# External Debt, Currency Risk, and International Monetary Policy Transmission*

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**Abstract**

I argue that countries' dollar-denominated net external debt (dollar debt) helps explain the large differences in risk premia across currencies and how U.S. monetary policy affects the global economy. When the U.S. dollar strengthens, the real value of dollar debt increases, weakening the currencies of countries with large amounts of dollar debt and impeding their consumptions. Because the dollar tends to strengthen in bad times, high-dollar-debt currencies are bad hedges and thus have to offer high risk premia. My empirical findings support this idea. First, dollar debt captures exchange-rate and debt-issuance responses to U.S. monetary policy shocks. Second, dollar debt captures the cross-sectional variation in currency risk premia. I develop a general equilibrium model with financial frictions and currency choice of debt denomination that corroborates my findings.

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# 1 Introduction

About 60% of the world's external debt is denominated in U.S. dollars. I argue that countries' dollar-denominated net external debt (dollar debt) creates balance-sheet mismatches that help explain currency risk premia and how U.S. monetary policy affects the global economy. A large literature documents uncovered interest rate parity (UIP) violation; on average, exchange-rate movement does not offset interest-rate differentials between currencies. The cross-sectional violation is economically large and easy to trade. Carry trade – the strategy of investing in high-interest-rate currencies by borrowing in low-interest-rate currencies – gives a Sharpe ratio similar to that in the U.S. stock market. The risk-based explanation is simple: High interest rates mostly reflect risk compensation for lending in currencies that depreciate in bad times. However, although the risk-based explanation is arguably the most accepted, we are still far from fully understanding the mechanisms behind the risk premia.

The main idea of this paper is akin to a standard Fisher's debt deflation. The dollar tends to strengthen after bad news, which means countries with large amounts of ex-ante dollar debt will experience large increases in their real debt burdens, which are negative wealth shocks weakening their currencies and impeding their consumptions.[1] The asset-pricing implication is that high-dollar-debt currencies have to offer high risk premia because they are bad hedges. When collateral constraints are binding, the increases in debt burdens amplify the decline in consumption and credit growth. These forces are the backbone of the theoretical framework behind my empirical work.

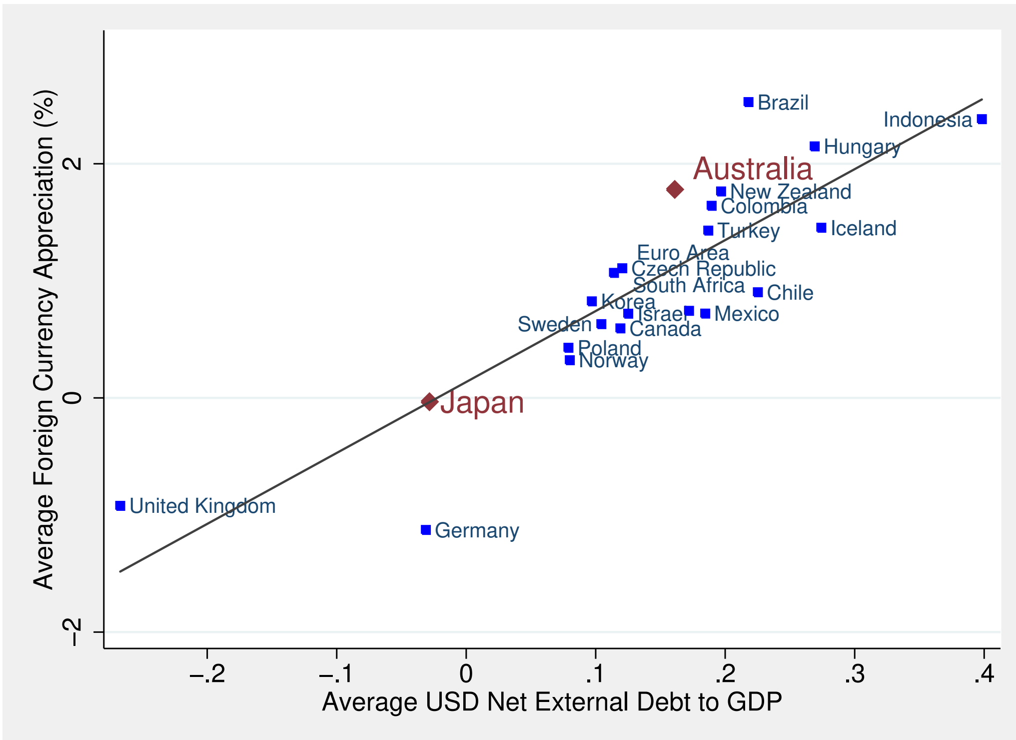
I perform event studies on two type of events, U.S. monetary policy announcements and rare disasters. These two sources of risks are special. First, they are arguably responsible for about two thirds of currency risk premia (Barro 2006, Farhi et al. 2009, Mueller et al. 2017). Second, these shocks have direct effects on dollar value, for example, through changes in the supply of dollars and the demand for safe assets, respectively. Finally, the availability of high-frequency data on fed funds futures means exogenous monetary policy shocks can be more convincingly identified, which allows me to study causal effects of U.S. monetary policy shocks. My main empirical findings are as follows.

First, countries' dollar-denominated net external debt relative to their GDP (*USDebt*) capture the cross-sectional variation in exchange-rate responses to U.S. monetary policy shocks. As an illustration, Figure 1 plots the average exchange-rate movement in two-day windows around FOMC announcements with unexpected cuts in the fed funds rate, against the average *USDebt* before the events. The unexpected component of fed-funds-rate decisions is identified by changes in the fed-funds-futures rate in 30-minute windows around FOMC announcements. Across all currencies,

[1] Empirically, Gourinchas et al. 2010 shows the dollar strengthens in global downturns. Theoretically, Hassan 2013, He et al. 2015, and Richmond 2016 offer some explanations why the dollar is a safe asset.

the average exchange-rate change is positive; an unexpected cut in the fed funds rate is associated with a systematic dollar depreciation.[2] My finding is the positive slope; higher-*USDebt* currencies appreciate more against the dollar.

Figure 1: Exchange-Rate Sensitivities to U.S. Monetary Policy Shocks versus *USDebt*




This figure plots the average exchange-rate movement in a two-day window, from day *t-1* closing price to day *t+1* closing price, bracketing FOMC announcements with an unexpected cut in the fed funds rate of five basis points or larger, against the foreign country's average ex-ante *USDebt*. A positive change in the exchange rate denotes appreciation against the dollar. The sample period is from January 1994 to December 2007.

This cross sectional variation in exchange-rate sensitivities to U.S. monetary shocks is statistically and economically significant. For example, following a one-percentage-point unexpected cut in the fed funds rate, currencies of countries with 25% *USDebt* appreciate by around 5% against the dollar within two days, whereas zero-*USDebt* currencies only appreciate by around 2%. This pattern also emerges in the time series: A currency becomes more exposed to U.S. monetary shocks when the country's *USDebt* increases. I decompose each country's *USDebt* into two components: its own time-series average and the deviation from it. Both components are equally significant, statistically and economically.

*USDebt* captures the first-order cross sectional variation in exchange-rate sensitivities to U.S.

[2]The fact that U.S. monetary expansions cause a systematic dollar depreciation is already empirically documented (see, e.g., Eichenbaum and Evans 1995, Andersen et al. 2007 and Faust et al.) and is theoretically founded.

monetary shocks. I decompose dollar debt into its gross-assets and gross-liabilities components. Both sides are equally important, statistically and economically. I also decompose net-external-debt positions by sector of issuers, banking and non-banking, and by maturity. All components are important. The performance of *USDebt* is robust to controlling for other characteristics. In addition, I do not find evidence that the variation in the exposures is due to foreign-monetary-policy responses. Finally, I apply the same event-study design to monetary policy announcements by the European Central Bank and the Bank of Japan. I find that euro- and yen-denominated net external debt likewise capture currency exposures to the respective central bank's monetary shocks. These results support the idea that the debt deflation channel constitutes an important mechanism for international monetary policy transmission.

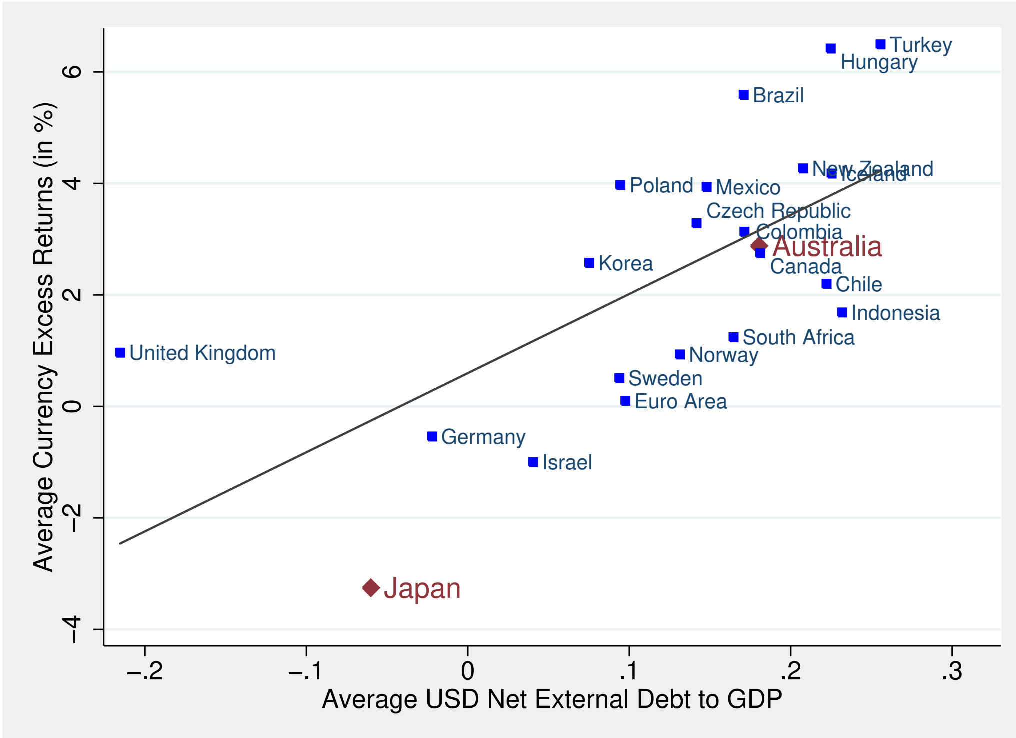
Second, after an unexpected cut in the fed funds rate, higher-*USDebt* countries increase their debt issuance, in both dollars and non-dollars, by larger amounts. For example, countries with 25% *USDebt* increase their dollar- and non-dollar debt by around 1.5 and 0.6 percentage points in the quarter with a one-percentage-point unexpected cut in the fed funds rate, whereas zero-*USDebt* countries barely change their debt positions. The economically large debt-issuance responses from high-*USDebt* countries indicate that borrowers could be credit constrained. This finding offers a mechanism for how U.S. monetary policy affects the global economy, leading to what is called the "*global financial cycle*" in Rey 2015.

