In 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).

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 of holding the dollar bond. This result is similar to the equilibrium condition under complete markets that the home and foreign households' marginal utilities over consumption are also equalized (after unit conversion by the exchange rate $\exp(e_t)$ and multiplication with the Pareto weights π and $1 - \pi$):

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

As such, incomplete markets are an essential ingredient to make the convenience yields matter for exchange rates.

2.4 Calibration and the Steady State

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 calibrate the model at the quarterly frequency, and pick the following parameter values: $\gamma = 1$, $\sigma = 3$, $\alpha = 0.9$, $\delta = 0.99$, $\eta = 1/3$, and $\bar{y} = \bar{y}^* = 1$. I choose $\bar{\theta}^*_H = 0$ so that the demand shifter is neutral in the steady state. I calibrate the variables $\omega_H, \omega_F^*, \omega_H^*, \omega_F$ so that in the non-stochastic 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 relative to the foreign bonds, which is in line with the empirical estimates in Jiang, Krishnamurthy, and Lustig (2021a). Also, I target the steady state 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, 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 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 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.

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%

3 Model Mechanism

This section examines several impulse response patterns through the lens of Proposition 1 to understand the model's economic mechanism. I show how the movements in the bond convenience yields that home and foreign households impute to the U.S. bond 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 state. In this model, I highlight a different aspect of the global recession: it coincides with a 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. Upon the arrival of the shock, we can see an increase in the 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, which is consistent with the dollar appreciation upon the arrival of the shock 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.

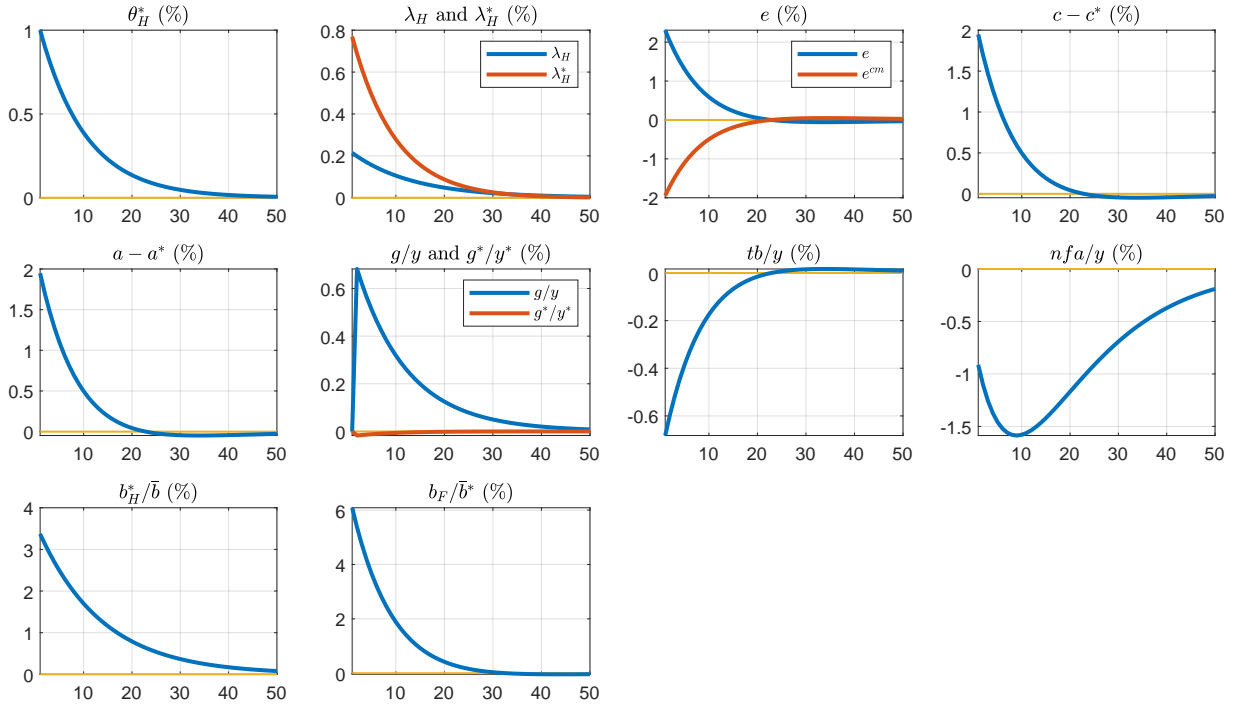


Figure 2: Impulse Responses to Dollar Bond Demand Shock.

