Uncertainty Shocks, Capital Flows, and International Risk Spillovers*

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Abstract

Risk aversion and foreign investors' changing appetite for risk-taking have been shown to be key determinants of the global financial cycle. To match these facts, we propose a two-country macroeconomic framework featuring time-varying uncertainty and cross-border holdings of risky assets by financial intermediaries to understand the sources and effects of global risk-on and risk-off events. We first consider an economy in financial autarky, and find that the presence of balance-sheet constrained intermediaries implies that higher uncertainty leads to sharp declines in asset prices and increases in risk premia. We next show how the economy transitions from autarky to financial openness: U.S. financial intermediaries acquire foreign assets to benefit from portfolio diversification, effectively becoming global intermediaries. With financial openness, an increase in U.S. uncertainty leads to deleveraging pressure on intermediaries in both countries as well as to increases in global risk premia and decreases in global asset values, consistent with the empirical evidence. We also show that the presence of financial constraints allows the model to generate effects of uncertainty shocks on exchange rates, the UIP premium, and capital flows that are consistent with the data.

Keywords: Financial Frictions; Risk premia; Time-varying uncertainty, U.S. Monetary Policy Spillovers, Global Financial Cycle.

JEL classification: E32; E44; F41.

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1 Introduction

There is a large empirical literature that shows the importance of global risk aversion, uncertainty, and related "risk sentiment" of global investors in driving international risky asset prices and capital flows (e.g. Rey (2013), Miranda-Agrippino and Rey (2020), Miranda-Agrippino and Rey (2021)). Dubbed as the "global financial cycle" (GFC), this process can lead to large fluctuations in domestic credit, volatile capital flows, and boom-bust cycles, especially in emerging markets (EMs) (e.g. di Giovanni et al. (2021) for Turkey, and Morais et al. (2019) for Mexico). To date, we still lack a theoretical framework to understand these empirically-shown sources and effects of uncertainty or "risk-on/risk-off" shocks in an open economy context.[1] Our paper provides such a model and tests the predictions of the model in the data.

Our objective is to understand the linkage between fluctuations in uncertainty in the "financial center" (the U.S.) and movements in risk premia, asset prices, and exchange rates globally. To this end, we propose a two-country dynamic macro model, consisting of the U.S. and a foreign economy such as an EM. A key feature of our model is the presence of balance-sheet constrained financial intermediaries. These intermediaries play a key role in determining global asset prices, exchange rates, and capital flows, as they are long-lived. The key exogenous driving force in our model is a shock to the standard deviation of U.S. capital's productivity (or dividend). This uncertainty shock generates time variation in uncertainty about intermediaries' prospective returns. Our modeling of these "uncertainty shocks" is similar to that in Basu and Bundick (2017). We believe this approach captures the reality that part of the uncertainty involving intermediaries' returns is outside the control of intermediaries due to unexpected exogenous disturbances.[2]

We begin by studying a *single-good* endowment economy, in which the exchange rate is fixed at unity by assumption. In each country there is a fixed supply of capital ("trees") which produce a random dividend ("fruit") each period. Crucially, the process driving dividends is completely uncorrelated across countries. In addition, the process for dividends in the U.S. features time-varying uncertainty. We assume the two countries are asymmetric, in the following sense: the financial center (the U.S.) can hold claims to productive capital both at home and abroad, while in the foreign country (the EM) agents can only purchase claims to their own capital. We follow the literature on intermediary asset pricing (see, for example, He and Krishnamurthy (2013)) in that through intermediaries' pricing of claims on assets, asset prices and risk premia are both linked to frictions in financial intermediation. The household sector does not have direct access to financial instruments in either country, and instead owns financial intermediaries who make investments decisions in these risky assets on its behalf.

[1] U.S. monetary policy has been shown to be a key driver of GFC (e.g., Bekaert et al. (2013), Rey (2013), Bruno and Shin (2015)). As EM capital flows are more risk-sensitive and EM monetary policy is less effective on short-term borrowing costs, U.S. monetary policy driven GFC effects EMs more than advanced economies (AEs) as documented by Kalemli-Ozcan (2019). See Degasperi et al. (2021) for a similar risk spillover mechanism of U.S. monetary policy transmission to AEs through long-term interest rates and the yield curve.

[2] Crucially, while uncertainty fluctuations are exogenous in our model, risk premia are fully endogenous, as we emphasize throughout.

We first consider a case in which countries are in (financial and trade) autarky: U.S. banks cannot hold foreign assets, and there is no trade in goods and services. This case provides a useful benchmark to illustrate how uncertainty shocks transmit in our economy. We find that an increase in uncertainty leads to considerable declines in asset values and in intermediaries' net worth, and to sharp increases in risk premia.

To show the importance of the friction in financial intermediation, we turn off the friction and apply the same uncertainty shock. Given a standard value of just 3 for households' risk aversion (which is equal to intermediaries' risk aversion in the frictionless case), the magnitudes of the effects of uncertainty shocks are very small, as expected; but, importantly, asset values following an increase in uncertainty go up, while they have been shown to go down in the data. In this respect, the intermediary friction is important for generating responses both qualitatively and quantitatively consistent with the evidence. In fact, the financing friction works to make intermediaries effectively highly risk averse, despite a very modest value of risk aversion in the utility function. The reason is that the tightness of intermediaries' constraints is countercylical, and therefore the marginal value of a unit of wealth (which helps relax financial constraints) is highly countercylclical as well.

This observation plays an important role in shaping the effects of uncertainty shocks in the model with frictions. The intuition for how these effects play out is as follows: a rise in uncertainty lowers the prospective value of intermediaries' activity, which endogenously forces them to deleverage. As all intermediaries face this deleveraging pressure simultaneously, the asset price has to go down. In addition, intermediaries use an "augmented" stochastic discount factor (SDF) to price assets, which fluctuates much more countercyclically than the standard household consumption-based SDF (the value of intermediary wealth is countercyclical, as just explained) This channel is important in accounting for the large elasticity of risk premia to movements in uncertainty shocks in our model. That is, we can get the large movements observed in the data without assuming a high risk aversion parameter.

We then examine what happens when we open up the economies. Financial openness introduces powerful motives for U.S. banks to hold foreign assets: given uncorrelated returns, the latter offer important hedging benefits. For this reason, our economy features capital flowing from the U.S. to the EM as the economy transits from autarky to financial openness. In effect, U.S. banks become *global intermediaries*, and play a powerful role in driving capital flows and global asset prices, consistent with the empirical GFC literature.[3]

In fact, the presence of these global intermediaries imparts a strong comovement in asset prices in the two countries, even if the dividends on the underlying assets evolve independently. This occurs through the optimal portfolio condition of these intermediaries, which states that they must be indifferent between holding assets of either country, and therefore implies that differences in expected returns between domestic and foreign capital are quickly arbitraged away. As an example, assume that the economy is hit by a disturbance that drives U.S. excess returns up and the U.S.

[3]In addition to aforementioned empirical papers, see also Avdjiev and Hale (2019), and Bräuning and Ivashina (2020) on capital flows to EM by U.S. banks due to search-for yield motives.

asset price down. Without any chance in foreign asset prices, global intermediaries would want to shift away from foreign assets and into U.S. assets. To restore equilibrium, the foreign asset price must fall.[4]

Next, we consider the effects of a rise in U.S. uncertainty. This means that the riskiness of U.S. capital's productivity rises, with no change in the riskiness in the productivity of EM capital. Through the effects described earlier when discussing the autarky case, this shock causes deleveraging pressure on the U.S. (now global) intermediaries. Because of the arbitrage channel described in the previous paragraph (tying together the movements in asset prices in both countries), the shock also implies that the effective riskiness of foreign assets endogenously rises. In this way the shock transmits to foreign intermediaries, which are also forced to deleverage. Overall, we find that uncertainty shocks originating in either country drive asset prices and intermediary capital down, as well as risk premia up, in both countries. What is important here is that the shock originates in the United States, but spills over to the foreign country via capital flows since U.S. financial intermediaries price both countries' assets. As the required return on emerging market assets rises, capital has to flow *out* of the emerging market to satisfy the equilibrium pricing condition. We believe our model is the first to show that an uncertainty shock that originates in the financial center of the world (the U.S.) can spill over strongly to emerging markets, and therefore have properties that resemble a global risk aversion shock. The two will be observationally equivalent in the data given the GFC—that is, the co-movement in risky asset prices and capital flows.

We next extend the model to a two-good economy in order to incorporate fluctuations in the real exchange rate, in which U.S. intermediaries can hold both U.S. government bonds (in U.S. dollars) and EM government bonds (denominated in local currency of EM).[5] This is an interesting extension not only because it permits richer trade dynamics between the countries, but also because we can now study the interaction between uncertainty shocks, risk premia, and the real exchange rate. It has been shown that uncertainty shocks proxied with VIX move together with the USD exchange rate (see, for example, Sarno et al. (2012), Lilley et al. (2019) and Shin et al. (2010)), and the UIP premia (see, for example, di Giovanni et al. (2021) and Kalemli-Ozcan and Varela (2021)). In this extended version of the model we explore the effects of uncertainty shocks on the exchange rate and the deviations from uncovered interest parity (UIP) condition. There are significant failures of UIP in the two-good economy model, due to movements in the "risk term" (i.e. the conditional covariance between intermediaries' SDF and the exchange rate) stemming from fluctuations in uncertainty. We show that the model-implied effects of uncertainty shocks on UIP premia and on exchange rates align quite well with their empirical counterparts (calculated via an identified VAR).

Our UIP deviations do not depend on limits to arbitrage stemming from financing frictions, as in Gabaix and Maggiori (2015) or Mukhin and Itskhoki (2019): we assume that global intermediaries do not face limits to arbitrage in pricing foreign-currency bonds. Yet, our model generates a sizable

[4]A similar form of propagation across markets has also been emphasized by Dedola and Lombardo (2012) and Perri and Quadrini (2018) in open economies, and by Gertler et al. (2016) in a closed economy with two sectors.

[5]See Du and Schreger (2016) who show increase in local currency denominated borrowing of EM sovereigns.

dollar appreciation in the wake of higher U.S. uncertainty. The reason is that these intermediaries are effectively highly exposed to U.S. dividend risk, in a way that makes the UIP premium on foreign currencies highly elastic to U.S. uncertainty. When U.S. uncertainty rises, the UIP premium shoots up, and the foreign currency depreciates sharply. By contrast, in a model without intermediary frictions, the dollar *depreciates* following higher uncertainty (though the magnitude is small as long as risk aversion is low). We show that the data indicates a stronger dollar following higher uncertainty, fully consistent with the implications of our model.

Our model builds on a substantial theoretical literature studying the effects of uncertainty shocks.Well-known examples include Bloom (2009) and Basu and Bundick (2017). Much of this literature focuses on closed economy settings. Our goal, instead, is to study the global effects of fluctuations in uncertainty. Another difference with the literature is that our work studies the role of financial constraints in shaping the effects of uncertainty. By contrast, the literature on time-varying uncertainty has mostly focused on settings without financing frictions (exceptions include Arellano et al. (2019) and Fernández-Villaverde and Guerrón-Quintana (2020), but the workings of the financing friction differs considerably between these models and ours).

There is a large literature emphasizing some form of intermediation friction in driving exchange rate dynamics. Well-known examples include Gabaix and Maggiori (2015), Mukhin and Itskhoki (2019), and Basu et al. (2020). We also emphasize intermediation frictions, but our results on the exchange-rate effects of uncertainty do *not* rely on limits to arbitrage in financing foreign bond positions. Instead, the critical feature of our model is the presence of *long-lived* financial intermediaries that face leverage constraints. This feature plays a key role in determining how the conditional covariance between intermediaries' SDFs and the exchange rate reacts following a rise in uncertainty about the future. By contrast, the papers just mentioned generally do not feature long-lived intermediaries.

We proceed as follows. Section 2 lays out the model. Section 3 shows the dynamic effects of the uncertainty shocks. Section 4 extend the model to two goods to incorporate the exchange rate. Section 5 concludes.