Third, higher-*USDebt* currencies depreciate more against the dollar in flight-to-safety episodes. In particular, I consider the LTCM collapse, the 9/11 terrorist attack, and the Lehman Brothers collapse. For example, in the month of the Lehman Brothers collapse, 25% *USDebt* currencies depreciated by 15%, while zero-*USDebt* currencies only depreciated by 5%. I complement these rare-disaster event studies by showing that higher-*USDebt* currencies are also more sensitive to monthly fluctuations in dollar value.[3]

Fourth, higher-*USDebt* currencies offer higher average currency excess returns, consistent with the idea that currencies that depreciate more in bad times — higher-*USDebt* currencies — have to offer higher risk premia because they are bad hedges. Figure 2 plots the average one-month currency excess returns against *USDebt* in a cross section of countries. I argue that carry trade is risky partly because it invests in high-*USDebt* currencies by borrowing in low-*USDebt* currencies. My explanation is consistent with the empirical asset pricing literature that finds a common risk factor in exchange rates (see, e.g., Lustig et al. 2011, Menkhoff et al. 2012, Lettau et al. 2014, and He et al. 2016) and currencies more sensitive to this factor offer higher expected returns, reflected in their higher interest rates.

[3]Monthly fluctuation of the dollar is computed as monthly exchange-rate movement of the dollar against a currency basket, representing systematic changes in the dollar value. This dollar fluctuation is also the dollar shock in Lustig et al. 2014 and Verdelhan 2012, who show that dollar risk is priced in the currency market.

Figure 2: Currency Risk Premia versus *USDebt*




This figure plots average one-month currency excess returns $rx$ against average ex-ante $USDebt$. $rx$ are measured in USD and based on borrowing 100 USD and investing the fund in a foreign currency. $rx_{t+1}$ is computed as $f_t^{1M} - s_{t+1}$, where $f_t^{1M}$ is the log one-month forward exchange rate at month $t$ and $s_{t+1}$ is the log spot exchange rate at month *t+1*. By covered interest-rate parity, $rx_{t+1}$ is approximately the one-month interest-rate differential minus USD appreciation during the month, $i_t^* - i_t^{USD} - \triangle s_{t+1}$. The sample period is from January 1994 to December 2014.

Why do agents borrow? In the cross section of OECD countries, countries with larger $USDebt$ have lower GDP per capita, higher GDP-per-capita growth, and higher share of young population. These correlations are in line with standard motives of borrowing and associated with binding collateral constraints. For example, to smooth consumption, agents with relatively high GDP-per-capita growth tend to borrow from agents with relatively low GDP-per-capita growth. These correlations are also documented in Lane and Milesi-Ferretti 2002.

Why the dollar is the dominant currency of debt denomination is still not clear, especially because its dominance is observed in both developed and developing countries (see, e.g., Eichengreen et al. 2002 and Maggiori et al. 2017). In the theoretical part of this paper, I offer a risk-based rationale for why countries choose to borrow in dollars instead of their own currencies.

I develop a qualitative general equilibrium model à la Alvarez et al. 2002 with endogenous debt denomination. The model generates my empirical findings. The contribution is that I show how frictions in the U.S. economy – U.S. monetary policy uncertainty combined with U.S. market segmentation – can lead to the global dominance of dollar debt. The idea is that, when U.S. traders are exposed to U.S. monetary policy risk due to U.S. market segmentation, the traders can share their risk exposure with the rest of the world by lending in dollars. Therefore, they set high price (low interest rate) on dollar bonds which in turn induces foreign agents to borrow in dollars instead of their domestic currencies.

In the model, the world consists of two countries, the United States, a large economy, and a small open economy. Each country is endowed with two type of goods, tradable and non-tradable. The U.S. asset market is segmented; when the U.S. government injects money through an open market operation, only traders in the U.S. are on the other side of the transaction, and only their marginal utilities determine asset prices. In this type of model, expansionary U.S. monetary shocks increase traders' consumption and lead to a systematic dollar depreciation.

The effect of U.S. monetary shocks on the foreign economy is similar to Mendoza 2010. For a given dollar debt and collateral constraint (expressed as a maximum debt-to-output ratio), expansionary U.S. monetary shocks lower their real debt burdens, making them wealthier, increasing domestic demand, increasing the relative price of domestic non-tradable goods, and thus appreciating their currencies as well as increasing their borrowing capacity through higher output value. To minimize exposure to U.S. monetary shocks, foreign agents should borrow in their own currencies, because domestic-currency debt has an *equity-like* payoff. When domestic currency appreciates, the real debt burdens increase which in turn dampens the spillover, instead of amplifying it.

Why do foreign agents choose to borrow in dollars? In the model, foreign agents want to borrow to smooth consumption because they have a high endowment growth. Given a collateral constraint, foreign agents face a trade-off: Dollar debt allows for a smoother expected consumption overtime because the dollar interest rate is lower, however, dollar debt leads to higher exposure to U.S. monetary shocks. When debt is low, dollar debt is worth the risk, because the marginal utility of consumption today (the marginal benefit of dollar debt) is high and the marginal increase in risk exposure (the marginal cost of dollar debt) is low. Subsequently, as debt (and thus dollar debt) increases, the equilibrium currency choice can be interior, because utility is concave and exposure to U.S. monetary shocks is convex in dollar debt.

Lastly, I study the efficiency of the equilibrium currency choice. From a second-best perspective, competitive markets can lead to an excessive dollar borrowing. Atomistic foreign agents do not internalize the effect of U.S. monetary shocks on the country's output value and thus their borrowing capacity. Therefore, they undervalue the insurance from domestic-currency debt.

**Related Literatures**. This paper is related to several strands of literature. The closest to my paper are papers offering economic explanations for the cross sectional variation in currency risk premia. Hassan 2013, Ready et al. 2013, and Richmond 2016 propose country size, commodity reserve, and trade-network centrality, respectively, as the fundamentals behind the risk premia. My paper complements these papers. Empirically, the proposed fundamentals do not diminish the role of *USDebt* in capturing exchange-rate sensitivities to U.S. monetary shocks and the risk premia. Theoretically, I study different sources of risk and transmission mechanisms that can generate currency risk premia.

This paper relates to the literature showing that U.S. monetary policy shocks affect various asset prices (see, e.g., Gurkaynak et al. 2004, Gertler and Karadi 2015, Gorodnichenko and Weber 2016) and there are large unconditional average excess returns earned on FOMC days, which can be interpreted as risk compensation for U.S. monetary policy uncertainty (Savor and Wilson 2014, Lucca and Moench 2015, and Mueller et al. 2017). I contribute to this literature by showing that *USDebt* captures the variation in the currency exposures to U.S. monetary shocks which are consistent with the idea that U.S. monetary policy uncertainty contributes to risk premia.

This paper also relates to the literature on international monetary-policy spillovers. This literature has a large body of studies focusing on the trade channel (see, e.g., Goldberg and Tille 2008, Gopinath et al. 2010, Burstein and Gopinath 2013, and Zhang 2017). My paper relates more closely to studies focusing on the balance-sheet channel (see, e.g., Bernanke and Gertler 1989, Rajan and Zingales 1995, Céspedes et al. 2004, and Cetorelli and Goldberg 2012). I offer an evidence that *USDebt* is an important characteristic of exposure to global shocks and suggest a mechanism for why U.S. economy is prominent globally.

This paper also closely relates to two papers that show the correlation between external wealth and interest rate differentials. Lane and Milesi-Ferretti 2002 is the first to show the correlation between external wealth and interest-rate differentials. Motivated by Gabaix and Maggiori 2014, Della Corte et al. 2016 show their global imbalance risk factor captures the cross-sectional variation in currency excess returns.[4] My paper provides essential additional findings. Empirically, my event-study results are new and I show the monotonic relationship between dollar debt and currency risk premia in the cross section. Theoretically, the economic mechanisms emphasized in this paper are different.

Lastly, this paper relates to the literature in currency choice of debt denomination (see, e.g., Chamon 2003, Jeanne 2003, Caballero and Krishnamurthy 2003, Korinek 2010, and Bocola and Lorenzoni 2017). Doepke and Schneider 2017 and Gopinath and Stein 2017 show how currency choice of trade invoicing and debt denomination can be complementary. For example, firms with dollar liabilities have an incentive to invoice their exports in dollars. Importantly, empirically,

[4]External wealth is external assets minus external liabilities in which assets and liabilities include both equity and debt securities. The risk factor is constructed by sorting currencies based on external wealth and the share of liabilities in foreign currencies.

exporters as well as firms without dollar revenue borrow in dollars, and both balance sheet and trade channels are relevant transmission mechanisms (Aguiar 2005, Lane and Shambaugh 2010, Du and Schreger 2016, and Salomao and Varela 2018).

# 2 Data

**Data sources** The definitions of debt securities and external positions are based on the guidelines of the International Monetary Fund (IMF). Debt securities include loans, bonds, debentures, certificates of deposit, bills, and notes. External liabilities (assets) are debt issued by residents (nonresidents) and owed to nonresidents (residents), regardless of the market of issuance.

I use the dataset of Lane and Milesi-Ferretti 2007 and Lane and Shambaugh 2010 for countries' external debt and their currency decompositions for all countries except Australia and New Zealand, whose governments publish their own, more detailed, data. I use countries' International Investment Position reports for the sector and maturity decompositions of the external debt. Table 1 and 2 show the summary statistics of the external debt. The data are annual, reported at the end of every year. Debt-to-GDP ratios are calculated using end-of-year exchange rates. International debt is debt issued under foreign law in international markets. International-debt-issuance data are from the debt statistics of the Bank for International Settlements. The data are quarterly and reported as the dollar equivalent of the face value.

I study currencies of the OECD and big emerging market (EM) countries that adopt flexible exchange rates. I study 22 currencies: 18 OECD and 4 EM countries. Table 1 reports the currencies in sample. The baseline period for the U.S. monetary policy event study is from January 1994 to December 2007, during which 112 events occur based on eight scheduled FOMC meetings per year. The United States enters the zero lower bound (ZLB) in December 2008. During the ZLB, fed funds rate has a low variance and is not the main monetary policy instrument.