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.

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

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, the seigniorage revenue is also expected to last, leading to an increase in the expected future seigniorage revenues. The 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:

$$a_t = \mathbb{E}_t \left[\sum_{s=t}^{\infty} \delta^s \frac{c_s^{-\gamma}}{c_t^{-\gamma}} c_s \right].$$

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 the 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 the 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 also implies a stronger dollar that is consistent with the asset market clearing described by Proposition 1. 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 the model by comparing it to the segmented-market model. To do so, 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 model 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 impulse 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. consumption increases relative to the foreign consumption, while the U.S. labor and production decline. The U.S.

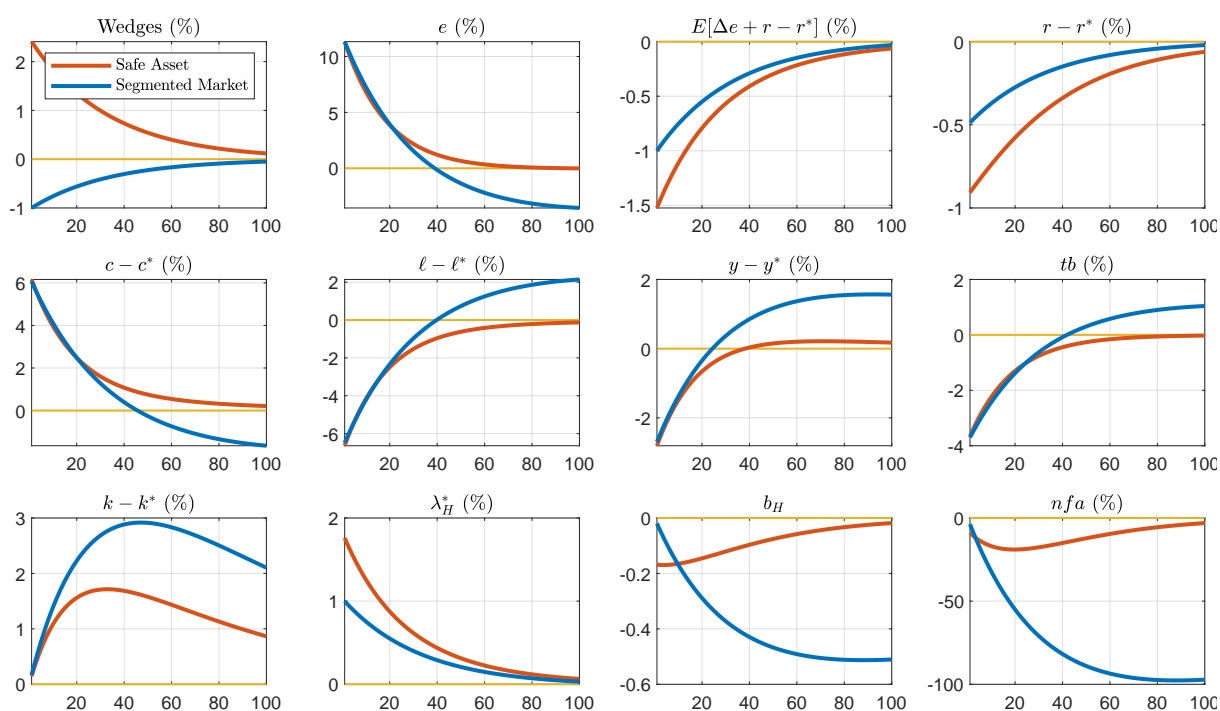


Figure 3: Comparing Segmented-Market and Safe-Asset Models.

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 production differential, the trade balance, the investment differential, the exchange rate wedge, the U.S. bond holdings, and the NFA.

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 the 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:

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

which, as the second panel in the third row 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 persistently upon the shock's arrival in both models, they eventually decline below the steady-state level and overshoot in the opposite direction in the segmented-market model, but not in the safe-asset model. To understand this difference, let us recall that the net foreign assets (NFA) has 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 $\overline{nfa} \stackrel{\text{def}}{=} \lim_{k \rightarrow \infty} \mathbb{E}_t[nfa_{t+k}]$ 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.² As a result, as the last panel of [Figure \(3\)](#) shows, the U.S. first accumulates a negative NFA by building up a negative position on the home bond b_H , which is paid back 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 offset 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 that I characterize in the previous section. In this case, the U.S. negative NFA does not require subsequent trade surpluses to pay back, 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.