2 Model

We begin by studying a single-good exchange economy (as in Lucas (1978)) with two countries. While it is straightforward to extend the model to allow for endogenous production, focusing on an endowment economy helps make our analysis transparent. Accordingly, we assume there is fixed aggregate supply of capital ("trees") in each country, that produce a random amount of output ("fruit") each period. The productivity of capital, Z_t, follows an exogenous random process that is uncorrelated across countries. In addition, and crucially, the volatility of Z_t in the home economy (which we take to represent the United States) is *time-varying*. Thus, uncertainty shocks are captured by the volatility of (next-period) home productivity, denoted σ_{zt}.

We assume that claims on capital held by financial intermediaries are subject to financing frictions (as in, for example, He and Krishnamurthy (2013)). In our analysis, we primarily focus on the effect of σ_{zt} on price of capital Q_t, credit spread (or risk premium) $E_t(R_{kt+1}) - R_t$, intermediary net worth N_t, as well as on the cross-border effects of higher uncertainty.

2.1 Home Economy

We assume home represents the United States, and foreign is an EM. We use * to denote the foreign economy.

2.1.1 Endowment

Aggregate capital in each country is exogenous and its aggregate supply normalized to unity. Capital's productivity is exogenous and given by random variable Z_t, subject to time-varying volatility:

$$Z_t = (1 - \rho_z) + \rho_z Z_{t-1} + \sigma_{zt-1}\varepsilon_{zt} \tag{1}$$

$$\sigma_{zt} = (1 - \rho_\sigma)\overline{\sigma}_z + \rho_\sigma \sigma_{zt-1} + \varepsilon_{\sigma t} \tag{2}$$

A positive shock to $\varepsilon_{\sigma t}$ means that agents feel more uncertain about the future productivity of capital. The formulation of uncertainty fluctuations is similar to the one used by Basu and Bundick (2017).

2.1.2 Households

Domestic households consume and save via deposits at financial intermediaries. Utility is

$$E_t \left(\sum_{i=0}^{\infty} \beta^i \frac{C_{t+i}^{1-\varrho} - 1}{1 - \varrho} \right), \tag{3}$$

where C_t is consumption. The budget constraint is:

$$C_t + D_t \leq R_{t-1} D_{t-1} + T_t, \tag{4}$$

where D_t is deposits, R_{t-1} is the safe interest rate between $t-1$ and t, and T_t is net transfers from bankers.The first-order condition of the households' optimization problem is

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\varrho} \right] R_t = 1 \tag{5}$$

The representative household includes a set of *bankers* who run financial intermediaries. Because they are members of the household, they use the household's stochastic discount factor (SDF) to value payoffs, and therefore they are risk averse to the extent that the household is. The presence of financial constraints, however, works to magnify the bankers' risk aversion, as we show. We next turn to describing the bankers' problem.

2.1.3 Financial intermediaries

Financial intermediaries ("banks," for short) obtain funds from households and also through internally accumulated net worth. They use these funds to finance claims on both domestic capital, K_{it}, and on foreign capital, K_{Fit} (which denotes claims on foreign capital held by home banker i). Bankers exit with probability $1-\sigma$, at which point they pay out their earnings to the household. Exiting bankers are replaced by a set of entrant bankers who receive initial equity endowment equal to fraction ξ of the value of the aggregate capital stock.

For a continuing banker i, the budget constraint states that the bank's expenditures (consisting of asset purchases, both at home and abroad, and repayment on debt obtained from domestic households, $R_{t-1}D_{t-1}$) cannot exceed its revenues (stemming from new financing raised from households, D_t, and payments of previous-period loans):

$$Q_tK_{it} + Q_t^*K_{Fit} + R_{t-1}D_{it-1} \leq D_{it} + (Z_t + Q_t)K_{it-1} + (Z_t^* + Q_t^*)K_{Fit-1} \tag{6}$$

where Z_t, Z_t^* denote the productivity of domestic and foreign capital, respectively. The variable Q_t is the price of claims on domestic capital and Q_t^* is the price of claims on foreign capital.

The balance sheet identity of the bank dictates that the capital funded within a given period—domestic and foreign—must equal the sum of the banker's own net worth (N_{it}) and debt raised from domestic households (D_{it}):

$$Q_tK_{it} + Q_t^*K_{Fit} = D_{it} + N_{it} \tag{7}$$

Combining equations (6) and (7), we obtain the net worth evolution equation:

$$N_{it} = (R_{kt} - R_{t-1})Q_{t-1}K_{it-1} + (R_{kt}^* - R_{t-1})Q_{t-1}^*K_{Fit-1} + R_{t-1}N_{it-1} \tag{8}$$

where $R_{kt} \equiv \frac{Z_t+Q_t}{Q_{t-1}}$ and $R_{kt}^* \equiv \frac{Z_t^*+Q_t^*}{Q_{t-1}^*}$. Define the "leverage," denoted by ϕ_{it}, and the ratio of the value of foreign to total assets in intermediary i's balance sheet, denoted by x_{it}, as the following, respectively:

$$\phi_{it} \equiv \frac{Q_tK_{it} + Q_t^*K_{Fit}}{N_{it}}, \tag{9}$$

$$x_{it} \equiv \frac{Q_t^*K_{Ft}}{Q_tK_{it} + Q_t^*K_{Fit}}. \tag{10}$$

Equation (8) then can be written as

$$N_{it} = [(R_{kt} - R_{t-1})(1 - x_{it}) + (R^*_{kt} - R_{t-1})x_{it}]\phi_{it} + R_{t-1}N_{it-1}, \tag{11}$$

which will help in formulating the banker's constrained optimization problem.

We motivate a friction in the banks' ability to raise funds by a simple limited enforcement problem, following Gertler and Kiyotaki (2010): after borrowing funds, the banker can renege on the obligations to depositors and instead divert a fraction of the assets he or she owns. This puts an endogenous limit on how much creditors allow the banker to lever up in the first place. Thus, the banker's objective is:

$$V_{it} = \max_{K_{it}, K_{Fit}, D_{it}} \quad E_t \Lambda_{t,t+1} \left[(1 - \sigma)N_{it+1} + \sigma V_{it+1}\right] \tag{12}$$

subject to the evolution of net worth, equation (8), and the incentive compatibility constraint

$$V_{it} \geq \theta(Q_t K_{it} + Q^*_t K_{Ft}) \tag{13}$$

where $\Lambda_{t,t+1} \equiv \beta \frac{C_{t+1}^{-\varrho}}{C_t^{-\varrho}}$ denotes the household's stochastic discount factor, and the parameter θ denotes the fraction that can be diverted. The incentive compatibility constraint states that the value of "misbehaving" must be no larger than the value of operating "honestly."

We solve the banker's problem by undetermined coefficients. As it is standard, we begin by guessing that the value function is linear:

$$V_{it} = \Psi_t N_{it},$$

where Ψ_t is non-bank-specific. Define expected discounted returns

$$\mu_t \equiv E_t[\Lambda_{t+1}\Omega_{t+1}(R_{kt+1} - R_t)] \tag{14}$$

$$\mu_{xt} \equiv E_t[\Lambda_{t+1}\Omega_{t+1}(R^*_{kt+1} - R_t)] \tag{15}$$

$$\nu_t \equiv E_t(\Lambda_{t+1}\Omega_{t+1})R_t \tag{16}$$

$$\Omega_{t+1} \equiv (1 - \sigma) + \sigma\Psi_{t+1} \tag{17}$$

Then the banker's problem can be re-written as

$$\Psi_t = \max_{\phi_{it}, x_{it}} \quad [\mu_t(1 - x_{it}) + \mu_{xt}x_{it}]\phi_{it} + \nu_t \tag{18}$$

subject to

$$\phi_{it} \leq \frac{\Psi_t}{\theta}. \tag{19}$$

Then the first-order condition with respect to x_{it} for the banker's problem is

$$\mu_{xt} = \mu_t. \tag{20}$$

This optimal portfolio condition states that the expected discounted excess returns on domestic and foreign assets held by U.S. intermediaries have to equalize. As long as $\mu_t > 0$, the constraint (19) always binds. In our calibration below, the constraint always binds in a neighborhood of the steady state, so that (19) holds with equality. Observe that ϕ_{it} is the same for all i. The undetermined coefficient Ψ_t can be solved from (18): $\Psi_t = \mu_t \phi_t + \nu_t$.

In each period, any banker i exits with probability $1 - \sigma$. The exiting bankers are replaced by new entrants who receive a transfer from the household equal to fraction ξ of the value of the capital stock in the previous period. Accordingly, the evolution of aggregate net worth, $N_t \equiv \int N_{it} di$, is

$$N_t = \sigma \left\{ [(R_{kt} - R_{t-1})(1 - x_{t-1}) + (R^*_{kt} - R_{t-1})x_{t-1}]\phi_{t-1} + R_{t-1} \right\} N_{t-1} + (1 - \sigma)\xi Q_{t-1} \tag{21}$$

2.2 Foreign Economy

The foreign economy is analogous to home, with one difference: foreign intermediaries cannot hold home capital, only capital of their own economy.[6] We assume that the foreign productivity process, Z^*_t, is given by

$$Z^*_t = (1 - \rho_z) + \rho_z Z^*_{t-1} + \overline{\sigma}_z \varepsilon^*_{zt}, \tag{22}$$

where ε^*_{zt} follows an *iid* process (and is thus uncorrelated with ε_{zt}).

2.3 Market Clearing

There are four markets: for home deposits, for foreign deposits, for claims on home capital, and for claims on foreign capital. Deposit market clearing requires that the amount supplied by households in each country equals amount demanded by intermediaries: $D_t = \int D_{it} di, D^*_t = \int D^*_{it} di$. Home capital can only be held by home bankers. Thus, $\int K_{it} di = 1$. Foreign capital can be held either by domestic or by foreign bankers, so we have

$$K_{Ft} + K^*_{Ft} = 1 \tag{23}$$

where K_{Ft} is total claims by home bankers on foreign capital, and K^*_{Ft} is total claims by foreign bankers on foreign capital.

Given the above, combining home bankers' and households' budget constraints gives the aggre-

[6] This assumption is justified by the observation that net foreign liabilities and gross foreign liabilities for emerging markets moves closely. See, for example, Duttagupta et al. (2013) and Avdjiev et al. (2017).

gate resource constraint for the U.S:

$$C_t + Q_t^* \Delta K_{Ft} = Z_t + Z_t^* K_{Ft-1} \tag{24}$$

Similarly, one can derive the resource constraint for the foreign economy:

$$C_t^* + Q_t^* \Delta K_{Ft}^* = Z_t^* K_{Ft-1}^* \tag{25}$$

Note that combining (24) and (25) give the world resource constraint:

$$C_t + C_t^* = Z_t + Z_t^*. \tag{26}$$

The complete set of equilibrium conditions are presented in Appendix A.

2.4 Calibration

Table 1 shows the parameter values we use in the model experiments shown below. The household risk aversion, ϱ, and discount factor, β, are set to reasonably conventional values. The parameters specific to the intermediary friction include the banking survival rate, σ, the transfer rate to new bankers, ξ, and the fraction of assets that can be diverted, θ. We set the survival rate to 0.97, similar to Gertler and Karadi (2011), implying a long horizon for bankers of nearly ten years. We set θ and ξ to hit two targets: a steady-state credit spread (or risk premium) of one hundred basis points, and a leverage ratio of five. The first target reflects the average values of corporate bond spreads. The second target is a conservative estimate of intermediary leverage. The parameter values resulting from these targets, $\theta = 0.33$ and $\xi = 0.08$, are well within the range of values used within the related literature.

The bottom of Table 1 shows the parameters pertaining to the stochastic processes (including for the uncertainty shock). We take these parameters from Basu and Bundick (2017).

3 Dynamic Effects of Uncertainty Shocks

In this section, we consider the effects of higher uncertainty. We start our analysis with an economy in autarky, which we think is a useful benchmark in clarifying how uncertainty shocks interact with intermediaries' financial constraint. We then consider the effects of higher uncertainty in the financially integrated economy.