Currencies enter and exit my sample based on their exchange-rate regime in Ilzetzki et al. 2011. I define a flexible exchange-rate currency as one that has a variance exceeding a 2% band around the dollar and other anchor currencies such as the euro. A 2% band is when the probability that the monthly exchange-rate change remains within a +/- 2% band over a rolling five-year period is 80% or higher. For comparison, the probability of monthly JPY/USD exchange-rate changes being within a +/- 2% band is 30% in the 1994-2007 period. I exclude currencies during hyperinflation and when they have multiple exchange rates, specifically, when there are large discrepancies between the official and market exchange rates.

Spot- and forward-exchange-rates data are from Barclays and Thomson Reuters, available in Datastream. Fed-funds-futures-based measures of U.S. monetary shocks are from Gorodnichenko and Weber 2016. Table 3 shows the summary statistics of U.S. monetary shocks.

**Identifying U.S. monetary policy shocks** Financial markets are forward-looking, and thus unlikely to respond to anticipated policy news. This behavior makes identifying the unexpected component of the Fed's interest-rate decision crucial. In this paper, I use the method introduced by Kuttner 2001, also used in other papers, such as Bernanke and Kuttner 2005, to calculate the surprise component of the fed-funds-rate decision. The method is based on the changes in the 30-day fed-funds-futures rate in 30-minute windows bracketing the FOMC press releases. The key identifying assumption is that only U.S. monetary policy news moves the fed-funds-futures rate within the 30-minute window around FOMC press releases.

Specifically, the surprise component of the announced fed-funds-rate decision is calculated as

$$\mu_t = \frac{D}{D-t}\left(ff^0_{t+\triangle t^+} - ff^0_{t-\triangle t^-}\right), \tag{1}$$

where $t$ is the time of the FOMC announcement, $ff^0_{t+\triangle t^+}$ is the fed-funds-futures rate 20 minutes after $t$, $ff^0_{t-\triangle t^-}$ is the fed-funds-futures rate 10 minutes before $t$, $D$ is the number of days in the month, and $D-t$ is the number of days left in the month. The $D/(D-t)$ term adjusts for the fact that the fed funds futures settle on the average effective overnight fed funds rate over the one-month period.

For the high-frequency event study on the effect of U.S. monetary shocks on exchange rates, the measure of U.S. monetary shocks at date $t$ are the shocks identified in the 30-minute window at date $t$. For the study on the effect of U.S. monetary shocks on debt issuance, because debt issuance data are quarterly, I aggregate the shocks identified in the 30-minute window in each quarter to get a quarterly measure of U.S. monetary policy shocks. This aggregation is introduced by Gorodnichenko and Weber 2016 and also used in other papers, such as Gertler and Karadi 2015 and Wong 2016.

# 3 Empirical Results

I summarize my four main empirical findings as follows : (1) higher-*USDebt* currencies are more sensitive to U.S. monetary policy shocks; (2) external-debt issuance of higher-*USDebt* countries are more sensitive to U.S. monetary policy shocks; (3) during flight-to-safety episodes, higher-*USDebt* currencies depreciate more against the dollar; and (4) *USDebt* is significantly correlated with currency excess returns and forward premia, both in the cross section and time series.

## 3.1 Exchange rate responses to U.S. monetary shocks

### 3.1.1 Specification

To test the importance of ex-ante debt positions in explaining the effect of U.S. monetary shocks on exchange rates, I perform an event study on FOMC announcement days and estimate the following panel specification:

$$\triangle s_{it} = \beta_0 + \beta_\mu \mu_t + \beta_{Debt}\left[Debt_{it-1}\mu_t\right] + \gamma_{Debt} Debt_{it-1} + \varepsilon_{it}, \tag{2}$$

where $\triangle s_{it}$ is a percentage change in exchange rate defined as currency $i$ per dollar in a one-day window bracketing an event, positive $\triangle s_{it}$ denotes dollar appreciation, $\mu_t$ is a U.S. monetary policy shock, positive $\mu_t$ denotes an unexpected fed-funds-rate increase, $Debt_{it-1}$ is country *i's* net-external-debt-to-GDP ratio in the year prior to the event, and positive $Debt_{it-1}$ denotes a net borrower.

The specification means a one-percentage-point unexpected decrease in the fed funds rate is associated with $\beta_\mu + \beta_{Debt} Debt_{it-1}$ percent of currency $i$ appreciation against the dollar in the one-day window bracketing an FOMC announcement. I am interested in $\beta_{Debt}$, which tests the importance of ex-ante debt positions in capturing the effect of U.S. monetary shocks on exchange rates.

### 3.1.2 Main results

In this section, I discuss the results of the event study on the effects of U.S. monetary shocks on exchange rates. Table 4 column (1) shows $\beta_\mu$ is positive; an unexpected cut in the fed funds rate causes dollar depreciation against the currency basket. Importantly, $\beta_{USDebt}$ is positive; the foreign-currency appreciation against the dollar is larger for higher-$USDebt$ countries. The $\beta_{USDebt}$ estimate of 7.4 implies a hypothetical one-percentage-point unexpected cut in the fed funds rate is associated with around a 2% appreciation against the dollar for a country with a zero $USDebt$, and around 3.5% for a country with a 25% $USDebt$ in the one-day window.

In column (2), I add countries' net external debt denominated in non-dollars ($NonUSDebt$) as regressors. $\beta_{NonUSDDebt}$ is significant, but the point estimate is half of $\beta_{USDDebt}$. This result indicates the importance of the dollar-debt-deflation channel, because, although all borrowers gain from a lower real refinancing rate regardless of the currency denomination of their debt, only borrowers with a dollar-debt position gain from dollar depreciation.

In column (3), I decompose net dollar-debt position ($USDebt$) into its gross liabilities and assets components. The coefficient estimate on the gross liabilities is positive, whereas that of gross assets is negative. The sign means higher dollar liabilities are associated with a larger appreciation against the dollar for a given expansionary shock, whereas higher dollar assets are associated with a smaller appreciation. The absolute magnitudes are statistically indistinguishable. These results indicate the importance of the dollar-debt-deflation channel, because to the first order, this channel predicts symmetric yet opposite effects of gross assets and liabilities. That is, the net position should capture the first-order effect.

In Table 5, I decompose each country's *USDebt* into its time-series average and the deviation from it to test the importance of the cross sectional and time series variation of *USDebt* in capturing exchange-rate sensitivities to U.S. monetary shocks. The results show both components are equally important, statistically and economically. That is, higher dollar debt in both dimensions is associated with equally larger exchange-rate exposure to the shocks.

In Table 6, I test whether expansionary and contractionary monetary shocks have asymmetric effects on exchange rates. To test the asymmetric, I set a dummy variable equal to 1 for contractionary shocks, and include the interactions of this dummy and the explanatory variables in the baseline regression specification. I also examine the results excluding the meeting on February 4, 1994 which is a potential outlier for two reasons. First, it has the largest unexpected rate increase (0.16%) in my sample. Second, it is the only FOMC announcement day in my sample which coincided with employment release and Bernanke and Kuttner 2005 note the importance of the employment news in affecting asset prices on FOMC announcement days. Table 6 indicates a smaller effect of contractionary shocks, but the difference is not statistically significant after excluding the meeting on February 4, 1994. When I focus on a relatively balance panel, that is, only include currencies which are in sample for at least 60% of the time, the asymmetric effect is economically and statistically not significant. Figure 1 plots the average exchange-rate movement in one-day windows around FOMC announcements with expansionary shocks of 5 basis points or larger and contractionary shocks of 4 basis points or larger, against the average *USDebt* before the events. The figure suggests the asymmetric effect is not significant.

In Table 7, I add EM currencies to the sample. Comparing the results of columns (2) and (4), I find the sensitivities to U.S. monetary shocks captured by *USDebt* are significant, although capturing the effect on EM currencies requires a two-day window. The fact that EM currencies are less liquid and less flexible in terms of the degree of exchange-rate flexibility may explain the longer event window. I do not find significant changes or reversal in the exchange-rate responses beyond the two-day window.

### 3.1.3 Main robustness checks

In this section, I show the importance of *USDebt* in capturing exchange-rate sensitivities to U.S. monetary shocks is robust to controlling for other potentially important variables.

**Financial variables.** In Table 8 column (1), I add the expected component of the changes in the fed funds rate as regressors. The coefficients associated with the expected component are not significant, whereas the coefficients associated with the surprise component are similar to those in the baseline specification. This result is consistent with forward-looking financial markets and a causal effect of U.S. monetary shocks on exchange rates.

In column (2), I add one-month forward premia as regressors. I find the forward premia do not capture exchange-rate exposures to U.S. monetary shocks after controlling for $USDebt$. Furthermore, the point estimate and significance of $\beta_{USDebt}$ remain stable. The sample size is smaller than the baseline's because of the availability of forward rates. This result shows $USDebt$ performs better in capturing exchange-rate exposures to U.S. monetary shocks.

In column (3), I add one-day changes in one-month forward premia $\triangle r_t^{1M}$ as regressors. The idea is that if the variation in exchange-rate changes on event days is due to variation in foreign interest rates, $\triangle r_t^{1M}$ should absorb the cross country variation and make $\beta_{USDebt}$ not significant. The result shows no evidence for this scenario. If foreign central banks control their short-term interest rates, this result also implies my finding is not driven by foreign central banks' monetary-policy responses.[5]

In column (5) to (8), I control for trade-network centrality (Richmond 2016) and GDP share (Hassan 2013), the macro fundamentals proposed to explain the cross sectional variation in currency risk premia. The results suggest these fundamentals do not drive the variation in the currency exposures captured by $USDebt$.

**Macro variables.** In Table 8 columns (1) to (3), I control for countries' trade in 3 forms: net-export-to-GDP, dollar-invoiced net-export-to-GDP, and dollar-invoiced gross-export-to-GDP and gross-import-to-GDP ratios separately. The dollar-trade variables are based on the invoice currency pricing data of Gopinath (2015), combined with the trade data from the Penn World Table. The results show the trade variables do not affect the variation in the currency exposures captured by $USDebt$.

In columns (4) to (8), I control for countries' domestic debt in three forms: domestic-debt-to-GDP, government-debt-to-GDP, and non-financial-sector-debt-to-GDP ratios. The results show domestic-debt variables do not affect the variation in the currency exposures captured by $USDebt$. Because most domestic debt is denominated in domestic currencies, this result supports the importance of the dollar-debt-deflation channel. Theoretically, what could be important is the interaction between dollar debt and domestic debt; for the same $USDebt$ and thus roughly the same initial positive wealth shocks from dollar depreciation, financial frictions can lead to a larger increase

[5] For more details, in the appendix, I estimate event-study specification (2) with changes in foreign short-term rates as the dependent variables.

in consumption in countries with larger within-country wealth distribution between lenders and borrowers. The result in column (7) is consistent with this hypothesis.