The second difference between the two models is in their implications for cross-border capital flows. For example, the b_H panel 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.

²In [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.

More broadly speaking, the safe-asset model makes unique predictions about the capital flows, which I study in detail in Section 4.

Finally, different microfoundations of the exchange rate wedge can have different policy implications. Under the segmented market view, the government can stabilize the exchange rate by affecting the financiers' balance sheets or their expectation of the currency risk (Itskhoki and Mukhin, 2023). Under the convenience yield view, exchange rate intervention can take the form of regulating the supply of safe assets, which can be done by either fiscal or monetary policies (Jiang et al., 2020).

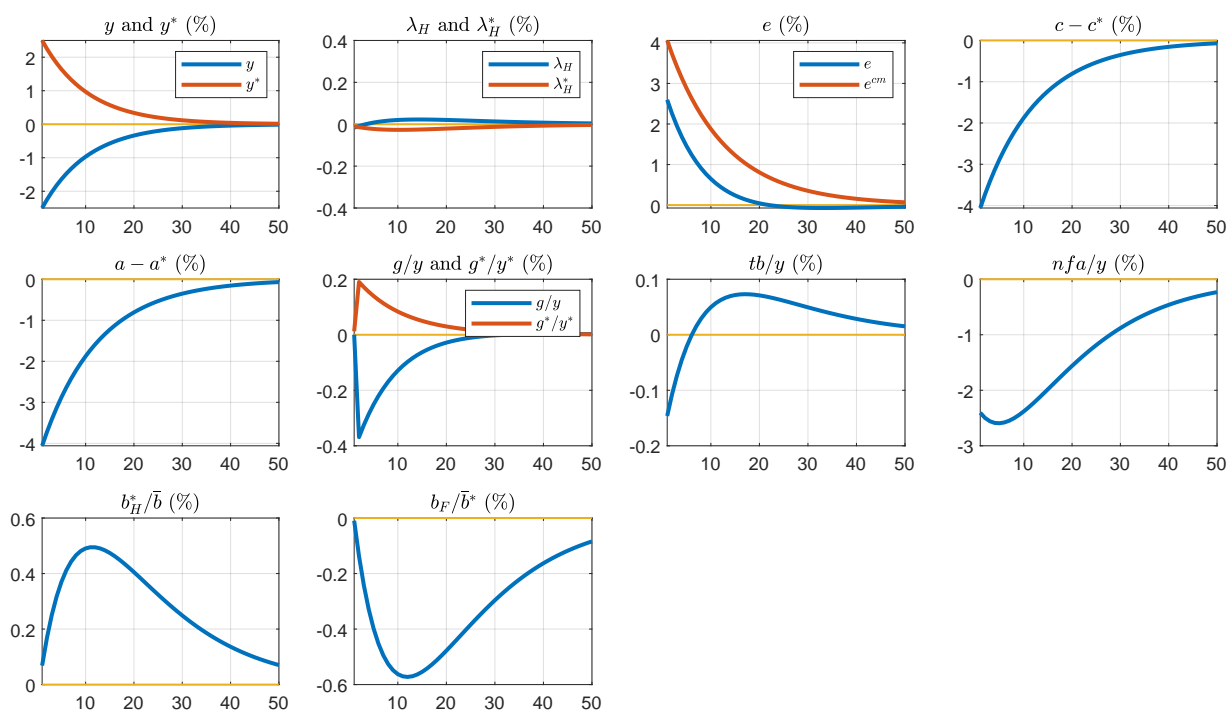


Figure 4: Impulse Responses to Endowment Shock.

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.

3.3 Endowment Shocks

For comparison, let us consider an asymmetric endowment 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 the exchange rate formula (6) in Proposition 1, reproduced below,

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

an increase in the U.S. marginal utility over consumption relative to the foreign, or, equivalently, a reduction in the U.S. consumption relative to the foreign, leads to dollar appreciation.