3.1 Uncertainty shocks in autarky

Table 2 presents the conditional covariances between various endogenous variables in the model (as shown in rows 2-5), such as between the home and foreign asset values, Q and Q^*, and between the banker's SDF and the asset payoffs $Z + Q$ (both home and foreign). By assumption, the dividends Z and Z^* are uncorrelated across countries (first row). As expected, in autarky (second column with numbers), the asset values across countries are uncorrelated as well. The covariance between home bankers' SDF, $\mathbf{\Omega}$, and the home asset's payoff is highly negative: when asset returns are low, banker net worth is high and therefore financial constraints are tight, making a unit of net wroth highly valuable. Also as expected, the covariance between home bankers' SDF and the returns on the foreign asset is zero.

Figure 1 shows the effects on the home economy of an increase in uncertainty when the economy is in financial autarky. Uncertainty, σ_{zt}, increases to about 0.7 percent from its steady-state value of 0.4 percent, implying that returns to intermediaries from holding home productive assets become more uncertain unexpectedly. As shown in the figure, this gives rise to a sharp increase in the credit spread (or risk premium for holding the asset), a decline in the price of capital (the asset value), and a loss in intermediary equity (or net worth).

In order to understand the mechanics, it is useful to remember a few model equations. In autarky, all "fruits" are consumed domestically, implying that $C_t = Z_t$, which in turn gives rise to the following expression for households' SDF: $\Lambda_t = \beta(Z_t/Z_{t-1})^{-\varrho}$. Define the banker's SDF, $\mathbf{\Omega}_t$, as

$$\mathbf{\Omega}_t \equiv \Lambda_t \underbrace{(1 - \sigma + \sigma\Psi_t)}_{=\Omega_t} \tag{27}$$

where Ψ_t is given by (18). Moreover, from equation (19) at equality, one can write the maximum leverage allowed, denoted $\overline{\phi}_t$, after imposing the optimal portfolio condition (20), as

$$\overline{\phi}_t = \frac{\nu_t}{\theta - \mu_t}. \tag{28}$$

Using the definition of multipliers in equations (14)-(17), *maximum leverage* $\overline{\phi}_t$ can then be written as:

$$\overline{\phi}_t = \frac{E_t(\mathbf{\Omega}_{t+1})R_t}{\theta - E_t[\mathbf{\Omega}_{t+1}(\frac{Z_{t+1}+Q_{t+1}}{Q_t} - R_t)]}. \tag{29}$$

As shown in (29), maximum leverage is a forward-looking variable that depends positively on both the discounted value of a unit of net worth, $E_t(\mathbf{\Omega}_{t+1})R_t$, and on the excess return per unit of bank assets, $E_t[\mathbf{\Omega}_{t+1}(\frac{Z_{t+1}+Q_{t+1}}{Q_t} - R_t)]$. The reason is that both variables raise the continuation value of the bank, and so reduce the incentives to misbehave.[7] Observe that given expectations of future variables and R_t, $\overline{\phi}_t$ is a decreasing function of Q_t.

On the other hand, *actual* leverage $\phi_t = Q_t/N_t$ also depends negatively on Q_t. This can be seen from the evolution of aggregate net worth, which, in autarky, is given by:

$$N_t = \sigma(\underbrace{R_{kt}}_{=\frac{Z_t+Q_t}{Q_{t-1}}} - R_{t-1})\phi_{t-1}N_{t-1} + \sigma R_{t-1}N_{t-1} + (1-\sigma)\xi Q_{t-1}, \tag{30}$$

[7] Note that maximum leverage decreases in θ, the amount the banker can obtain by misbehaving.

Note that a higher Q_t raises the banker's return R_{kt}. Further, to the extent the banker is leveraged in the first place (ϕ_{t-1} is much larger than unity), N_t will tend to increase more than one for one with Q_t. In this way, actual leverage ϕ_t will tend to fall as Q_t rises, implying that it is a downward-sloping schedule in Q_t. Note also that actual leverage is a backward-looking object, so it does not shift with changes in risk. The role of risk on equilibrium asset prices and leverage can be illustrated graphically as in Figure 2. The blue schedule represents the link between actual leverage and the asset price, and the orange one displays the relationship between maximum leverage and the asset price. As discussed before, both schedules are downward sloping in Q_t. In addition, the maximum-leverage schedule is steeper. Now consider an increase in σ_{zt}. The higher uncertainty leads to a more negative conditional covariance between $Z_{t+1} + Q_{t+1}$ and the discount factor $\mathbf{\Omega}_{t+1}$, which lowers $E_t[\mathbf{\Omega}_{t+1}(Z_{t+1} + Q_{t+1})]$. Thus, with higher risk the orange schedule shifts left, and the blue schedule doesn't move. So the new equilibrium following higher risk is given by lower Q_t and lower net worth N_t (as well higher leverage).

Turning to the effects of higher risk on the credit spread (or risk premium), we can derive an expression for the risk premium from (29), after imposing the condition that leverage constraint always binds (such that $\phi_t = \bar{\phi}_t$):[8]

$$E_t(R_{kt+1}) - R_t = \frac{Cov_t(\mathbf{\Omega}_{t+1}, -R_{kt+1}) + \theta}{E_t(\mathbf{\Omega}_{t+1})} - \phi_t^{-1} R_t \tag{31}$$

Moreover, one can write the standard expression for the risk premium in a setting without intermediary frictions as:

$$E_t(R_{kt+1}) - R_t = \frac{Cov_t(\Lambda_{t+1}, -R_{kt+1})}{E_t(\Lambda_{t+1})} \tag{32}$$

Comparing equations (31) and (32), two features of our model with intermediary frictions are worth highlighting for the determination of the risk premium. First, the covariance term in (31) fluctuates much more, as the banker's SDF $\mathbf{\Omega}_{t+1}$ is much more countercyclical than the household's SDF Λ_{t+1}.

Second, in the model with frictions, the premium is *also* positively related to leverage ϕ_t. This occurs because the incentives to misbehave increase with higher leverage, leading banks to require a larger excess return for holding assets. This feature adds an extra kick to the effects of volatility through the impact of higher risk on leverage.[9] Thus, the presence of frictions in intermediation has a significant bearing for the determination of risk premia in the model. In this sense the model fits into the "intermediary asset pricing" category (He and Krishnamurthy (2013); see He et al. (2017) for evidence).

Going back to Figure 1, one can see the implications of this feature of our model in terms of asset pricing. The blue lines illustrate the effects of higher uncertainty just described. The gray lines show the effects of uncertainty in a frictionless model. The frictionless setting is characterized

[8] Note that we flip the sign of the covariance so that it's positive and increasing in risk.

[9] There is also a constant additive term given by the agency frictions parameter θ.

by the following two equations:

$$\beta E_t(\frac{Z_{t+1}^{-\varrho}}{Z_t^{-\varrho}})R_t = 1, \tag{33}$$

$$\beta E_t[\frac{Z_{t+1}^{-\varrho}}{Z_t^{-\varrho}}(Z_{t+1} + Q_{t+1})] = Q_t. \tag{34}$$

These equations constitute a simple Lucas (1978) asset pricing model, and can be used to compute the impact of higher uncertainty σ_{zt} on the asset price Q_t, the risk-free rate R_t, and the risk premium. As is well known, such a frictionless setting predicts very small effects of risk (see Mehra and Prescott (1985)) for low values of ϱ. Thus, as Figure 1 makes clear, the dynamic effects of an increase in uncertainty are an order of magnitude smaller compared with our model with intermediary frictions (recall that in our baseline calibration we have a risk aversion, ϱ, of just 2.5). In addition, in the frictionless model the asset value Q_t moves very little and in the "opposite" direction of what is typically found in the empirical literature: it goes *up* with higher uncertainty, while the empirical literature finds that asset prices fall when measures of uncertainty rise (see, for example, Miranda-Agrippino and Rey (2021)).

3.2 Uncertainty shocks with financial integration

We next analyze the case in which the two countries are financially integrated. Table 2 shows the conditional covariances with financial integration (the first row with numbers), and compares the results with the economy in financial autarky (the second row with numbers). As shown in the table, the asset values across countries, Q and Q^*, become highly positively correlated across the two countries with integration, although the dividends (Z and Z^*) are assumed to be uncorrelated. Moreover, home bankers' SDF comoves negatively with the foreign country's payoff, and the conditional covariances within each country become significantly smaller. This reflects a (well-known) risk-sharing arrangement between countries that emerges due to financial integration.

We now turn to the dynamic effects of higher home uncertainty in a world in which countries are financially integrated, shown in Figure 3. The key observation is that a rise in home uncertainty affects the foreign economy variables by almost as much as it does the home economy variables: the increases in the risk premium abroad, and the declines in the foreign asset values and intermediary net worth, are nearly of the same magnitude as their counterparts at home. Thus, the model features powerful spillovers on foreign economies of increases in home uncertainty.

What drives these larges cross-border effects? Recall from the analysis of the autarky case that the key channel trough which higher uncertainly feeds into the economy is by making the conditional covariance between intermediaries payoffs and their SDF more negative. In effect, intermediation becomes riskier, which endogenously tightens intermediaries' leverage constraints. Now consider higher uncertainty under financial integration. In the second column, second row of Figure 3, we plot the covariances between home bankers' SDF and the excess return on home securities (blue solid line) and between foreign bankers' SDF and foreign securities (orange dash-dotted line). As shown, higher uncertainty leads both of these covariances to move down in tandem: in each case, the covariance increases (in absolute magnitude) relative to its pre-shock value—where the magnitutes are similar to the time path of the shock σ_{zt} itself. Thus, with higher home uncertainty, *both* home and foreign assets effectively become riskier, and thus *both* sets of intermediaries face deleveraging pressure.[10]

To understand why the covariances move synchronously, it is helpful to recall the optimal portfolio for U.S. (or global) banks, equation (20):

$$E_t(\mathbf{\Omega}_{t+1} R^*_{kt+1}) = E_t(\mathbf{\Omega}_{t+1} R_{kt+1}) \tag{35}$$

Suppose that a standard adverse productivity shock (a negative disturbance to Z_t) hurts home banks' net worth. This limits home banks' ability to arbitrage, and triggers a rise in the domestic expected return on capital (the right-hand side of (35)) and a decline in Q_t. Note that a first-order approximation is sufficient for the present argument: observe that $E_t(\mathbf{\Omega}_{t+1})$ vanishes from (35) to a first order. Without any change in foreign variables, equation (35) would be violated: the left-hand side would exceed the right-hand side, indicating that global intermediaries have incentives to pull investments out of the foreign economy and into the domestic one. To restore porftolio optimality, the foreign expected excess return must rise as well, which occurs through a fall in Q^*_t.

In turn, the tight link between Q_t and Q^*_t induced by the presence of global banks helps explain why *all* conditional covariances increase with higher uncertainty. Suppose that the riskiness of home productivity goes up. This makes home securities more risky not just because their dividend process has turned more volatile, but also (and mainly) because their price has turned more volatile as well. But through arbitrage by global banks, the foreign price Q^*_t turns more volatile at the same time, and thus the risk facing foreign bankers also rises—as reflected in the more-negative covariance shown in Figure 3.

Observe also that the effects of the shock are considerably muted under financial integration relative to the autarky economy: comparing Figure 1 with Figure 3, the risk premium increases much more in autarky, and Q_t and N_t fall more, given the same increase in uncertainty. Key to this finding is that movements in domestic productivity Z_t have considerably smaller effects under financial integration. In autarky, lower home productivity, and the consequent drop in net worth, must be accommodated by lower Q_t. The usual financial accelerator dynamics operate powerfully: lower N_t leads to lower Q_t, which feeds back into net worth. Financial integration introduces a second margin of adjustment: now Q^*_t also falls (through global banks' portfolio condition). In turn, this mitigates the required adjustment of Q_t and N_t. The covariances between discount factors and asset payoffs are thus much smaller (in absolute value) under financial integration, as made clear by Table 2. This also means that they increase by less (in absolute value) with integration. In this way, the size of the impulse that triggers deleveraging pressure (which ultimately rests on the

[10] Figure ?? in the Appendix shows the effects with financial integration but without intermediary frictions. As in the case with autarky, the (cross-border) effects of higher uncertainty are very small. But more importantly, the asset values in the model, Q and Q^*, move in opposite directions, contrary to what is implied by the empirical estimates.

magnitude of the rise in the conditional covariances between SDF and asset payoffs) is smaller under financial integration.