#### 3.1.4 Other reserve currencies

In this section, I discuss the results of performing event studies on the Bank of Japan (BOJ) and European Central Bank (ECB) monetary-policy announcements. I find qualitatively the same result; the exchange rates of countries with higher amounts of net external debt denominated in the central bank's currency are more sensitive to the monetary shocks of the respective central banks.

Table 13 shows the results of regression specification 2 for the BOJ events. Columns (1) and (2) show that, for both one- and two-day event windows, $\beta_{CBDebt}$ is positive; the currencies of higher-*JPY Debt* countries appreciate more against the Japanese yen after BOJ expansionary monetary shocks. For both event windows, $\beta_{NonCBDebt}$ is close to zero; *NonJPY Debt* does not capture exchange-rate sensitivity to BOJ monetary shocks. $\beta_{CBDebt}$ is statistically stronger and economically larger for the two-day window. The stronger results under the two-day window are consistent with the fact that EM currencies are important for the variation in *JPY Debt*, however, EM currencies are relatively slower in reflecting the monetary shocks. Column (3) and (4) show that the results are robust to extending the sample period to December 2014.

Columns (5) to (8) show that the ECB event study yields qualitatively the same result, the currencies of countries with higher *EURDebt* are more sensitive to ECB monetary shocks. However, the results are only statistically significant for the longer sample period. The fact that the ECB has a more active monetary policy and the standard deviation of the ECB monetary shocks is about 50% larger after 2007 may explain the pattern. Moreover, $\beta_{NonCBDebt}$ is negative, which says, for the same *EURDebt*, currencies with higher non-euro debt are less sensitive to ECB monetary shocks. Finally, the ECB results are economically smaller; its $\beta_{CBDebt}$ is about one fifth of that of the Fed.

## 3.2 Debt issuance responses to U.S. monetary shocks

#### 3.2.1 Summary statistics

Table 14 shows the summary statistics of the quarterly debt issuance and quarterly changes in debt issuance relative to GDP of all countries as well as by four sub-groups: high-debt OECD countries, low-debt OECD countries, EM countries, and the financial centers. Except for the low-debt OECD countries, the trend in debt issuance, as indicated by the average quarterly changes in debt issuance, is small. Across all countries, the average debt issuance is higher in the quarter with expansionary U.S. monetary shocks than in the quarter with contractionary monetary shocks. The difference is large for the high-debt OECD and the EM countries. The low-debt-OECD-countries debt issuance does not show the same pattern, however, the downward trend in their debt issuance may lead to this pattern. Looking at the quarterly changes in debt issuance, their average change is smaller in the quarter of expansionary U.S. monetary shocks. These debt issuance patterns suggest that U.S. monetary shocks affect external debt issuance, which I will study in this section.

#### 3.2.2 Specification

To study the importance of ex-ante debt position in capturing how external-debt issuance responds to U.S. monetary shocks, I estimate the following panel specification:

$$\triangle Debt_{i,t} = \alpha_0 + \beta_\mu \mu_t + \beta_{\mu,Debt}\left[\mu_t \times Debt_{i,t-1}\right] + \gamma_{Debt}\left[Debt_{i,t-1}\right] + control_{i,t-1} + \varepsilon_{i,t}, \quad (3)$$

where one period is a quarter, $\triangle Debt_{i,t}$ is one-quarter change of country *i's* external-debt issuance in period $t$ normalized by the GDP at the end of the previous year of period $t$, $\mu_t$ is U.S. monetary policy shocks in period $t$, and $Debt_{i,t}$ is country *i's* net-external-debt-to-GDP ratio at the end of the previous year of period $t$. The baseline control variables are the lagged dependent variables of lag 1 to 4, country fixed effects, and quarter fixed effects. I am interested in the estimates of $\beta_{\mu,Debt}$ because it tests the importance of ex-ante debt positions in capturing debt-issuance responses to U.S. monetary shocks.

#### 3.2.3 Main results

Table 15 shows high-$USDebt_{-1}$ countries issue more dollar debt after expansionary monetary shocks. Countries with 25% $USDebt_{-1}$ increase their $USDebt$ by around 0.7 to 1.5 percentage points, depending on whether I count $\beta_\mu$ as zero, following a hypothetical one-percentage-point unexpected cut in the fed funds rate. To make sure the relationship is not spurious, I add the expected fed-funds-rate changes. The result in column (2) supports the causal effect of U.S. monetary shocks on debt issuance; there is no evidence that the expected fed-funds-rate changes affect the debt issuance. In column (3), I add $NonUSDebt_{-1}$ as a regressor, the result shows no evidence that $NonUSDebt_{-1}$ captures the dollar-debt-issuance response to U.S. monetary shocks. In column (4), I run the regression using a longer period, from 1994 to 2014, to increase the number of observations and hopefully power. I find the same result but statistically stronger.

To examine whether U.S. monetary shocks also affect debt issuance in other currencies and whether borrowers only substitute among currencies, I estimate specification 3 with debt issuance in non-dollars and in all currencies as the dependent variables. Table 16 column (3) and (4) show that high-$USDebt_{-1}$ countries also increase their debt issuance in non-dollar currencies after expansionary U.S. monetary shocks, but the increase is smaller for countries with non-dollar liabilities. In the data, countries with 25% $USDebt_{-1}$ on average have 8% non-dollar debt liabilities. Therefore, the point estimates suggest countries with 25% $USDebt_{-1}$ increase their non-dollar debt issuance by around 0.5 to 1 percentage point, depending on whether I count $\beta_{\mu}$ as zero, following a hypothetical one-percentage-point unexpected cut in the fed funds rate.

**Main robustness checks.** The results above remain qualitatively and quantitatively the same when I control for other fundamentals and study the OECD and EM market separately. I use the longer sample period for the robustness checks to increase power as I add more explanatory variables and limit the currencies in sample. Table 17 shows the results when I control for potentially important fundamentals. Table 18 shows the results when I examine the OECD and EM countries separately. The point estimates are quantitatively similar. The t-statistics of the EM countries is weaker which is not surprising given the smaller sample size and variation in $USDebt$.

## 3.3 Exchange rate movement in flight-to-safety episodes

In this section, I discuss the cross sectional variation in the exchange-rate movement around the recent flight-to-safety episodes: the Long-Term Capital Management (LTCM) bankruptcy in September 1998 , the terrorist attack on September 11, 2001, and the Lehman Brothers' bankruptcy filing on September 15, 2008. Figure 8 plots the exchange-rate movements against $USDebt$ for the later two events, whose event dates are relatively identified.

To estimate the magnitude of the exchange-rate movements, I allocate currencies to four group based on their $USDebt$. Figure 9 shows the exchange-rate depreciations in these flight-to-safety episodes increase monotonically from the lowest to the highest $USDebt$ portfolios. The size of the bubble is a proxy for the severity of the events, a simple average of the decrease in the one-year Treasury yield and S&P 500 index in the event window. Table 19 shows the summary statistics of exchange-rate movement in the two-business-day and one-month window bracketing the events. The depreciations around these events are economically large. For example, initially, in the two-day window around the Lehman Brothers collapse, the lowest-$USDebt$ currencies barely move while the highest-$USDebt$ currencies depreciate by 2%. As flight to safety escalates, the average and high-minus-low depreciation becomes larger. The lowest-$USDebt$ currencies depreciate by 3% while the highest-$USDebt$ currencies depreciate by 12%. The same patterns happen around the LTCM collapse and the 9/11 terrorist attacks.

### 3.4 Dollar debt, expected returns, and exchange rates

To illustrate the currency risk implication of $USDebt$, let us consider the Euler equation of a marginal investor. Currency $i$'s expected excess return is

$$E_t[rx_{i,t+1}] = \left(\frac{cov_t[m_{t+1}, s_{i,t+1}]}{var_t[m_{t+1}]}\right)\left(\frac{var_t[m_{t+1}]}{E_t[m_{t+1}]}\right) = \beta_{i,t}\lambda_t, \tag{4}$$

where $m_{t+1}$ is the stochastic discount factor at *t+1*, which is proportional to the marginal utility of consumption at *t+1*. An increase in $s_{i,t+1}$ denotes currency *i's* real depreciation against the dollar. The second equality is the beta representation, where $\lambda_t$ is the price of risk, which is common across currencies, and $\beta_{i,t}$ is the quantity of risk associated with currency $i$. This paper argues $USDebt_{i,t}$ partially explains why currencies have different $\beta_{i,t}$. Note that currency $i$'s expected excess return at $t$ is the forward premium at $t$ minus the expected dollar appreciation ($E_t[rx_{i,t+1}] = fp_{i,t} - E_t[\triangle s_{i,t+1}]$). Therefore, in the special case in which the expected exchange-rate movement is constant across currencies, for example, when exchange rates follow a random walk, forward premia summarize the cross-sectional variation in the expected excess returns.

**Summary statistics.** Euler equation (4) shows that currencies that depreciate more when marginal utility is high — that is, higher-$USDebt$ currencies — have to offer higher risk premia because they are bad hedges. Table 20 shows an empirical pattern consistent with this prediction: the average excess returns from investing in foreign currencies increase monotonically from the lowest- to the highest-$USDebt$ currency portfolios. The $USDebt$-HML gives an annualized Sharpe ratio of .70, which is similar to as if one invests based on forward premia, due to the high correlations between the two.

Table 21 reports the average excess returns from investing in the $USDebt$-HML portfolio for a two-day window around the scheduled FOMC announcements. These two-day FOMC trades give average excess returns that increase monotonically from the lowest- to the highest-$USDebt$ currency portfolios. Table 24 in the Appendix reports the returns of the FOMC trades from double-sorted portfolios based on $USDebt$, country size, and trade-network centrality. The results indicate $USDebt$ performs better in capturing currency risk premia with respect to U.S. monetary policy uncertainty.

**Statistical tests.** To test the correlation between dollar debt and currency excess returns, and to test whether non-dollar debt exhibits the same correlation, I estimate the following panel regression specification:

$$rx_{i,t+1} = \alpha + \beta_{USDebt} USDebt_{i,t} + \beta_c control_{i,t} + \varepsilon_{i,t},$$

where $rx_{i,t+1}$ is one-month currency excess return from month $t$ to $t+1$, $USDebt_{i,t}$ is the dollar debt of country $i$ at the end of the previous year of month $t$, and $control_{i,t}$ are control variables which vary across specification. The controls include non-dollar debt, currency and month-year (time) fixed effects. The standard errors are clustered at monthly level.