That said, if only the marginal utility channel were operative, I would have observed an even stronger dollar appreciation, as shown in the red curve in the exchange rate panel. To understand this effect, I 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 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 complete-market 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 en-

dowment shock simultaneously impacts the supply of consumption goods and the wealth distribution. To isolate the latter effect, I also 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 wealth transfer shock persistently increases the U.S. wealth a relative to the foreign wealth a^* , which also raises the U.S. consumption share. The wealthier U.S. households buy more U.S. bond and crowd out the foreign households in this market. As a result, the foreign households hold less U.S. bond and impute a

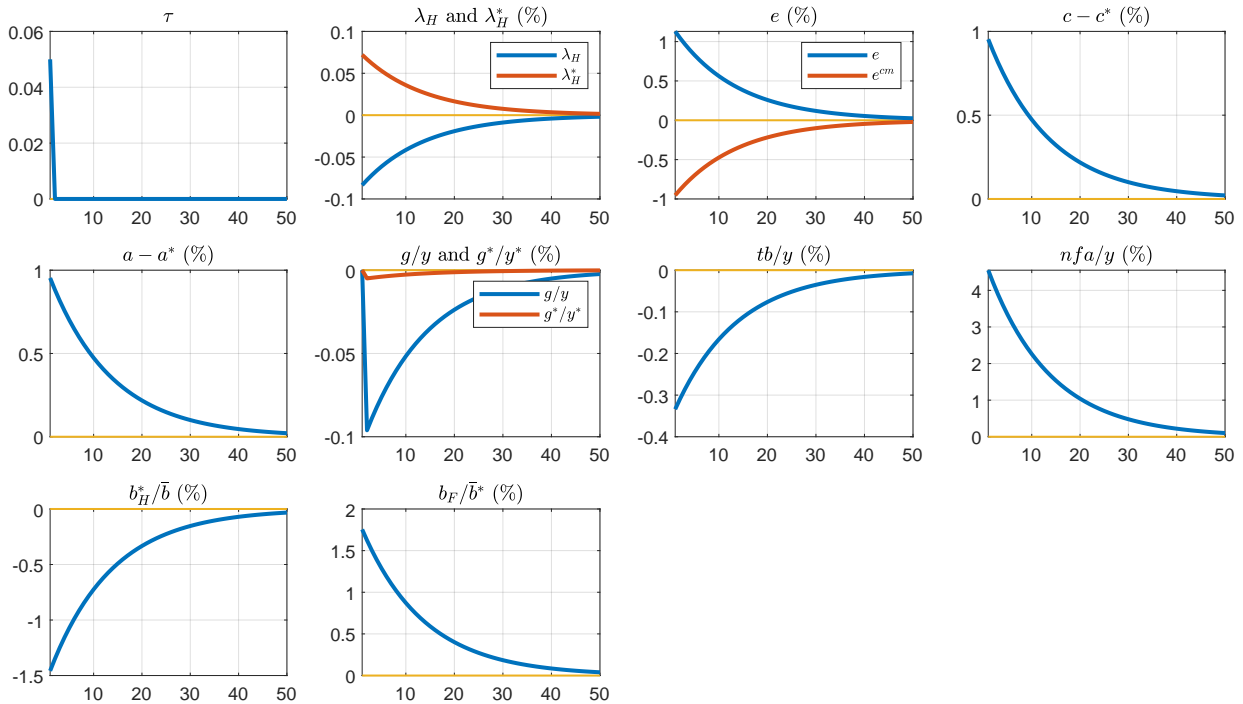


Figure 5: Impulse Responses to Wealth Transfer Shock.

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.

higher 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 also 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 second 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 makes the foreign households move along the 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.

4 Capital Flows and the Exchange Rate

This model connects exchange rate movements to bond holdings, which allows us to explore the relationship between the capital flows and the exchange rate and the roles played by 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 increase their notional holdings of the U.S. bond, and a positive np_t^* means that the U.S. households increase their notional holdings of the foreign bond. I define the net capital flows as their difference:

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

which is increasing in the net amount of funds that flow from the foreign country to the U.S., which happens 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

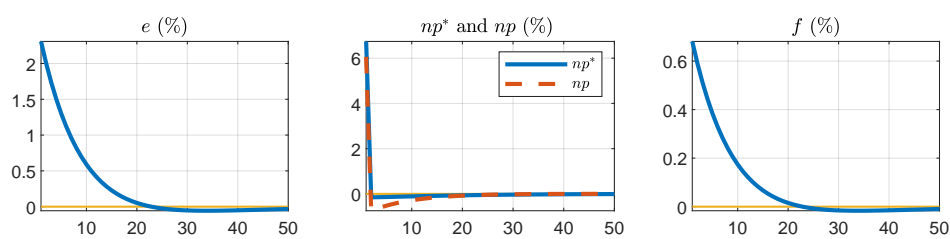
The safe asset demand shock and the wealth transfer shock offer two complementary ways of thinking about the relationship between capital flows and exchange rates. First, let us revisit the safe asset demand shock in [Figure \(2\)](#). As the foreign households' demand for the U.S. debt increases, they have a positive net purchase of the U.S. bond (i.e., np^* increases), while the U.S. households have a positive net purchase of the foreign bond (i.e., np increases). As a result, there

are capital flows going in both directions, as shown in the middle panel of Figure (6)(a).