Overall, our findings offer a very natural explanation for the high degree of comovement between measures of U.S. uncertainty, such as the VIX, and corporate bond spreads for different countries.[11] More formally, Figure 4 shows the empirical counterpart of the effects of an increase in U.S. uncertainty. These empirical estimates are obtained from a standard Vector Autoregressive (VAR) model including measures of credit spreads (proxying for the risk premium) in the United States, advanced foreign economies (AFEs) and emerging market economies (EMEs) as well as the VXO. Uncertainty shocks are identified by assuming that they are the only ones shocks that move the VXO on impact, as in Basu and Bundick (2017). The figure also reproduces the results predicted by the model. In the data, a one-standard-deviation uncertainty shock increases the VXO by around 15 percent, and leads to an increase in corporate bond spreads in the U.S. and in AFEs of just under 0.2 percentage points, and around 0.25 percentage points in EME corporate bond spreads. The model-implied effects are generally very close to the empirical ones. Overall, we argue that the model does pretty well in matching the observed responses in credit spreads globally to an increase in uncertainty.

4 Uncertainty Shocks and Exchange Rates

We have so far studied a single-good economy real in which the real exchange rate is accordingly fixed at unity by assumption, and trade results entirely from consumption-smoothing motivations. We next study an extension with two goods in which the exchange rate can fluctuate. Our goal is to study the effect of uncertainty on the exchange rate. We make a number of simplifications to the previous setting to make the analysis transparent. In particular, we abstract from cross-border holdings of risky securities, and from financial frictions in the foreign economy. We next describe the economy and derive the key equilibrium relationships.

4.1 Home Households

Domestic households continue to maximize (3), but now C_t is a Cobb-Douglas aggregate of a home-produced good, $C_{H,t}$, and a foreign-produced one, $C_{F,t}$:

$$C_t = \left(\frac{C_{H,t}}{\omega}\right)^{\omega} \left(\frac{C_{F,t}}{1-\omega}\right)^{(1-\omega)}, \tag{36}$$

where the parameter $\omega \in (0.5, 1]$ governs home bias in consumption preferences. We denote the terms of trade (defined as the price of the foreign good in terms of the home good) by $\mathcal{T}_t$, and the real exchange rate (defined as the price of the foreign consumption basket in terms of the home basket) by $\mathcal{S}_t$. We assume that both countries practice producer currency pricing. Under this

[11] See, for example, Figure 11 in Appendix, in which we use the VXO to proxy for U.S. uncertainty

assumption, it is straightforward to show that $\mathcal{T}_t$ and S_t must satisfy the following condition:

$$\mathcal{S}_t = \mathcal{T}_t^{2\omega-1}. \tag{37}$$

Given consumer optimality, demands for home and foreign goods satisfy

$$C_{H,t} = \omega \mathcal{T}_t^{1-\omega} C_t, \tag{38}$$

$$C_{F,t} = (1-\omega)\mathcal{T}_t^{-\omega} C_t. \tag{39}$$

The home consumer's intertemporal optimality condition is

$$1 = E_t(\Lambda_{t+1})R_t, \tag{40}$$

where R_t is the home real interest rate and Λ_t is the household's SDF between $t-1$ and t, given by

$$\Lambda_t = \beta \frac{C_t^{-\varrho}}{C_{t-1}^{-\varrho}} \tag{41}$$

4.2 Home Financial Intermediaries and Government Bonds

As before, home financial intermediaries hold domestic risky securities. In addition, they can also hold a (real) foreign government bond as well, denominated in the foreign currency. We continue to think of these institutions as "global banks," as they hold international government bonds in addition to domestic private securities.

A continuing banker i's budget constraint is

$$Q_t K_{it} + R_{t-1}D_{it-1} + \mathcal{S}_t B_{it}^* \leq D_{it} + (Z_t + Q_t)K_{it-1} + \mathcal{S}_t R_{t-1}^* B_{it-1}^*, \tag{42}$$

where B_{it}^* is the intermediary's holdings of the foreign government bond, and R_t^* is the foreign-currency interest rate.

The intermediary's balance sheet identity is

$$Q_t K_{it} + \mathcal{S}_t B_{it}^* = D_{it} + N_{it}. \tag{43}$$

As a benchmark, we assume that the intermediary can divert holdings of private assets (capital), but *cannot* divert its portfolio of government bond holdings: the incentive constraint (the counterpart of equation (13)) reads

$$V_{it} \geq \theta Q_t K_{it}. \tag{44}$$

This assumption implies that the intermediary does not face limits to arbitrage in its financing of foreign government bonds. Given this assumption, it is straightforward to show that the following condition must hold:

$$E_t\left[\Lambda_{t+1}\Omega_{t+1}\left(\frac{\mathcal{S}_{t+1}R_t^*}{\mathcal{S}_t}-R_t\right)\right]=0. \tag{45}$$

That is, there is perfect arbitrage between bonds denominated in different currencies. Note, however, that the relevant discount factor is the global banks', $\Lambda_{t+1}\Omega_{t+1} \equiv \boldsymbol{\Omega}_{t+1}$. Through this term, the model generates substantial deviations from uncovered interest parity (UIP) in response to uncertainty shocks, as we will show.

Proceeding in similar steps as before, whenever the constraint binds we must have

$$\phi_t(1-y_t)=\frac{\Psi_t}{\theta}, \tag{46}$$

where again Ψ_t is the marginal value of net worth,

$$\phi_t=\frac{Q_t+\mathcal{S}_tB_t^*}{N_t} \tag{47}$$

is total leverage, and

$$y_t=\frac{\mathcal{S}_tB_t^*}{Q_t+\mathcal{S}_tB_t^*} \tag{48}$$

is the share of foreign government bonds in domestic banks' portfolio. (These expressions hold for each individual bank i as well as for the aggregate, denoted here by letters without i subscripts.)

The value of banker wealth satisfies

$$\mu_t(1-y_t)\phi_t+\nu_t, \tag{49}$$

where

$$\mu_t=E_t[\Lambda_{t+1}\Omega_{t+1}(R_{kt+1}-R_t)], \tag{50}$$

$$\nu_t=E_t(\Lambda_{t+1}\Omega_{t+1})R_t, \tag{51}$$

$$\Omega_{t+1}=(1-\sigma)+\sigma\Psi_{t+1}, \tag{52}$$

$$R_{k,t}=\frac{Z_t+Q_t}{Q_{t-1}}. \tag{53}$$

Combining (42) with (43) and aggregating across banks yields the law of motion for aggregate net worth:

$$N_t = \sigma \left\{ [(R_{kt} - R_{t-1})(1 - y_{t-1}) + (\frac{\mathcal{S}_t}{\mathcal{S}_{t-1}} R^*_{t-1} - R_{t-1})y_{t-1}]\phi_{t-1} + R_{t-1} \right\} N_{t-1} + (1-\sigma)\xi Q_{t-1} \tag{54}$$

4.3 The Foreign Economy

Foreign households face a problem analogous to home households. They may also hold the foreign government bond (which we assume is in zero aggregate net supply). The corresponding optimality conditions are the following:

$$1 = E_t(\Lambda^*_{t+1})R^*_t, \tag{55}$$

$$\Lambda^*_t = \beta^* \frac{C_t^{-*\varrho}}{C_{t-1}^{*-\varrho}}, \tag{56}$$

$$C^*_{F,t} = \omega \mathcal{T}_t^{-(1-\omega)} C^*_t, \tag{57}$$

$$C^*_{H,t} = (1-\omega)\mathcal{T}_t^{\omega} C^*_t. \tag{58}$$

4.4 Market Clearing

The total amount consumed of the home good must be equal to its total production:

$$Z_t = C_{H,t} + C^*_{H,t}. \tag{59}$$

(recall that we normalize the capital stock in each country to unity). A similar condition must hold for the foreign good:

$$Z^*_t = C^*_{F,t} + C_{F,t} \tag{60}$$

Finally, by combining home and foreign budget constraints it is possible to derive the following balance of payments condition:

$$C^*_{H,t} - \mathcal{T}_t C_{F,t} = \mathcal{T}_t^{\omega} \left(B^*_t - R^*_{t-1} B^*_{t-1} \right). \tag{61}$$

From equation (61), whenever home's imports exceed the value of exports, the home economy accumulates net foreign assets.

Equations (37), (38)-(41), (45)-(61) determine the endogenous variables $\Lambda_t, \Lambda^*_t, R_t, R^*_t, C_t, C^*_t, C_{H,t}, C^*_{H,t}, C_{F,t}, C^*_{F,t}, \mathcal{T}_t, \mathcal{S}_t, N_t, R_{k,t}, y_t, \phi_t, Q_t, \mu_t, \Omega_t, \nu_t, \Psi_t$, and B^*_t.

4.5 Dynamic Effects of Uncertainty Shocks on Exchange Rates

We now examine the model's implications for the effects of uncertainty on the exchange rate. We calibrate the home bias parameter, ω, to 0.95, to reflect the relatively small trade share of the United States with emerging market economies. All remaining parameters are calibrated as in Table 1.

Figure 5 shows the effect of higher U.S. uncertainty, σ_{zt} in our baseline model with intermediary frictions. As a reference, the figure also shows the effects of the same shock in the setting without intermediary frictions (dashed red lines).[12] In the absence of intermediary frictions, there are two competing forces in determining the response of the exchange rate: on the one hand, the home risk-free rate declines by more than the foreign rate, which exerts upward pressure on $\mathcal{S}_t$. On the other hand, the "risk adjustment" (the conditional covariance between Λ_{t+1} and $\mathcal{S}_{t+1}$), which is always negative, turns more negative when σ_{zt} rises, thus exerting downward pressure on $\mathcal{S}_t$ (see equation (45)). (To understand why the covariance is negative, consider a decline in U.S. productivity Z_t: lower supply of the U.S. "fruit" makes it more expensive relative to the foreign fruit, lowering $\mathcal{S}_t$; at the same time, lower U.S. consumption increases the U.S. household's SDF). The interest differential channel turns out to dominate, and the dollar depreciates. The size of the effect, however, is very small.

With intermediary frictions, the risk adjustment term is much more powerful: observe that the downward move of $Cov_t(\mathbf{\Omega}_{t+1}, \mathcal{S}_{t+1})$ is orders of magnitude larger than without frictions. The reason this risk-adjustment term is more powerful is that when U.S. fruit (Z_t) is low (which lowers $\mathcal{S}_t$), these bankers' returns are low, and therefore their constraints are tight. Thus, in a similar way as in the one-good model the presence of intermediaries' constraints made the covariance term in the risk premium much more elastic to movements in uncertainy, these constraints now also make the premium term in equation (45) more elastic to uncertainty. As a consequence, this risk effect dominates the interest differential channel, and the dollar now *appreciates* substantially *vis-á-vis* the foreign currency following the increase in uncertainty. Further, the magnitude of the appreciation is substantial. Accompanying the stronger dollar is a persistent outflow from foreign bonds ($\Delta B_t^* < 0$)—in contrast to the frictionless case, which featured a small inflow.

Figure 6 displays the effects of higher uncertainty on the UIP premium in our baseline model with intermediary frictions (solid blue line) and in a model without intermediary frictions (dashed red line). Note that the UIP premium is defined as the expected excess returns for holding emerging economy local bonds adjusted for the expected exchange rate depreciation of foreign currencies, $r_t^* + E_t(\Delta s_{t+1})$, over the (net) safe rate on U.S. bonds, r_t (lowercase denotes the log of uppercase letters). Consistent with the findings on the risk adjustment term $-Cov_t(\mathbf{\Omega}_{t+1}, \mathcal{S}_{t+1})$ we just described,[13]when uncertainty rises global investors require significantly larger excess returns for holding EM bonds in our baseline model, compared with the without intermediary frictions, consistent with the empirical evidence (see, for example, Kalemli-Ozcan and Varela (2021)).