Table 22 column (1) shows the result when the control is only time fixed effects. The result shows that, in the cross section, higher dollar debt has a statistically significant association with a higher average currency excess return. On average, currencies with a ten-percentage-points-higher dollar debt than the cross-section average offer about two-percentage-points-higher annualized one-month currency excess returns than the cross-section average. Column (2) shows the result when the control is only currency fixed effects. The result shows that, in the time series, higher dollar debt also has a statistically significant association with a higher average currency excess return. On average, currencies offer about 3.5-percentage-points-higher annualized one-month currency excess returns than their respective time series averages, when their dollar debt is ten-percentage-points higher than usual. Column (3) shows a higher dollar debt is also significantly associated with higher currency excess returns after controlling for both currency and time fixed effects.

Column (4) to (6) add non-dollar-foreign-currency debt, and column (7) to (9) add the euro and Japanese yen debt to the regressions. The idea is that, if the dollar is not special, that is, currency denomination of debt is not an important factor for currency risk premia, the correlation between other-currencies-denominated debt and excess returns is likely to be similar to that of dollar debt. The regression results show no evidence for a statistically significant association between non-dollar-foreign-currency debt and excess returns, and the point estimates are close to zero. Table 22 column (10) to (18) repeat the exercises for a longer sample period, from 1994 to 2014, and show the same results.

Lastly, for countries that exhibit strong trends in their $USDebt$, I expect their excess returns to follow. The data shows this pattern. Figure 10 plots one-month forward premia versus $USDebt$ of Mexico and Iceland, two countries that experience large changes in their $USDebt$ and whose forward rates are available.[6] I also observe the same pattern for South East Asian countries, which reduce their $USDebt$ over time following their 1998 currency crisis.

[6]Using currency forwards is important to isolate the exchange-rate risk-premium component in interest rates. That is, using currency forwards eliminates bond price risk and minimizes default risk, because the trading counter-party is large banks whose default risk is low and not currency specific.

# 4 Model

I study currency risk premia of small open economies with different external debt. I begin with a two-country, cash-in-advance, endowment economy with three periods ($t = 0, 1, 2$), a government, and a continuum of households of measure 1. The two countries are the United States, a large economy, and a small foreign economy. Country size represents total endowment in the country. In each period $t$, each household receives endowments of $y_{T,t}$ units of a freely transportable non-storable consumption good (henceforth, tradable good) and $y_{N,t}$ units of a non-transportable non-storable consumption good (henceforth, non-tradable good). The tradable good is common across countries. Foreign households have a high tradable-good endowment growth, which induces them to borrow to smooth consumption. Assets traded are only nominally risk-free bonds denominated in dollars and the foreign currency. The world economy has only one source of uncertainty: shocks to dollar-supply growth in period 1. The uncertainty is resolved at the beginning of period 1, and there is no uncertainty in period 2.

## 4.1 Setup

### 4.1.1 Environment

**Utility and endowment.** All variables are expressed in per-capita terms. Each household receives deterministic endowments of

$$\begin{aligned} y_{T,0} &= 1 - g,\ y_{T,1} = 1,\ y_{T,2} = 1 + g \\ y_{N,0} &= 1,\ y_{N,1} = 1,\ y_{N,2} = 1. \end{aligned}$$

U.S. households have $g^{US} = 0$, whereas foreign household have $g^* > 0$. The utility function is common across countries. Each household maximizes her lifetime expected utility:

$$U = E_0 \left[ \sum_{t=0}^{2} log\ (c_{T,t})^{1/2} (c_{N,t})^{1/2} \right],$$

where $c_{T,t}$ and $c_{N,t}$ are tradable- and non-tradable-good consumption, respectively, subject to her constraints.

**Nominal bonds.** The only traded securities are one-period nominally risk-free bonds denominated in the two currencies. A bond denominated in currency $J$ is a risk-free claim to one unit of currency $J$ next period. Its real payoff is the amount of tradable good that one unit of currency $J$ delivers at *t+1*: $\frac{1}{P^J_{T,t+1}}$, where $P^J_{T,t+1}$ is the nominal price of tradable good in currency $J$ at *t+1*.

**Exchange rates.** The law of one price in tradable goods determines the nominal exchange rate. The nominal exchange rate of currency $J$, $s_t^j$, is the ratio of tradable-good price in currency $J$, $P_{T,t}^j$, to tradable-good price in dollars, $P_{T,t}^{USD}$,

$$s_t^j = \frac{P_{T,t}^J}{P_{T,t}^{USD}}, \tag{5}$$

where higher $s_t^j$ denotes nominal appreciation of the dollar against currency $J$. The real exchange rate of currency $J$, $\varepsilon_t^J$, is the ratio of the consumption price index (CPI), which is

$$\varepsilon_t^J = \left(\frac{p_{N,t}^{US}}{p_{N,t}^J}\right)^{1/2},$$

where higher $\varepsilon_t^J$ denotes real appreciation of the dollar against currency $J$, and $p_{N,t}^{US}$ and $p_{N,t}^J$ are non-tradable-good prices (in units of tradable good) in the U.S. and country $J$, respectively. The derivation is in the appendix 5.

**Timeline.** The timeline follows Lucas 1982. In each period, there are two markets: asset and goods markets. In the asset market, households engage in competitive bond and currency trading. In the goods market, households buy goods using currencies of where the goods are from, and households sell their endowments of goods for currencies.

In each period, before the asset market opens, all governments decide their money supply simultaneously; thus, the stock of currencies in circulation is known to all households before they enter the asset market.[7] The U.S. government changes dollar supply via open market operations. The foreign government changes foreign-currency supply via a lump-sump tax or transfer. At the conclusion of asset trading, households disperse to trade goods using currencies. At the end of the period, households consume and the cash proceeds from selling endowments becomes the currency holdings at the beginning of the next period. At the beginning of period 0, all households receive lump-sum amounts of currencies that will be absorbed through a lump-sum tax at the end of the last period.

Given this timeline and the presence of bonds earning a positive nominal return in some currencies, households only hold the exact amounts of currencies needed to cover their perfectly predictable current-period good purchases.

[7] The results will be the same as if I allow the foreign central bank to respond to U.S. monetary shocks before the asset market opens and the foreign central bank targets a stable domestic-currency CPI.

**U.S. agents.** In the U.S., there are two types of households: traders and non-traders. The traders access the securities market, whereas the non-traders do not. Non-traders are hand-to-mouth agents: they do not make intertemporal decision; they simply spend all their cash holdings on goods, every period. The traders' date-$t$ period budget constraint, expressed in dollars, is

$$P_{T,t}^{USD}\left(c_{T,t}+p_{N,t}c_{N,t}\right)=M_{t-1}^{USD}-\left(D_{t}^{USD}-Q_{t}^{USD}D_{t+1}^{USD}\right)-\frac{1}{s_{t}^{J}}\left(D_{t}^{J}-Q_{t}^{J}D_{t+1}^{J}\right),$$

where $s_t^J$ is the nominal exchange rate and $Q_t^J$ is the price, expressed in currency $J$, of the one-period nominally risk-free bond denominated in currency $J$. The non-traders' date-$t$ period budget constraint is $P_{T,t}^{USD}c_{T,t}+P_{T,t}^{USD}p_{N,t}c_{N,t}=M_{t-1}^{USD}$.

The U.S. government changes date-1 dollar supply through open market operation. Its period budget constraint, expressed in dollars, at $t\geq 1$ is

$$D_{t}^{USD}-Q_{t}^{USD}D_{t+1}^{USD}-T_{t}^{US}=\mu_{t}M_{t-1}^{USD},$$

where $D_t^{USD}$ is the value of maturing dollar liabilities at $t$, $T_t^{US}$ is the tax receipt at $t$, and $\mu_t M_{t-1}^{USD}=M_t^{USD}-M_{t-1}^{USD}$ is the per-capita increase in dollar supply. All taxes associated with the open market operations are paid by the traders.

**Foreign agents.** In the foreign country, there is only one type of household. The representative foreign household chooses how much to borrow and lend in her currencies and in dollars. Her period-$t$ budget constraint, expressed in dollars, is

$$\begin{aligned}\frac{1}{s_{0}^{J}}P_{T,t}^{J}\left(c_{T,t}+p_{N,t}c_{N,t}\right)=&\frac{1}{s_{0}^{J}}P_{T,t}^{J}\left(y_{T,t}+p_{N,t}^{J}y_{N,t}\right)-\left(D_{t}^{USD}-Q_{t}^{USD}D_{t+1}^{USD}\right)\\&-\frac{1}{s_{0}^{J}}\left(D_{t}^{J}-Q_{t}^{J}D_{t+1}^{J}\right).\end{aligned}$$

She faces a collateral constraint, a maximum amount of gross debt liabilities relative to output. This constraint applies to the total as well as the debt liabilities in each currency, which is realistic when the same collateral can only be used once. For periods 0 and 1, the maximum face value of the debt outstanding is $\alpha$ of output in period 1. Specifically, the collateral constraint on the total debt, expressed in dollars, is

$$D_{t+1}^{USD}+\frac{1}{s_{t}^{J}}D_{t+1}^{J}\leq\alpha\left[P_{T,1}^{USD}\left(y_{T,1}^{j}+p_{N,1}^{J}y_{N,1}^{j}\right)\right]\quad t=0,1. \tag{6}$$

This type of borrowing constraint is standard and one common justification is limited enforcement of contracts.[8]

#### 4.1.2 Market Clearing

**Money market clearing**. Because goods must be purchased using local currencies and the cash-in-advance constraint is binding, the money market clearing condition in country $J$ is

$$M_t^J = P_{T,t}^J \left( y_{T,t}^j + p_{N,t}^J y_{N,t}^j \right) \ \forall J,t. \tag{7}$$

Without loss of generality, I standardize the nominal price of tradable good in period 0 to one unit, for all currencies. I assume the foreign government targets a stable domestic-currency price of tradable good.[9]

**Asset market and goods market clearing.** The market clearing conditions for tradable and non-tradable goods are

$$\theta \left[ (1-\phi)\, c_{T,t}^{NT,US} + \phi c_{T,t}^{US} \right] + (1-\theta)\, c_{T,t}^j = \theta y_{T,t}^{US} + (1-\theta)\, y_{T,t}^j \ \forall t, \tag{8}$$

$$(1-\phi)\, c_{N,t}^{NT,US} + \phi c_{N,t}^{US} = y_{N,t}^{US} \ \forall t, \text{ and} \tag{9}$$

$$c_{N,t}^j = y_{N,t}^j \ \forall t\ , \tag{10}$$

where $\theta$ is the size of the U.S. economy, $\phi$ is the share of the traders in the U.S., and $c_{x,t}^{NT,US}, c_{x,t}^{US}$ are the good-x consumption of the non-traders and traders, respectively, in the U.S. economy. The bond market clearing conditions are

$$D_{t+1}^{J,US} = -\frac{1}{\phi} \left( \frac{1-\theta}{\theta} \right) D_{t+1}^{J,j} \ \forall t, \text{ and} \tag{11}$$

$$D_{t+1}^{USD,US} = -\frac{1}{\phi} \left( \frac{1-\theta}{\theta} \right) D_{t+1}^{USD,j} \ \forall t,$$

where $D_{t+1}^{J,US}$ and $D_{t+1}^{J,j}$ are per-capita currency-$J$-denominated bonds held by the traders and agent $j$, respectively, and $D_{t+1}^{USD,US}$ and $D_{t+1}^{USD,j}$ are per-capita dollar-denominated bonds held by the traders and agent $j$, respectively.