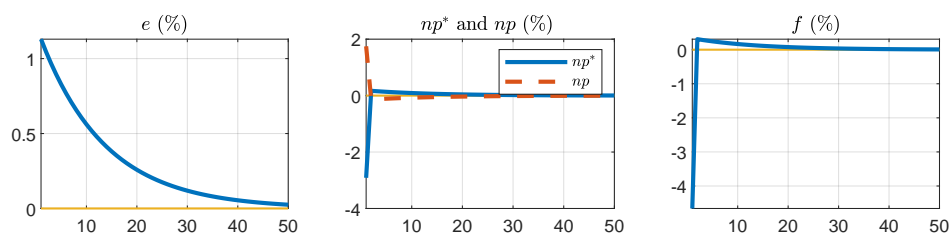
As more funds flow from the foreign country into the U.S. than the other way around, the net flow f into the U.S. is positive, and it is accompanied by dollar appreciation. This shock produces a positive correlation between the dollar's exchange rate e and the net inflow f , which is consistent with a large literature that emphasizes the flow-driven mechanism of exchange rate movements (Evans and Lyons, 2002; Hau and Rey, 2006; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021).

4.2 Supply Shocks: Outflows and Currency Appreciation

Next, let us revisit the wealth shock in Figure (5). As the U.S. households receive a wealth transfer, they not only consume more, but also hold more U.S. and foreign bonds: np increases and np^* decreases. As a result, the U.S. households move funds into the foreign country, while the foreign



(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 foreign country, and a negative net flow means an inflow into the U.S.

households move funds out of the U.S. These flows are shown in the middle panel of [Figure \(6\)\(b\)](#): when the wealth shock arrives, the U.S. has a positive net purchase of the foreign bond, while the foreign country has a negative net purchase of the U.S. bond. Both flows are in the same direction from the U.S. to the foreign country (i.e., $f < 0$). As the dollar appreciates, this shock produces a negative correlation between the dollar's exchange rate e and the net inflow f .

This result shows that the flow-exchange rate relation can go both ways, depending on the nature of the shock. 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.

As mentioned in the introduction using [Figure \(1\)](#), it is useful to regard the former 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. The latter shock is more like a supply shock. As the U.S. households hold more U.S. bond and reduce the residual supply of the U.S. bond available to the foreign households, the supply curve faced by the foreign households shifts. 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 both cases, the increase in the convenience yield on the U.S. bond from the foreign perspective leads to a dollar depreciation, but the accompanying capital flows are in opposite directions.

4.3 Empirical Implications

Different shocks predict opposite relationships between exchange rate and capital flows. In this subsection, let us 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. Treasuries. The outflows are the U.S. net purchases of foreign bonds. The data are quarterly. [Appendix B](#) provides more details.

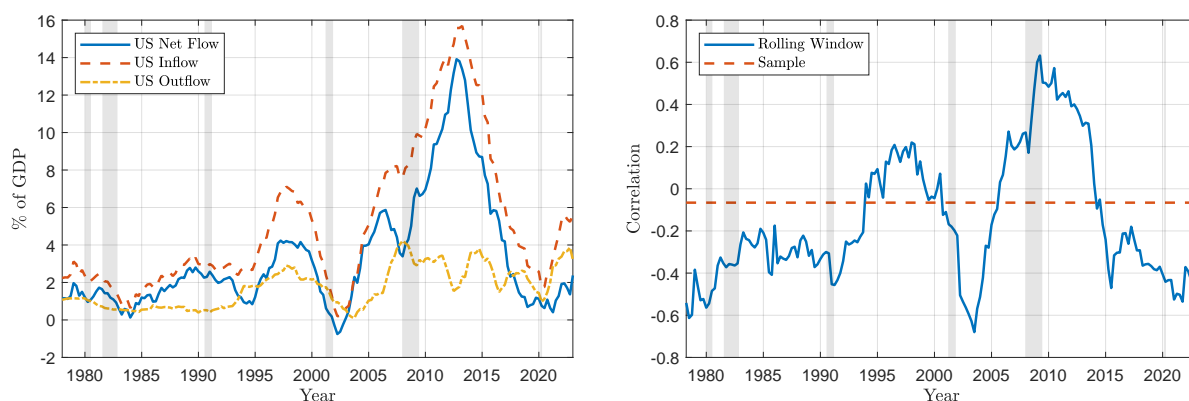
[Figure \(7\)\(a\)](#) reports the U.S. inflows, outflows, and net flows. To show the lower-frequency trend, I average these flows in 5-year rolling windows. Each value in the x axis represents the last