[12] See Figure 10 in the Appendix for a zoomed-in version of the figure without intermediate frictions.

[13] The UIP premium and the conditional covariance between SDF and future exchange rate can be shown to satisfy

These findings appear consistent with the often-discussed notion of the dollar as a "safe haven" currency which appreciates, especially against emerging market currencies, in times of higher uncertainty. More specifically, they may rationalize the observed positive correlation between the VIX and the dollar exchange rate against EMs.

Figure 7 shows the effects of uncertainty shock on exchange rate, both implied by an empirical VAR model (solid black lines) and the model (blue lines). As before, the model does a reasonably good job in matching the observed responses of exchange rate to an increase in uncertainty: the dollar appreciates in both the model and the data in response to higher uncertainty. We also compare the model's implications for the UIP premium with those found in the data, using the empirical measures of the UIP premium constructed by Kalemli-Ozcan and Varela (2021). We compute a single foreign UIP premium time series by taking the average of all countries in the sample, and then estimate a VAR with the UIP premium and the VXO. As shown in Figure 8 the UIP premium in the data rises significantly following an uncertainty shock. The model-implied response aligns quite well with the data for this case as well.

5 Conclusion

We presented an open economy macro model with financial intermediaries that are balance-sheet-constrained and subject to time-varying uncertainty in the prospective returns on their capital holdings. We show that in a financially integrated world, an increase in U.S. uncertainty leads to global deleveraging pressure, a decrease in global asset prices, and a rise in global risk premia, with magnitudes consistent with those obtained from an identified VAR. The model also implies an appreciation of the dollar and a rise in uncovered interest parity premia on foreign currencies in the wake of higher U.S. uncertainty, also consistent with the data. Possible next steps include using the model to shed light on the differential behavior between advanced and emerging economies observed in the data.

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the following equation:

$$E_t\left(\frac{\frac{\mathcal{S}_{t+1}}{\mathcal{S}_t}R_t^*}{R_t}\right) = \frac{-Cov_t(\boldsymbol{\Omega}_{t+1}, \frac{\frac{\mathcal{S}_{t+1}}{\mathcal{S}_t}R_t^*}{R_t})}{E_t(\Omega_{t+1})} + 1. \quad (62)$$

Thus, the UIP premium on foreign currencies (the left-hand side) is increasing in $-Cov_t(\boldsymbol{\Omega}_{t+1}, \mathcal{S}_{t+1})$.

Table 1: Parameter Values

Parameter	Description	Value	Source/Target
ϱ	Risk aversion	3	
β	Discount factor	0.995	Basu and Bundick (2017)
σ	Survival rate of bankers	0.97	Gertler and Karadi (2011)
ξ	Transfer to entering bankers	0.09	Leverage = 5 (assets/equity)
θ	Fraction of capital that can be diverted	0.34	Spread = 1 p.p. per year
ω	Home bias (two-good model)	0.95	
ρ_σ	Persistence of uncertainty shock	0.75	Basu and Bundick (2017)
$\overline{\sigma}_z$	Average SD of productivity shock	0.004	Basu and Bundick (2017)
ρ_z	Persistence of productivity shock	0.90	

Table 2: Conditional covariances (with constant uncertainty)

Variable	Financial Integration	Autarky
$Cov_t(Z_{t+1}, Z^*_{t+1})$	0	0
$Cov_t(Q_{t+1}, Q^*_{t+1})$	14.26	0
$Cov_t(\mathbf{\Omega}_{t+1}, Q_{t+1} + Z_{t+1})$	-0.72	-1.44
$Cov_t(\mathbf{\Omega}_{t+1}, Q^*_{t+1} + Z^*_{t+1})$	-0.72	0
$Cov_t(\mathbf{\Omega}^*_{t+1}, Q^*_{t+1} + Z^*_{t+1})$	-0.72	-1.44

Figure 1: Dynamic effects of uncertainty shock in autarky

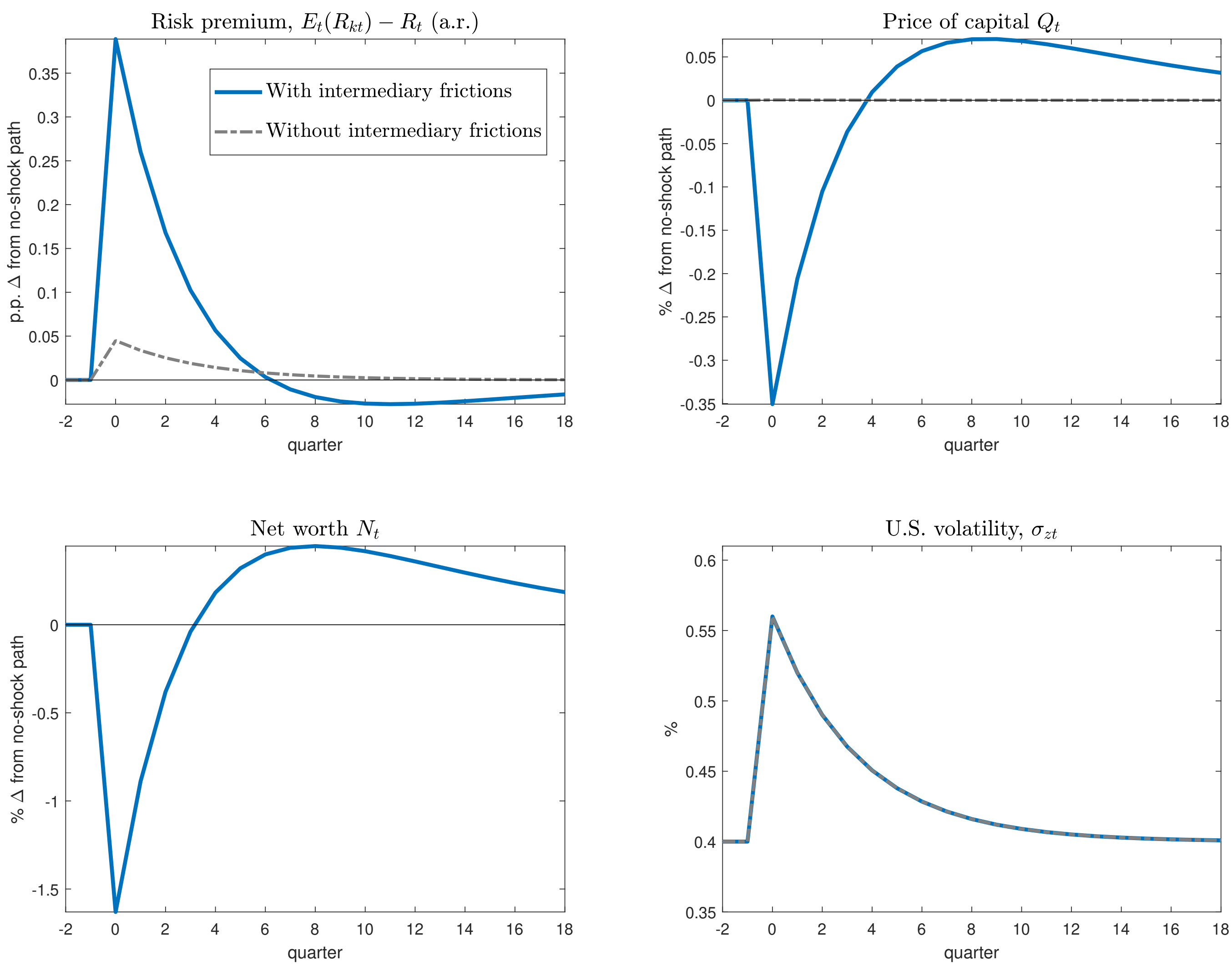


Figure 2: Effects of higher uncertainty on equilibrium price Q_t and leverage ϕ_t