[8] The assumption that the right-hand side of the borrowing constraint at both periods 0 and 1 is the same is made for simplicity and does not affect the qualitative results of the model. Essentially, with this borrowing constraint, there is no trend in the amount a foreign agent is allowed to borrow, and this assumption simplifies the analysis considerably, by ensuring the consumption of a constrained borrower at period 1 is always equal to 1 absent any shocks.

[9] This assumption is not important for the takeaways of the model, but it is convenient because it eliminates expected trends in the nominal exchange rates and thus simplifies the equilibrium expressions.

**Equilibrium definition.** Given the endowments $\{y_{N,t}, y_{T,t}\}_{t=0}^{2}$ and money supply distribution $\{M_t\}_{t=0}^{2}$, an equilibrium is a vector of asset prices $\{Q_t\}_{t=0}^{2}$, good prices $\{P_{T,t}, p_{N,t}\}_{t=0}^{2}$, consumption choices $\{c_{T,t}, c_{N,t}\}_{t=0}^{2}$, asset holdings $\{D_t\}_{t=1}^{2}$, and money holdings $\{M_t\}_{t=0}^{2}$ such that in each period $t \geq 0$, (1) all households maximize their utility subject to their constraints, taking prices and other agents' actions as given, (2) all government budget constraints hold, (3) asset and goods market clear, and (4) the law of one price in tradable good holds.

### 4.1.3 Solving the model

I solve the model recursively. I first analyze the equilibrium in period 1 and 2, taking as given the balance-sheet position decided in period 0, and then I return to period 0 to solve the optimal portfolio and equilibrium asset prices. I begin with the case in which collateral constraints are binding and the U.S. economy is sufficiently large such that the closed-economy solutions of the effect of U.S. monetary shocks on dollar value, U.S. consumption, and real interest rate are good approximations for the open-economy solutions. That is, I solve the model with the size of U.S. economy $\theta = 1$. In this case, the effect of U.S. monetary shocks on the U.S. economy is analogous to Alvarez et al. 2001. Throughout, I assume the cash-in-advance constraint binds and real value refers to value in units of tradable goods.

To illustrate the effect of U.S. monetary shocks $\mu$, I log linearize around the equilibrium when $\mu$ equals 0, which is the following. The nominal price of tradable good in all currencies is 1, and thus the nominal exchange rate also equals 1. Both traders and non-traders in the U.S. consume one unit of tradable and non-tradable goods. The real interest rate also equals 1. With binding collateral constraints, foreign borrowers only roll over their debt, and thus their tradable and non-tradable consumptions equal 1. By the Euler equation $p_N = c_T / c_N$, the real exchange rate equals 1. Finally, the following lemma is useful in analyzing the effect of U.S. monetary shocks on exchange rates.

**Lemma 1.** *The unexpected real and nominal exchange-rate appreciation of currency $J$ is increasing in the representative agent $j$'s unexpected tradable-good consumption. Specifically,*

$$d\log \varepsilon^J = d\log p_N^{USD} - d\log c_T^j, \tag{12}$$

$$d\log s_T^J \approx d\log P_T^{USD} - \frac{1}{2} d\log c_T^j. \tag{13}$$

The intuition for the former is that, given the Cobb-Douglas utility function, higher $c_T$ leads to a higher demand for non-tradable good, which means $p_N^J$ has to increase to clear non-tradable-good market in country $J$. For the latter, given the same amount of currency-$J$ in circulation, higher

$p_N^J$ means lower $P_T^J$. Finally, higher $p_N^J$ and lower $P_T^J$ imply the real and nominal exchange-rate appreciation of currency-$J$, respectively. The proofs are in the appendix.

## 4.2 Equilibrium in period 1 and 2

### 4.2.1 The Effect of U.S. Monetary Shocks on the U.S. Economy

In this section, I describe how U.S. monetary shocks $(\mu)$ affect dollar value and traders' consumptions, which are important for the equilibrium asset prices. Traders' cash-in-advance constraint in period 1 after open market operations is

$$P_{T,1}^{USD}\left(c_{T,1}^{US}+p_{N,1}^{US}c_{N,1}^{US}\right)=M_0^{USD}+\frac{\mu M_0^{USD}}{\phi}, \tag{14}$$

where $\phi$ is the share of traders in the U.S. economy, $\frac{\mu M_0^{USD}}{\phi}$ is the increase in dollar holding per trader from the open market operations, $c_{T,1}^{US}, c_{N,1}^{US}$ are tradable- and non-tradable-good consumption of traders in period 1. The term $\frac{\mu M_0^{USD}}{\phi}$ reflects the feature that only traders participate in the open market operations. In equilibrium, traders' consumption in terms of $\mu$ are $c_{T,1}^{US}=\left[\frac{1+\mu/\phi}{1+\mu}\right]$ and $c_{N,1}^{US}=\left[\frac{1+\mu/\phi}{1+\mu}\right]$.[10] Around $\mu$ equals zero, period-1 unexpected log changes in tradable-good dollar price, and in traders' tradable-good consumption are

$$d\log P_{T,1}^{USD}=\mu \tag{15}$$

$$d\log c_{T,1}^{US}=\frac{1-\phi}{\phi}\mu. \tag{16}$$

Expansionary monetary shock $\mu$ leads to a one-to-one increase in the tradable- and non-tradable-good dollar inflation and to an increase in the traders' tradable- and non-tradable-good consumption by $\frac{1-\phi}{\phi}\mu$. Intuitively, the inflation redistributes wealth from non-traders to traders, and $\frac{1-\phi}{\phi}\mu$ is the inflation tax on non-traders per trader.

The real interest rate in period 1 changes because traders' Euler equation, $c_{T,1}^{US}=q_1c_{T,2}^{US}$, has to hold. Intuitively, because expansionary monetary shocks make traders consume more today, the equilibrium real interest rate has to fall.[11] The effect of U.S. monetary shocks $\mu$ on the real interest

[10]The detailed proof is in the appendix 5.

[11]Both traders and non-traders enter period 2 with the same money holding of $M_1^{USD}$ from selling endowments in period 1. Although dollar injections through open market operation mean traders have maturing dollar bond of $\triangle M_1$ in period 1, the government also applies an equal amount of lump-sum transfer so that government budget constraint holds.

rate is

$$d\,log\,(1+r_1) = -\frac{1-\phi}{\phi}\mu. \tag{17}$$

### 4.2.2 The Effect of U.S. Monetary Shocks on the Foreign Economy

In this section, I describe how U.S. monetary shocks ($\mu$) affect the foreign economy. From the period budget constraint, we already can see the partial equilibrium effect of expansionary U.S. monetary shocks: dollar inflation (thus a systematic dollar depreciation) increases borrowers' tradable-good consumption by reducing the real debt burdens of dollar debt. To the first order, this channel only affects borrowers with dollar positions. Specifically, the period budget constraint combined with binding collateral constraints and non-tradable-good market clearing gives

$$c^j_{T,1} = y^j_{T,1} - \underbrace{\left(\frac{D^{USD}_1}{P^{USD}_{T,1}} + \frac{D^{DC}_1}{P^{DC}_{T,1}}\right)}_{\text{Real Debt Payment}} + \underbrace{q_1\alpha\left(y^j_{T,1} + p^{DC}_{N,1}y^j_{N,1}\right)}_{\text{Real Debt Issuance}}, \tag{18}$$

where $\frac{D^{USD}_1}{P^{USD}_{T,1}}$ and $\frac{D^{DC}_1}{P^{DC}_{T,1}}$ are the real value of dollar and domestic-currency nominal debt due in period 1, $q_1$ is the real interest rate between period 1 and 2, and $\alpha\left(y^j_{T,1} + p^{DC}_{N,1}y^j_{N,1}\right)$ is the real value of debt issued in period 1. Because there is no uncertainty in period 2, bonds denominated in all currencies have the same real interest rate and I can proceed as if real debt is the only asset traded in period 1.

My framework incorporates another three transmission mechanisms of $\mu$ to foreign consumption: the revaluation of domestic-currency debt, borrowing capacity, and refinancing cost. They clarify how the currency of debt denomination can be important. Log linearizing equation (18) around $\mu$ equals 0 gives

$$\begin{aligned} d\,log\left(c^j_{T,1}\right) = {} & \underbrace{d^{USD,j}_1\,d\,log\left(P^{USD}_{T,1}\right)}_{\text{Revaluation of USD Debt}} + \underbrace{d^{DC,j}_1\,d\,log\left(P^{DC}_{T,1}\right)}_{\text{Revaluation of DC Debt}} \\ & + \underbrace{\alpha\,d\,log\left(p^{DC}_{N,1}\right)}_{\text{Revaluation of Borrowing Capacity}} + \underbrace{2\alpha\,d\,log(q_1)}_{\text{Revaluation of Real Refinancing Cost}}, \end{aligned} \tag{19}$$

where $d_1 = D_1/E_0\left[P_{T,1}\right]$ is the expected real value of the nominal debt. The real refinancing cost channel is well known; regardless of the currency denomination, borrowers gain from a lower real refinancing cost. My framework shows the importance of debt denomination: The consumption exposure can be small even though the external debt is high if the debt are denominated in domestic currencies, because domestic-currency debt has an *equity-like* payoff that mitigates the spillover. Intuitively, suppose the real interest rate declines, which then allows for increases in tradable-good consumptions today. However, first, as in Lemma 1, higher $c_T$ leads to a lower nominal domestic-currency price of tradable good, which means the real value of domestic-currency debt increases, offsetting the initial spillover-consumption gain. Second, as in Lemma 1, higher $c_T$ leads to a higher borrowing capacity through the higher $p_N$, which means the lower consumption gain just discussed also leads to a smaller increase in borrowing capacity, further mitigating the spillover. Third, the smaller increase in borrowing capacity means smaller gains from the lower interest rate, further mitigating the spillover.