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.

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.



(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.

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 heterogeneity 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 be seen in different periods and drive a time-varying correlation.

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.³

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 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 in the periods outside the global crises, then, we should expect to see a negative flow-exchange rate correlation in these periods.

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

³Interestingly, 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](#)).

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

	<i>Dependent variable: Flow-FX Correlation</i>		
	(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. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

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. Treasuries. 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 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 first demand-driven channel with the close-to-zero unconditional correlation ob-

served 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

5.1 Model Specification

This section evaluates the equilibrium exchange rate, consumption, and capital flow moments in the model and compares them to the data. To tease out the effects of different shocks, I consider three specifications of the model.

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 $u_{F,t}$:

$$\begin{aligned}\log y_t &= (1 - \rho)\bar{y} + \rho \log y_{t-1} + 0.025u_{G,t} + 0.025u_{H,t}, \\ \log y_t^* &= (1 - \rho)\bar{y}^* + \rho \log y_{t-1}^* + 0.025u_{G,t} + 0.025u_{F,t},\end{aligned}$$

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:

$$\theta_{H,t}^* = (1 - \rho)\bar{\theta}_H^* + \rho\theta_{H,t-1}^* - 0.01u_{G,t} + 0.01u_{\theta,t};$$

to capture the countercyclicality in dollar bond demand, I assume that the innovation to the bond demand loads negatively on the global endowment shock. 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 $\tau_t = 0.03u_{\tau,t}$, where $u_{\tau,t}$ is inde-

pendent and standard normal variables. 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 not only exchange rates and interest rates, but also consumption quantities and portfolio flows. The second column reports their values in the data, based on the time series of the U.S. against a basket of 10 developed countries from 1985Q1 to 2022Q4 for exchange rate, interest rate, and NFA data, and from 1973 to 2022 for the consumption data. [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 and the global endowment level, 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 when the bond convenience yield differential widens.

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, much 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 change in the U.S. consumption share $\Delta c - \Delta c^{wld}$, defined as the difference between the log U.S. consumption and the log world consumption in the same numéraire, and the average consumption growth $\Delta \bar{c} = (\Delta c + \Delta c^*)/2$, defined as the mean of home and foreign log consumption growth in their own numéraires. 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, and the U.S. consumption share tends to increase when the global consumption growth is

Table 3: Simulation Results

Shocks	Data	Model 1 (y, y^*)	Model 2 (y, y^*, θ_H^*)	Model 3 (y, y^*, θ_H^*, τ)
Exchange Rates				
$autocorr(\Delta e)$	0.089	-0.052	-0.063	-0.061
$\sigma(\Delta e)(\%)$	3.798	2.322	3.927	3.988
$corr(e, \bar{c})$	-0.257	0.324	-0.289	-0.281
$corr(\Delta e, \Delta(\lambda_h^* - \lambda_h))$	0.223	-0.073	0.377	0.379
Interest Rate				
$autocorr(r - r^*)$	0.940	0.888	0.905	0.905
$\sigma(r - r^*)/\sigma(\Delta e)$	0.110	0.288	0.350	0.345
Fama β	1.725	-0.588	0.296	0.291
Consumption				
$corr(\Delta c, \Delta c^*)$	0.650	0.640	0.504	0.496
$corr(\Delta c - \Delta c^{wld}, \Delta \bar{c})$	-0.246	0.506	-0.478	-0.469
$corr(\Delta c - \Delta c^*, \Delta e)$	0.006	-0.959	0.031	0.053
Net Foreign Assets and Capital Flows				
$corr(\Delta nfa, \Delta \bar{c})$	0.291	0.800	0.816	0.681
$corr(\Delta nfa, \Delta e)$	-0.372	-0.419	-0.744	-0.519
$corr(f, e)$	-0.028	0.211	0.253	-0.016

Notes: This table reports the exchange rate, interest rate, and economic fundamentals' moments in the data and in different versions of the model. Model 1 features the endowment shocks only. Model 2 features both the endowment shocks and the bond demand shock. Model 3 features endowment, bond demand, and wealth transfer shocks. The model is at quarterly frequency.

low. Moreover, consistent with [Backus and Smith \(1993\)](#), the consumption growth differential is weakly correlated with the exchange rate movement.