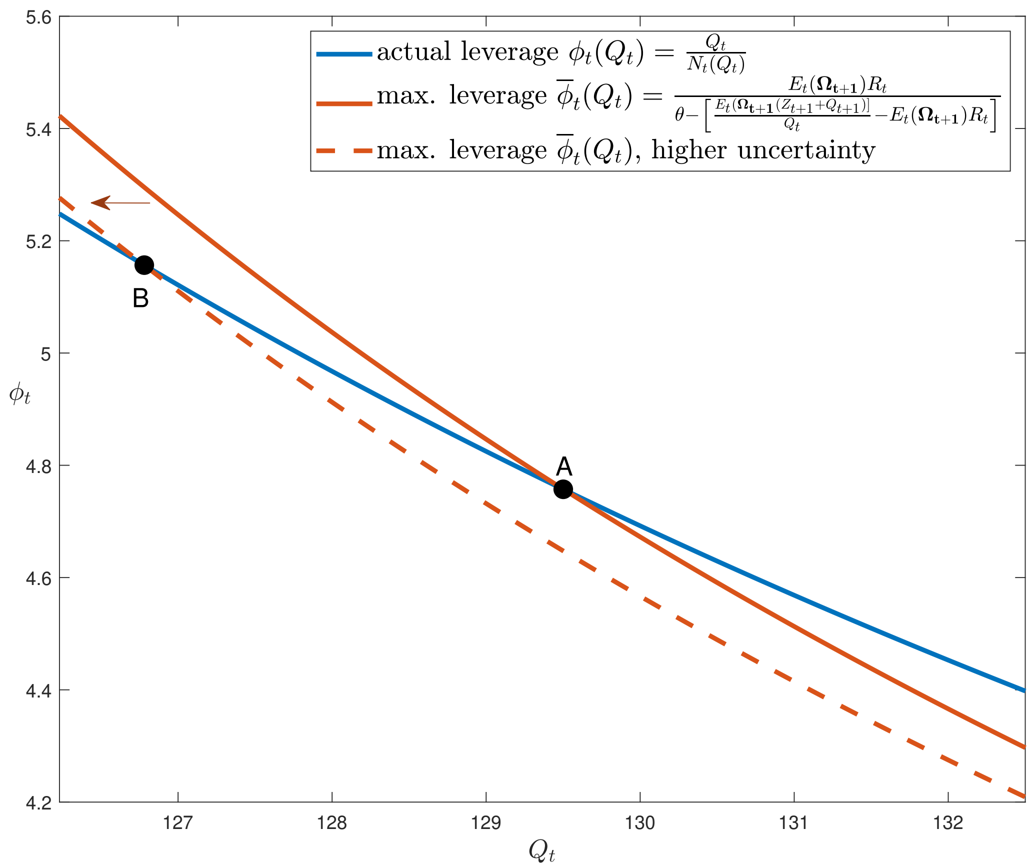


Figure 3: Dynamic effects of U.S. uncertainty shock with financial integration

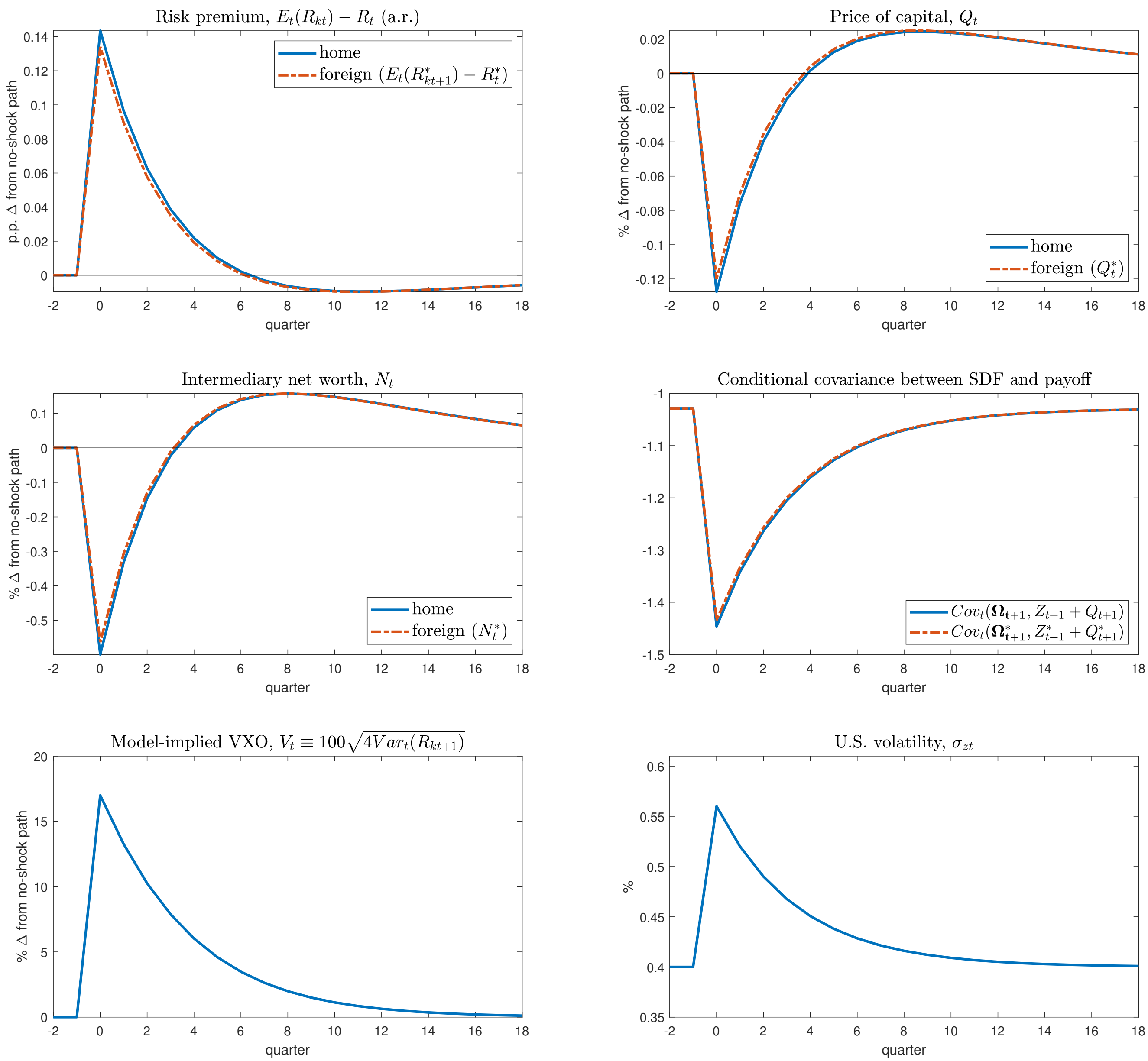


Figure 4: Effects of uncertainty shock on credit spreads, VAR v. model

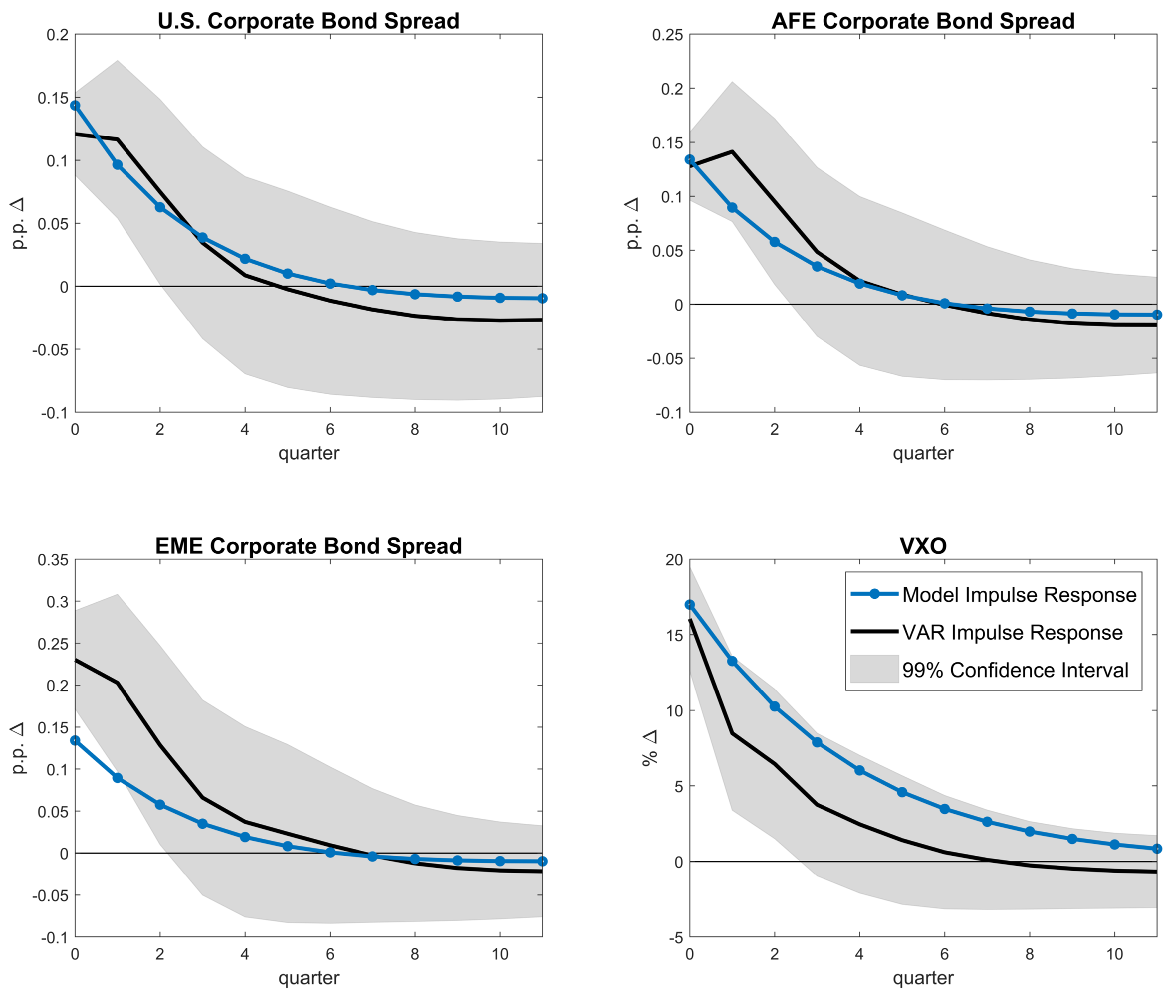


Figure 5: Exchange rate model, effects of U.S. uncertainty shock

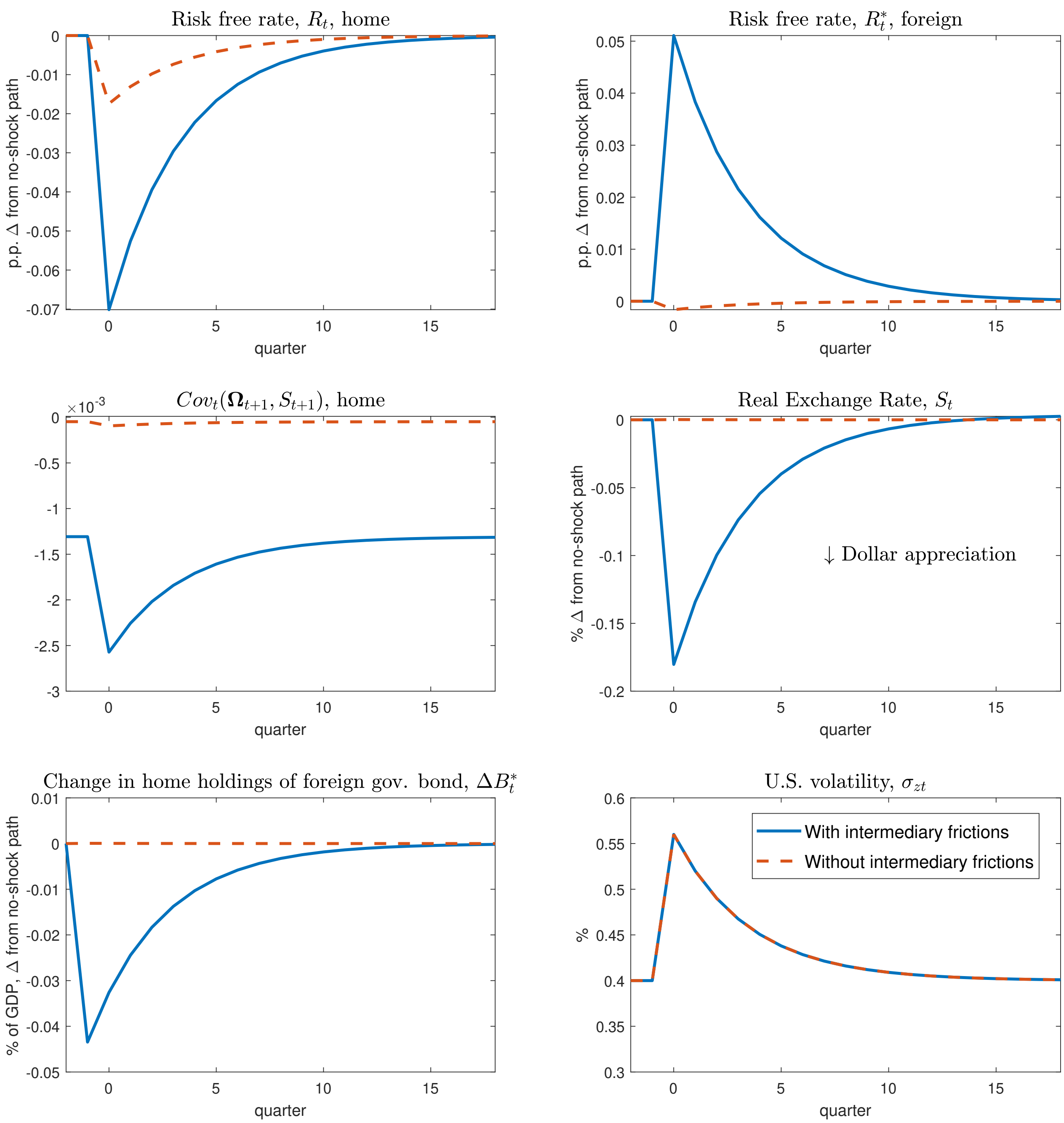


Figure 6: Exchange rate model, effects of U.S. uncertainty shock on UIP premium

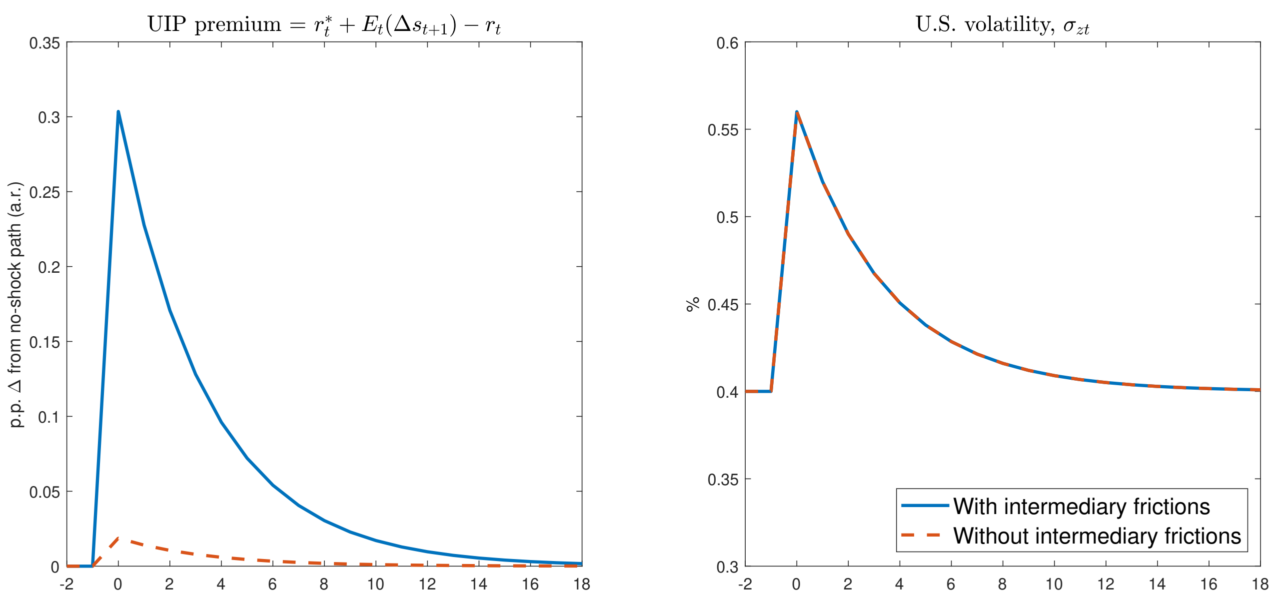


Figure 7: Effects of uncertainty shock on exchange rate, VAR v. model

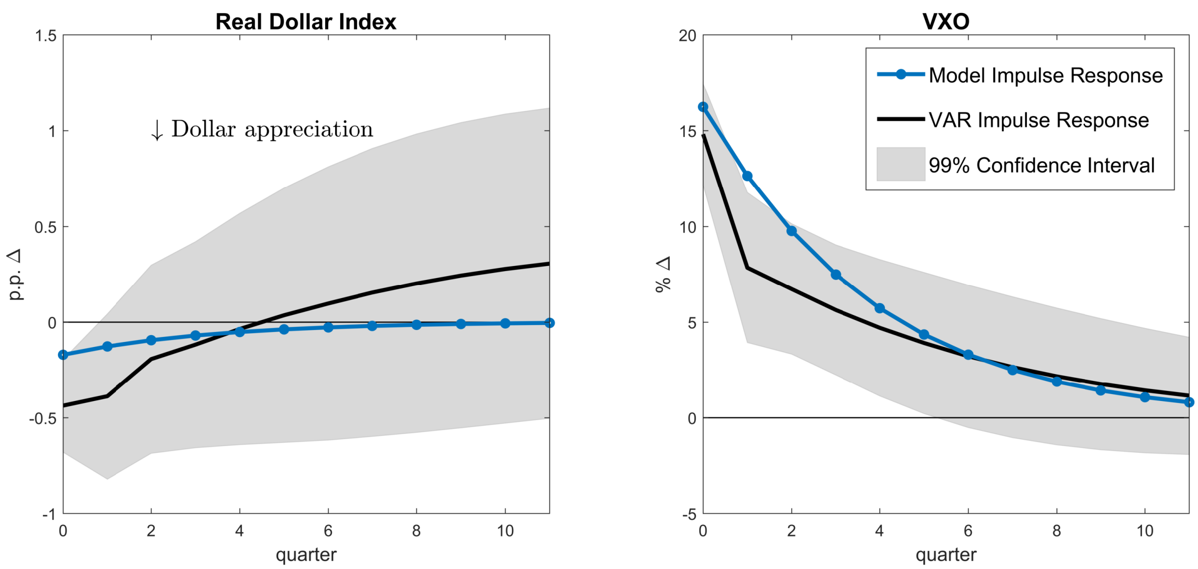
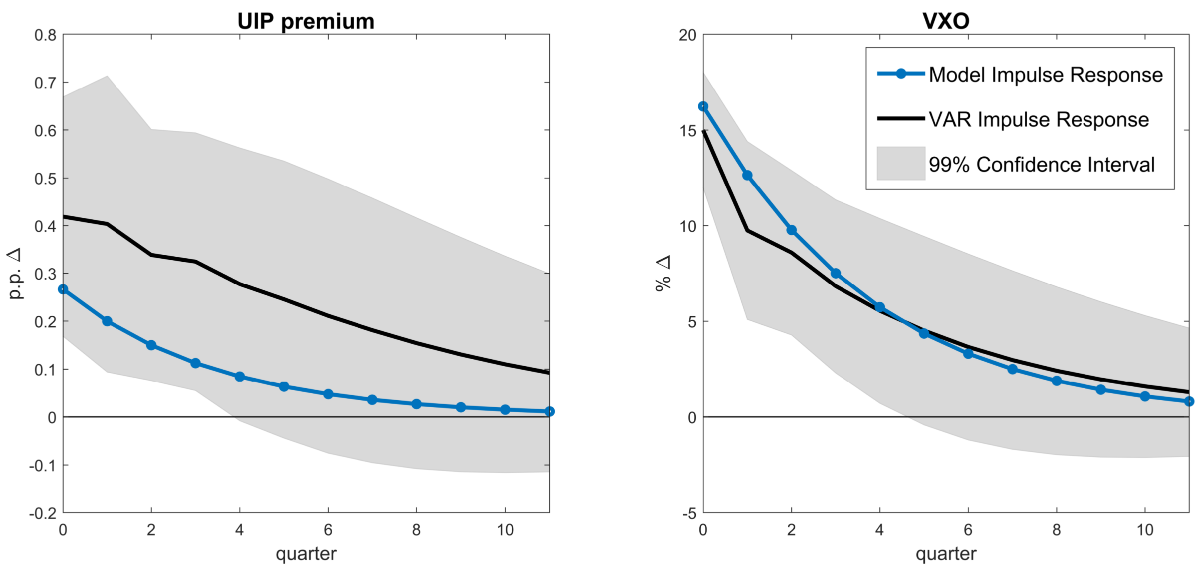


Figure 8: Effects of uncertainty shock on UIP premium, VAR v. model



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A Complete Set of Equilibrium Conditions

Home:

$$1 = E_t(\Lambda_{t+1})R_t \tag{63}$$

$$\Lambda_t = \beta \frac{C_t^{-\varrho}}{C_{t-1}^{-\varrho}} \tag{64}$$

$$N_t = \sigma \left\{ [(R_{kt} - R_{t-1})(1 - x_{t-1}) + (R_{kt}^* - R_{t-1})x_{t-1}]\phi_{t-1} + R_{t-1} \right\} N_{t-1} + (1 - \sigma)\xi Q_{t-1} \tag{65}$$

$$R_{kt} = \frac{Z_t + Q_t}{Q_{t-1}} \tag{66}$$

$$\mu_t = E_t[\Lambda_{t+1}\Omega_{t+1}(R_{kt+1} - R_t)] \tag{67}$$

$$\mu_{xt} = E_t[\Lambda_{t+1}\Omega_{t+1}(R_{kt+1}^* - R_t)] \tag{68}$$

$$\nu_t = E_t(\Lambda_{t+1}\Omega_{t+1})R_t \tag{69}$$

$$\Omega_{t+1} = (1 - \sigma) + \sigma\Psi_{t+1} \tag{70}$$

$$\mu_{xt} = \mu_t \tag{71}$$

$$\phi_t = \frac{\Psi_t}{\theta} \tag{72}$$

$$\Psi_t = [\mu_t(1 - x_t) + \mu_{xt}x_t]\phi_t + \nu_t \tag{73}$$