Algebraically, combining the effect of $\mu$ on dollar inflation (15) and real interest rate (17), equation (19) gives the equilibrium tradable-good consumption exposure $(\beta_\mu^j)$ to U.S. monetary shocks in terms of ex-ante balance sheet:

$$d\,log\left(c_{T,1}^j\right) = \left(\frac{d_1^{USD,j} + d_1^j\frac{1-\phi}{\phi}}{1-\frac{1}{2}d_1^{USD,j}}\right)\mu = \beta_\mu^j\mu. \tag{20}$$

Figure (3) illustrates the importance of the currency denomination. The figure shows $\beta_\mu^j$ for different debt-to-GDP ratios ($\alpha$) when all debt is in dollars and when all debt is in domestic currencies. When external debt is in domestic currencies, variation in leverage leads to a considerably smaller variation in $\beta_\mu^j$, which suggests the importance of dollar debt as the determinant of $\beta_\mu^j$, consistent with my empirical findings.

Figure 3: Exposure to U.S. Monetary Shocks vs. Debt-to-GDP Ratios


The left and right figures plot equation (19) for different maximum-debt-to-GDP ratio ($\alpha$) when all debt is in dollars and when all debt is in domestic currencies, respectively. Both figures are based on U.S. market segmentation $\left(\frac{1-\phi}{\phi}\right)$ of $\frac{1}{3}$.

My framework generates results consistent with the empirical findings; the exchange rate and debt issuance of higher-dollar-debt countries are more sensitive to U.S. monetary shocks.

**Proposition 1.** The response of currency-$J$ nominal exchange rate to U.S. monetary shocks $\mu$ is

$$d\,log\left(S_1^J\right) = \underbrace{\left(-\mu\right)}_{\text{Common effect}} + \underbrace{\left(-\frac{1}{2}\beta_\mu^j \mu\right)}_{\text{Country specific effect}} \quad , \tag{21}$$

where $d\,log\left(s_1^J\right) < 0$ denotes currency-$J$ nominal exchange-rate appreciation against the dollar. The first term is the common effect coming from dollar inflation. The second term is the country-specific effect coming from the effect of $\mu$ on the price of tradable good in currency $J$. Because $\beta_\mu^j$ is increasing dollar liabilities, larger dollar liabilities $d_1^{USD,j}$ leads to a larger exchange-rate appreciation for a given expansionary shock $\mu$.

**Proposition 2.** The response of real-debt issuance, as a ratio to the expected output, to an unexpected dollar injection $\mu$ is

$$\frac{d\left(d_2\right)}{E_0\left[y_{T,1} + p_{N,1}y_{N,1}\right]} = \frac{1}{2}\beta_\mu^j \alpha\mu \quad , \tag{22}$$

where $d_2$ is the change in the face value of real-debt issuance in period 1 and the denominator is the expected value of output in period 1. The larger the dollar-debt liabilities $d_1^{USD}$, the larger $\beta_\mu^j$, and thus the increase in $j$*'s* real-debt issuance (relative to the expected output) in response to an unexpected expansionary shocks $\mu$.

## 4.3 Equilibrium in period 0

In this section, I return to period 0 to find the equilibrium currency risk premia and currency choice of debt denomination. Lastly, I proceed with studying the efficiency properties of the competitive equilibrium in my framework.

### 4.3.1 Currency Risk Premia

Because the traders determine asset prices, their Euler equations with respect to all one-period nominally risk-free bonds hold in equilibrium. Specifically, $Q_0^J = E_0\left[\frac{u'\left(c_{T,1}^{US}\right)}{u'\left(c_{T,0}^{US}\right)}\frac{P_{T,0}^J}{P_{T,1}^J}\right]$ where $Q_0^J$ is the period-0 nominal price, in the domestic currencies, of a one-period nominally risk-free bond paying one unit of the domestic currency of an arbitrary foreign economy $J$. I can express $Q_0^J$ as

$$Q_0^J = Cov(u'\left(c_{T,1}^{US}\right), \frac{1}{P_{T,1}^{USD}}) + Cov(u'\left(c_{T,1}^{US}\right), \frac{1}{s_{T,1}^J}). \tag{23}$$

The price of bonds denominated in riskier currencies — currencies that depreciate more when the trader's marginal utility is high — is lower. Given the effect of U.S. monetary shocks ($\mu$) on traders' consumption (equation 14) and exchange rate (equation 21), log linearizing equation (23) around $\mu = 0$ gives the first-order difference in currency risk premia of dollar bonds and bonds denominated in a foreign currency as a function of the country's balance sheet.

**Proposition 3.** *The difference in the log expected returns of domestic-currency-J- and dollar-denominated nominally-risk-free one-period bonds is*

$$i_0^J - i_0^{USD} - E_0\left[\triangle s_1\right] = \underbrace{\left(\beta_\mu^{US}\right)}_{\frac{dlog\left(c_{T,1}^{US}\right)}{d\mu}} \underbrace{\left(1 + \frac{1}{2}\beta_\mu^j\right)}_{\frac{d\,log\left(s_1^J\right)}{d\mu}} \sigma_\mu^2, \tag{24}$$

*where $\beta_\mu^{US}$ and $\beta_\mu^j$ are the sensitivity of the traders' and representative agent j's tradable-good consumption $\left(d\,log\,c_{T,1}\right)$ to U.S. monetary shocks $\mu$, respectively.* The proof is in the appendix 5. The term $i_0^{DC} - i_0^{USD} - E_0\left[\triangle s_1\right]$ is the log expected return, expressed in dollars, of investing in domestic-currency bonds by borrowing in dollar bonds. The expression shows U.S. traders demand high risk premia on bonds denominated in high $\beta_\mu^j$ currencies, which are the currencies of countries with high dollar debt. When the expected exchange-rate movement is zero, for example, when exchange rates follow a random walk, high currency risk premia translate to high forward premia.

#### 4.3.2 Currency Choice of Debt Denomination

In this section, I discuss the optimal currency choice of debt denomination when borrowers face binding collateral constraints. The dominance of dollar debt is stronger when collateral constraints are more binding (that is, borrowing capacity is much smaller than ideal, the debt level if there is no collateral constraint) and when the traders are more exposed to U.S. monetary shocks. The former happens when borrowing capacity is much smaller than endowment growth. The latter happens when the U.S. market is more segmented. The basic ideas are apparent in the first-order approximation of foreign agents' Euler equations:

$$\underbrace{\left(q_0^{USD} - q_0^{DC}\right)\frac{\bar{c}_{T,1}^j}{c_{T,0}^j}}_{\text{Marginal benefit of USD debt}} \geq \underbrace{\beta_\mu^j\left(1+\frac{1}{2}\beta_\mu^j\right)\sigma_\mu^2}_{\text{Marginal cost of USD debt}} \tag{25}$$

$$\text{where } c_{T,0}^j = 1 - g^j + q_0^{USD}\,2\alpha - (q_0^{USD} - q_0^{DC})\,d_1^{DC,j}$$

$$\beta_\mu^j = \left[\frac{d_1^{USD,j} + 2\alpha\,\frac{1-\phi}{\phi}}{1-\frac{1}{2}d_1^{USD,j}}\right].$$

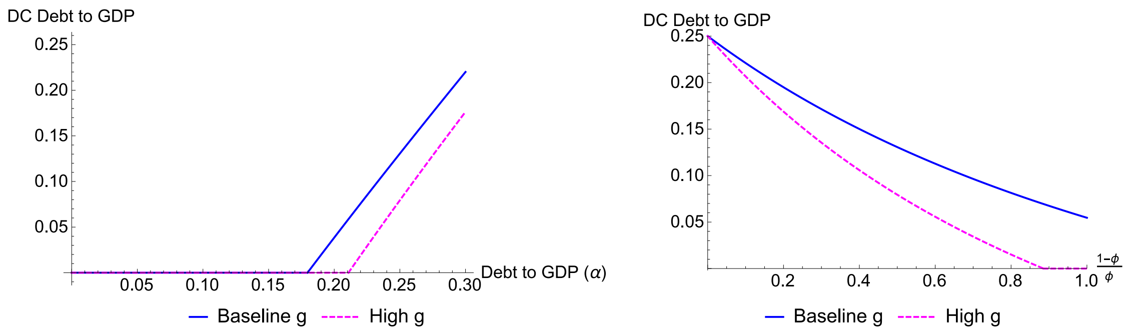
For a given limited borrowing capacity $\alpha$, on the one hand, because dollar debt has a lower interest rate ($q_0^{USD} - q_0^j$ is positive), dollar debt gives a higher tradable-good consumption today ($c_{T,0}^j$) and thus a smoother intertemporal consumption, in expectation. On the other hand, dollar debt increases her exposure ($\beta_\mu^j$) to shocks and thus leads to a more volatile consumption. This tradeoff is the key determinant in the optimal currency choice. When borrowing capacity is low, borrowing only in dollars is optimal. The illustration is clear when I give a country with zero international position (autarky) a small amount of borrowing capacity. The marginal benefit of dollar debt is high; borrowing in dollars is cheaper and borrowers' marginal utility of consumption today is high. Whereas the marginal cost of dollar debt is negligible, the effect of dollar debt on $\beta_\mu^j$ is small when the existing external debt is low. Therefore, borrowing in dollars is optimal. Increasing the borrowing capacity by a small amount and applying the same argument shows that borrowing only in dollars is optimal for a range of borrowing capacity.

However, as dollar debt increases, its marginal benefit declines due to diminishing marginal utility, whereas its marginal cost increases as $\beta_\mu^j$ is convex in dollar debt. Therefore, under some conditions, the optimal currency choice is interior. In the interior solutions, the risk-sharing wedge between the traders and foreign households ($\frac{\beta_\mu^j}{\beta_\mu^{US}}$) equals the intertemporal wedge in consumption ($\frac{\bar{c}_{T,1}^j}{c_{T,0}^j}$),

$$\frac{\beta_\mu^j}{\beta_\mu^{US}} = \frac{\bar{c}_{T,1}^j}{c_{T,0}^j}. \tag{26}$$

Figure 4 shows the optimal domestic-currency debt is increasing in borrowing capacity ($\alpha$) and decreasing in the U.S. market segmentation ($\frac{1-\phi}{\phi}$). Furthermore, for the same borrowing capacity and market segmentation, countries with more binding collateral constraint – higher $g$ countries – have a wider range of debt-to-GDP ratio such that most liabilities are in dollars, because the interior solution condition (26) is met only after a sufficiently high borrowing capacity due borrowers' high intertemporal wedge. The model sheds some light on the *original si*n: the interaction of risk sharing and limited borrowing capacity may give rise to the ubiquity of dollar debt.