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 assets, and suffers portfolio losses when the dollar appreciates. This panel also reports the correlation between the net capital flow $f = np^* - np$ and the exchange rate movement, which, as we discussed in the previous section, is close to zero.

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 cyclicalities, the dollar is stronger when the global consumption is high, which is counterfactual.⁴ 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.

The correlated endowment shocks generate a positive correlation between the U.S. and foreign consumption. With endowment shocks alone, the U.S. consumption share is positively correlated with the average consumption growth, and the U.S.-foreign consumption growth differential is negatively correlated with the dollar exchange rate movement. Both features are inconsistent with

⁴This is a result of my calibration choice. High endowment implies lower expected growth and lower 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.

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 behaves like a standard international business cycle model and fails to generate key features of the international monetary system and the exchange rate observed in the data.

5.4 Adding the Bond Demand Shock

Introducing the bond demand shock makes the exchange rate more volatile. It also overturns the cyclicity of the dollar: as the demand for U.S. safe assets increases in global recessions, 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.

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 the currency risk premium, which is not present in this model. If we introduce variations in the currency risk premium, we can generate a quantitatively greater Fama beta.

The bond demand shock also alters the consumption dynamics. While the U.S. and foreign consumption growth rates are still positively correlated, the 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. Moreover, a shift in the safe asset demand appreciates the dollar while increasing the U.S. households' seigniorage revenue

and consumption, leading to a positive correlation between the U.S. consumption and the dollar exchange rate, which resolves the [Backus and Smith \(1993\)](#) puzzle.

Finally, as a positive bond demand shock lowers the U.S. NFA while appreciating 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. 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 cyclicity, the Fama regression beta, the U.S. consumption share's cyclicity, and the [Backus and Smith \(1993\)](#) puzzle. It still generates a strong correlation between the net capital flow and the exchange rate, which, as we will see next, can be reversed by the wealth transfer shock.

5.5 Adding the Wealth Transfer Shock

In the last model, I introduce the wealth transfer shock. The exchange rate movement remains close to a random walk. It is interesting to note that while the bond demand shock and the endowment shocks are themselves persistent, the wealth transfer shock is purely transitory. However, the latter shock still creates persistent exchange rate movements by creating 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 second mechanism to reverse the [Backus and Smith \(1993\)](#) correlation which is separate from the bond demand shock. As discussed in Section 3.4, the wealth transfer shock alone moves the U.S. consumption and the dollar's currency value in the same direction, even in the absence of the demand shifts in the safe asset market.

Moreover, the NFA and capital flows have very 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 the U.S. NFA. Similarly, the wealth transfer shock also reduces the correlation between the U.S. NFA and the global consumption growth, as it shifts the consumption distribution and the NFA position without affecting the global endowment level.

Finally, from our discussion in Section 4, while the safe asset demand shock appreciates the dollar while the U.S. experiences net inflows, the wealth transfer shock appreciates the dollar while the U.S. experiences net outflows. The countervailing force brought by the wealth transfer shock is necessary to 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 demand for U.S. safe assets. Compared to the insurance-provision view of the U.S. exorbitant privilege, my model predicts that the dollar appreciates and the U.S. consumption and wealth shares increase during global recessions, despite the fact that the U.S. suffers losses on its external portfolio. In doing so, the model sheds new light on the nature of the U.S. exorbitant privilege and duty, 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,

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

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

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

and 4 Euler equations

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

A.2 Proof of Proposition 1

Proof. Linearize the Euler equation to get

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

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

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

Let $\lim_{j \rightarrow \infty} e_{t+j+1} = \bar{e}$. **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 $\bar{c} = \lim_{j \rightarrow \infty} c_{t+j+1}$, $\bar{c}^* = \lim_{j \rightarrow \infty} c_{t+j+1}^*$. 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