$$\phi_t = \frac{Q_t + Q_t^* K_{Ft}}{N_t} \tag{74}$$

$$x_t = \frac{Q_t^* K_{Ft}}{Q_t + Q_t^* K_{Ft}} \tag{75}$$

$$C_t + Q_t^* \Delta K_{Ft} = Z_t + Z_t^* K_{Ft-1} \tag{76}$$

Foreign:

$$1 = E_t(\Lambda_{t+1}^*)R_t^* \tag{77}$$

$$\Lambda_t^* = \beta^* \frac{C_t^{-*\varrho}}{C_{t-1}^{*-\varrho}} \tag{78}$$

$$N_t^* = \sigma[(R_{kt}^* - R_{t-1}^*)\phi_{t-1}^* + R_{t-1}^*]N_{t-1}^* + (1 - \sigma)\xi^* Q_{t-1}^* \tag{79}$$

$$R_{kt}^* = \frac{Z_t^* + Q_t^*}{Q_{t-1}^*} \tag{80}$$

$$\mu_t^* = E_t[\Lambda_{t+1}^*\Omega_{t+1}^*(R_{kt+1}^* - R_t^*)] \tag{81}$$

$$\nu_t^* = E_t(\Lambda_{t+1}^*\Omega_{t+1}^*)R_t^* \tag{82}$$

$$\Omega^*_{t+1} = (1-\sigma) + \sigma\Psi^*_{t+1} \tag{83}$$

$$\phi^*_t = \frac{\Psi^*_t}{\theta^*} \tag{84}$$

$$\Psi^*_t = \mu^*_t\phi^*_t + \nu^*_t \tag{85}$$

$$\phi^*_t = \frac{Q^*_t K^*_t}{N^*_t} \tag{86}$$

$$C^*_t + Q^*_t \Delta K^*_{Ft} = Z^*_t K^*_{Ft-1} \tag{87}$$

Market clearing for claims on foreign capital:

$$K_{Ft} + K^*_{Ft} = 1 \tag{88}$$

The 26 equilibrium conditions above determine the evolution of the 26 endogenous variables $R_t, R^*_t, \Lambda_t, \Lambda^*_t, C_t, C^*_t, N_t, N^*_t, R_{kt}, R^*_{kt}, Q_t, Q^*_t, \mu_t, \mu^*_t, \mu_{xt}, \nu_t, \nu^*_t, \Omega_t, \Omega^*_t, \phi_t, \phi^*_t, \Psi_t, \Psi^*_t, x_t, K_{Ft}, K^*_{Ft}$, given the process for exogenous variables $Z_t, Z^*_t, \sigma_{zt}, \sigma^*_{zt}$.

B Additional model results

Figure 9: Effects of U.S. uncertainty shock with financial integration and no intermediary frictions

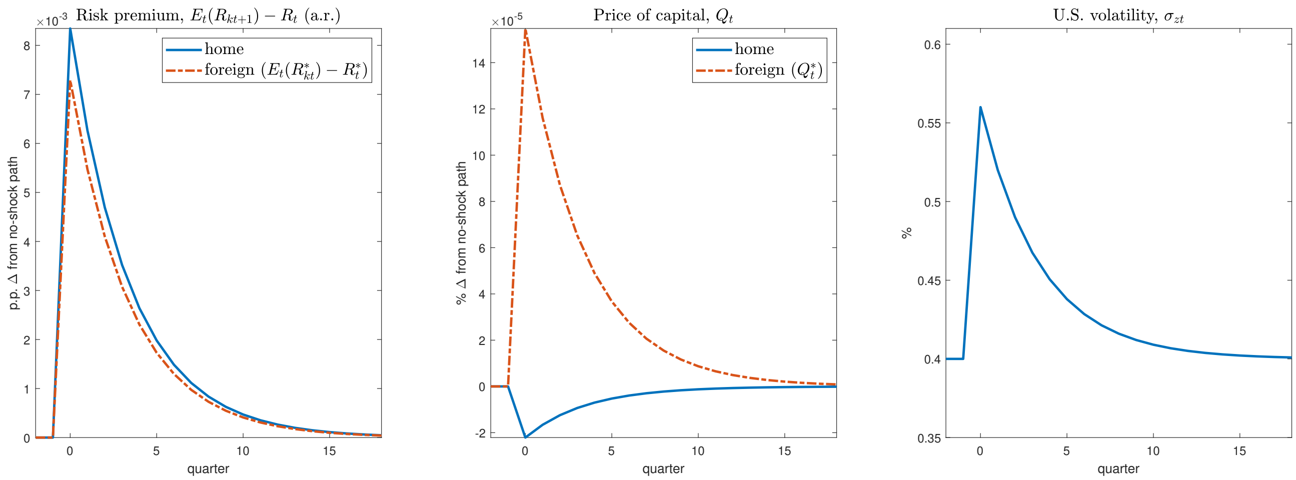
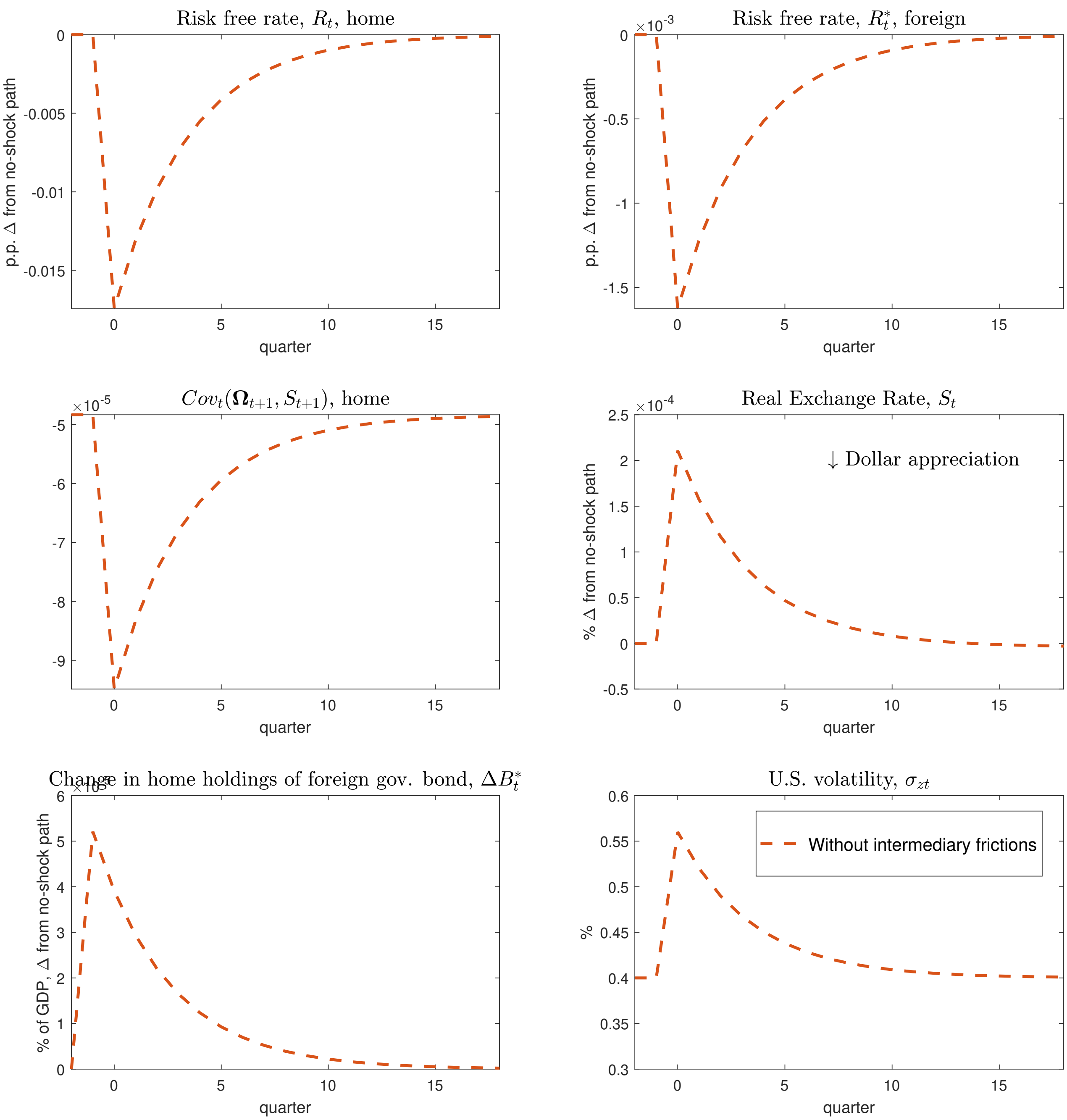


Figure 10: Exchange rate model, effects of U.S. uncertainty shock without intermediary frictions



C Data

Figure 11

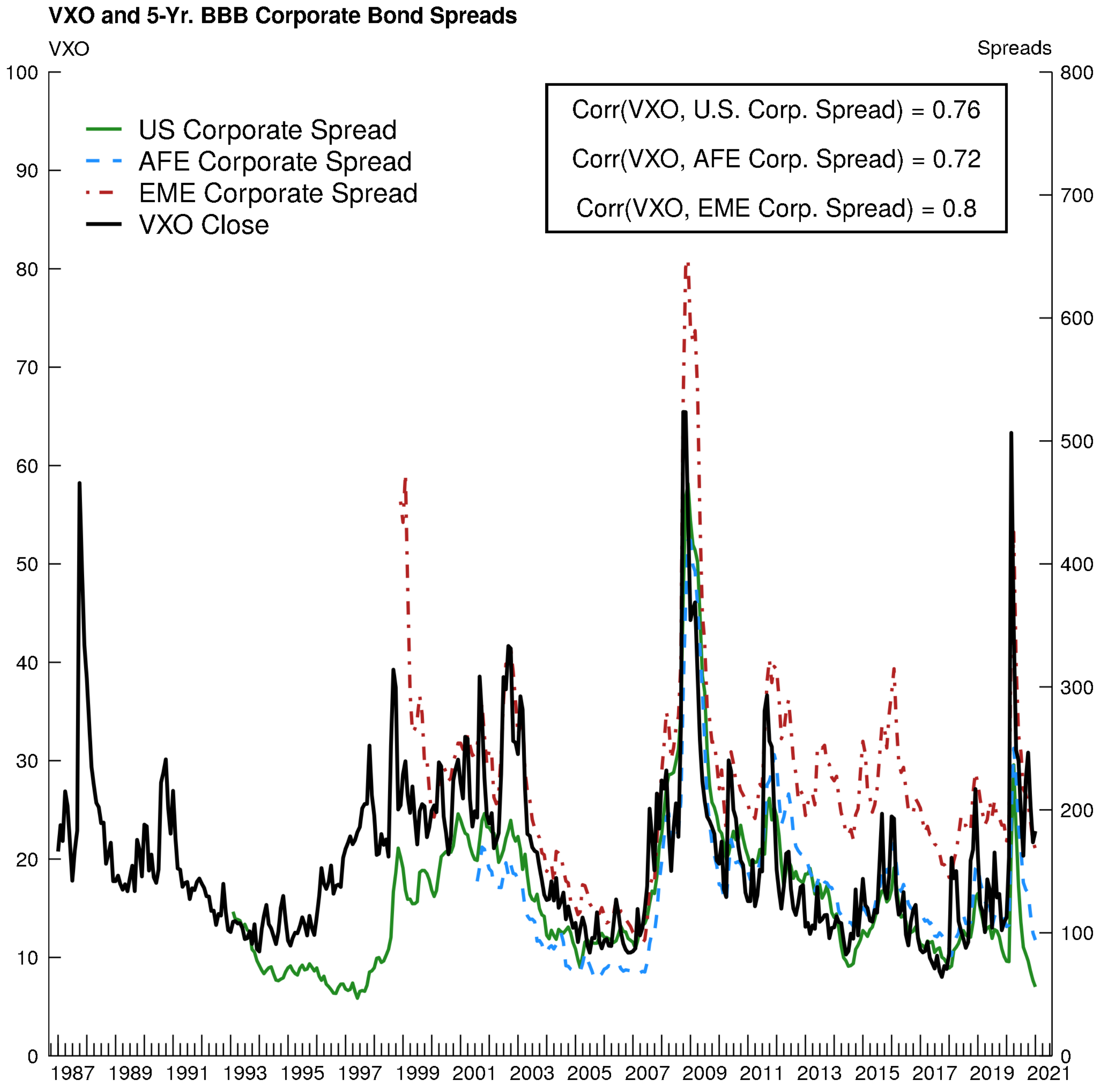

VXO and 5-Yr. BBB Corporate Bond Spreads
VXO
Spreads
US Corporate Spread
AFE Corporate Spread
EME Corporate Spread
VXO Close
Corr(VXO, U.S. Corp. Spread) = 0.76
Corr(VXO, AFE Corp. Spread) = 0.72
Corr(VXO, EME Corp. Spread) = 0.8
100
90
80
70
60
50
40
30
20
10
0
800
700
600
500
400
300
200
100
0
1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019 2021

Figure 12: VAR-predicted effects of uncertainty shock on credit spreads

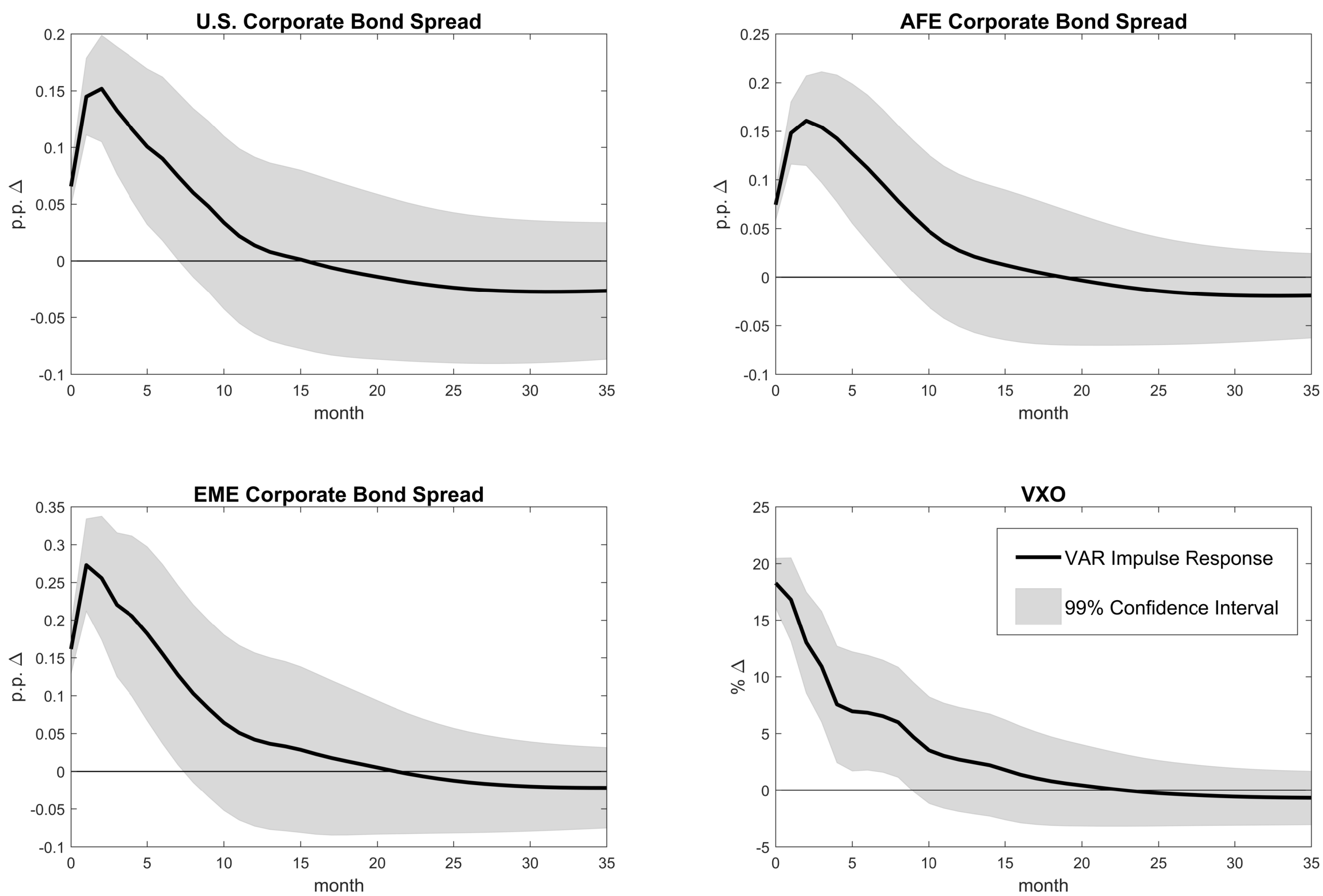


Figure 13: VAR-predicted effects of uncertainty shock on dollar exchange rates