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

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

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

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

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

with 4 budget constraint conditions, we can solve the 8 endogenous variables and the 4 lagrangian multipliers. 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:

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

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,

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

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,

$$[\alpha^{1-\eta} y_{H,t}^\eta + (1-\alpha)^{1-\eta} y_{F,t}^\eta]^{1/\eta-1} \alpha^{1-\eta} y_{H,t}^{\eta-1} = p_t,$$

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

$$\ell_t^{1/\nu} = c_t^{-\gamma} w_t,$$

$$[\alpha^{1-\eta} (y_{F,t}^*)^\eta + (1-\alpha)^{1-\eta} (y_{H,t}^*)^\eta]^{1/\eta-1} \alpha^{1-\eta} (y_{F,t}^*)^{\eta-1} = p_t^*,$$

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

$$(\ell_t^*)^{1/\nu} = (c_t^*)^{-\gamma} w_t^*,$$

8 equations that govern firm production and factor prices,

$$y_t = (\exp(a_t) k_t^\vartheta \ell_t^{(1-\vartheta)})^{1-\phi} x_t^\phi,$$

$$\ell_t w_t = p_t (1-\vartheta) (1-\phi) y_t,$$

$$k_t q_t = p_t \vartheta (1-\phi) y_t,$$

$$x_t = p_t \phi y_t,$$

$$y_t^* = (\exp(a_t^*) (k_t^*)^\vartheta (\ell_t^*)^{(1-\vartheta)})^{1-\phi} (x_t^*)^\phi,$$

$$\ell_t^* w_t^* = p_t^* (1-\vartheta) (1-\phi) y_t^*,$$

$$k_t^* q_t^* = p_t^* \vartheta (1-\phi) y_t^*,$$

$$x_t^* = p_t^* \phi y_t^*,$$

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,

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

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

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

2 budget constraints for households,

$$(w_t \ell_t + q_t k_t) + \exp(r_{t-1}) b_{H,t-1} = c_t + z_t + b_{H,t},$$

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

and 1 bond market clearing condition,

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

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:

$$\begin{aligned}\exp(-\lambda_{H,t}) &= \mathbb{E}_t [\exp(m_{t+1} + r_t)], \\ \exp(-\lambda_{F,t}) &= \mathbb{E}_t [\exp(m_{t+1} - \Delta e_{t+1} + r_t^*)], \\ \exp(-\lambda_{F,t}^*) &= \mathbb{E}_t [\exp(m_{t+1}^* + r_t^*)], \\ \exp(-\lambda_{H,t}^*) &= \mathbb{E}_t [\exp(m_{t+1}^* + \Delta e_{t+1} + r_t)],\end{aligned}$$

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

$$\begin{aligned}\bar{b}_t &= b_{H,t} + b_{H,t}^*, \\ \bar{b}_t^* &= b_{F,t} + b_{F,t}^*,\end{aligned}$$

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
<i>Common parameters</i>		
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
<i>segmented market parameters</i>		
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
<i>Convenience yield parameters</i>		
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 is from Datastream. We construct quarterly nominal exchange rate series between the U.S. and ten 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 ten countries.

GDP and consumption data are from the World Development Indicators (WDI) database. U.S. capital flows and NFA are from Bureau of Economic Analysis (BEA), Table S9.

B.1 Instruction for Replicating Results in Section 4

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. I welcome suggestions on how to obtain the U.S. net purchases of foreign Treasury 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.

B.2 Instruction for Replicating Results in 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.

To focus on the comparison between the U.S. and the 10 developed countries in the exchange rate sample, the log world GDP growth $\Delta\bar{c}$ is the weighted average of the log GDP growth in local real units across 11 countries: Australia, Canada, Germany, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The weights are their real GDP in local units in the previous year, cross-sectionally aligned using 2015 dollar values.⁵ Similarly, the log world nominal GDP growth in dollar is the weighted average of the log GDP growth in nominal dollar units across 11 countries. The weights are their nominal GDP in dollar in the previous year. The change in the U.S. log consumption share $\Delta c - \Delta w^{wld}$ is the log U.S. consumption growth in nominal dollar minus the log world GDP growth in nominal dollar.

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. The U.S. dollar exchange rate movement is the equal-weighted average in log.

⁵See <https://datahelpdesk.worldbank.org/knowledgebase/articles/114943-how-do-you-derive-constant-price-series-in-usd>