Figure 4: Optimal Domestic-Currency Debt




These figures show the domestic-currency (DC) debt-to-GDP ratios that solve equation (26). The baseline parameters are U.S. market segmentation $\left(\frac{1-\phi}{\phi}\right) = \frac{1}{2}$, tradable-good growth $(g) = 0.6$, variance of $\mu = 0.01$, and maximum debt-to-GDP ratio $(\alpha) = 0.25$, and the high tradable-good growth $(g)$ is 0.8.

## 4.4 Efficiency

In this section, I solve the second-best currency choice and show that the competitive market equilibrium can lead to an excessive amounts of dollar liabilities. Atomistic individual households undervalue the cost of dollar debt because they do not take into account the effect of their currency choice on the country's output value, which in turn affects their consumption volatilities. A social planner can improve welfare by incorporating this pecuniary externality.

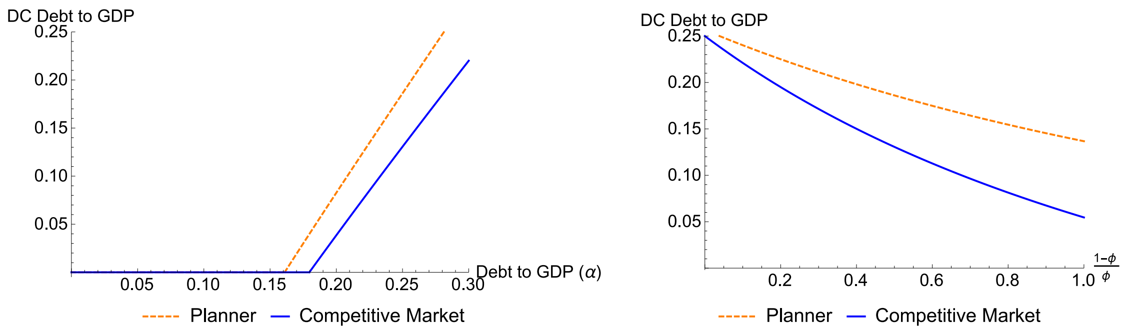
Specifically, the social planner solves foreign households' optimization problem while taking into account the effect of currency choice on the collateral value. The first-order approximation of the planner's Euler equation gives the following condition for an interior solution:

$$\frac{\bar{c}^j_{T,1}}{c^j_{T,0}} - \frac{\beta^j_\mu}{\beta^{US}_\mu} = \frac{1}{2} \underbrace{\frac{\partial \beta^j_\mu}{\partial d_1^{USD,j}}}_{>0} \underbrace{\frac{1}{(q_0^{USD} - q_0^{DC})}}_{>0} \left( \underbrace{\beta^j_\mu d_1^{USD,j}}_{>0} + \underbrace{\beta^{US}_\mu \frac{d_1^{DC,j}}{c^j_{T,0}}}_{>0} + \underbrace{\frac{1}{2}\beta^j_\mu \frac{(d_1^{USD,j} + d_1^{DC,j})^2}{(\bar{c}^j_{T,2})^2}}_{>0} \right) \sigma^2_\mu. \tag{27}$$

The planner does not equalize the risk-sharing wedge $(\frac{\beta^j_\mu}{\beta^{US}_\mu})$ with the inter-temporal wedge $(\frac{\bar{c}^j_{T,1}}{c^j_{T,0}})$, as opposed to the competitive market equilibrium. The term on the RHS is positive, which means the intertemporal rate of substitution is larger than that of the competitive market equilibrium, because the planner chooses higher share of domestic-currency debt and thus reduces the period-0 consumptions in exchange for lower consumption exposure to U.S. monetary shocks.

Figure 5 shows how the planner and competitive market domestic-currency debt differ for different debt limits $(\alpha)$ and U.S. market segmentation $\left(\frac{1-\phi}{\phi}\right)$. The domestic-currency liability chosen by the planner is weakly larger than that of the market in both dimensions. As the degree of market segmentation falls, the planner and market solution become closer and finally coincide under no segmentation.

Figure 5: The Competitive Market vs. Planner Currency Choice




These figures show the domestic-currency (DC) debt-to-GDP ratios of the competitive-market solution (26) and the planner solution (27). The baseline parameters are U.S. market segmentation $\left(\frac{1-\phi}{\phi}\right) = \frac{1}{2}$, tradable-good growth $(g) = 0.6$, variance of $\mu = 0.01$, and maximum debt-to-GDP ratio $(\alpha) = 0.25$.

# 5 Conclusion

I offer a novel economic explanation for currency risk premia. Countries' dollar-denominated net external debt (dollar debt) helps explain the large differences in risk premia across currencies and how U.S. monetary policy affects the global economy. When the U.S. dollar strengthens, the real value of dollar debt increases, weakening the currencies of countries with large amounts of dollar debt and impeding their consumptions. Because the dollar tends to strengthen in bad times, high-dollar-debt currencies are bad hedges and thus have to offer high risk premia. My empirical findings support this idea. First, dollar debt captures exchange-rate and debt-issuance responses to U.S. monetary policy shocks. Second, dollar debt captures the cross-sectional variation in currency risk premia. I develop a general equilibrium model with financial frictions and currency choice of debt denomination that corroborates my findings.

My empirical work offers a mechanism of how U.S. monetary policy may affect the global economy, leading to what is called the "*global financial cycle*" in Rey 2015. My model offers a risk-based rationale for why the dollar is the dominant currency of external-debt denomination, called the "*original sin*" in Eichengreen et al. 2002.

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# Tables

Table 1: Summary Statistics of Countries' External-Debt-to-GDP Ratios

This table shows the average net-external-debt-to-GDP ratios of the countries in my sample. The sample period of each country is the years between 1994 and 2014 during which the country adopts a flexible exchange rate defined based on Ilzetzki, Reinhart, and Rogoff (2011). The USD, EUR, JPY, GBP, CHF, DC, and ALL stand for the U.S. dollar, euro, Japanese yen, British pound sterling, Swiss franc, domestic currency, and all currencies, respectively.

| | | Average net-external-debt-to-GDP ratios in | | | | | | | | Years | OECD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Country | USD | EUR | JPY | GBP | CHF | FC | DC | ALL | in sample | member |
| 1 | Australia | 0.18 | 0.04 | 0.03 | 0.01 | 0.01 | 0.26 | 0.19 | 0.45 | 1994 - 2014 | Yes |
| 2 | Brazil | 0.17 | 0.02 | 0.01 | 0.00 | 0.00 | 0.20 | 0.00 | 0.19 | 2000 - 2014 | No |
| 3 | Canada | 0.17 | 0.01 | 0.01 | 0.00 | 0.00 | 0.20 | 0.12 | 0.32 | 2002 - 2014 | Yes |
| 4 | Chile | 0.22 | -0.02 | 0.00 | -0.01 | 0.00 | 0.19 | -0.01 | 0.18 | 2000 - 2014 | Yes |
| 5 | Colombia | 0.17 | 0.00 | 0.01 | -0.01 | 0.00 | 0.16 | 0.00 | 0.16 | 2000 - 2014 | No |
| 6 | Czech Republic | 0.15 | -0.06 | 0.00 | -0.02 | 0.00 | 0.07 | 0.00 | 0.07 | 2002 - 2014 | Yes |
| 7 | Euro Area | 0.11 | 0.00 | 0.02 | 0.02 | 0.02 | 0.22 | -0.01 | 0.21 | 1999 - 2014 | Yes |
| 8 | Germany | -0.02 | 0.00 | 0.04 | 0.01 | 0.03 | 0.12 | -0.05 | 0.07 | 1994 - 1998 | Yes |
| 9 | Hungary | 0.24 | 0.14 | 0.04 | 0.03 | 0.00 | 0.44 | 0.12 | 0.56 | 2004 - 2008 | Yes |
| 10 | Iceland | 0.28 | 0.97 | 0.05 | 0.02 | 0.03 | 1.31 | 0.10 | 1.41 | 2001 - 2007 | Yes |
| 11 | Indonesia | 0.21 | 0.03 | 0.14 | 0.00 | 0.00 | 0.38 | 0.00 | 0.38 | 1999 - 2014 | No |
| 12 | Israel | 0.02 | 0.02 | 0.01 | -0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 2006 - 2014 | Yes |
| 13 | Japan | -0.06 | -0.08 | -0.06 | -0.01 | 0.00 | -0.17 | -0.06 | -0.23 | 1994 - 2014 | Yes |
| 14 | Korea | 0.07 | 0.00 | 0.02 | 0.00 | 0.00 | 0.10 | 0.04 | 0.13 | 1999 - 2014 | Yes |
| 15 | Mexico | 0.15 | 0.00 | 0.02 | -0.01 | 0.00 | 0.16 | 0.00 | 0.15 | 1996 - 2014 | Yes |
| 16 | New Zealand | 0.20 | 0.01 | 0.04 | 0.02 | 0.01 | 0.34 | 0.26 | 0.60 | 1994 - 2014 | Yes |
| 17 | Norway | 0.11 | 0.14 | 0.06 | -0.08 | 0.02 | 0.25 | 0.02 | 0.26 | 1994 - 2014 | Yes |
| 18 | Poland | 0.09 | 0.16 | 0.03 | -0.01 | 0.02 | 0.31 | 0.00 | 0.31 | 1995 - 2014 | Yes |
| 19 | South Africa | 0.17 | -0.01 | 0.00 | -0.03 | 0.00 | 0.13 | 0.00 | 0.13 | 1996 - 2014 | No |
| 20 | Sweden | 0.09 | 0.18 | 0.07 | -0.01 | 0.02 | 0.41 | 0.09 | 0.50 | 1994 - 2014 | Yes |
| 21 | Turkey | 0.26 | 0.07 | 0.02 | -0.01 | 0.00 | 0.34 | 0.00 | 0.34 | 2003 - 2014 | Yes |
| 22 | United Kingdom | -0.21 | 0.08 | 0.06 | 0.29 | 0.00 | -0.02 | 0.29 | 0.27 | 1994 - 2001 , 2009 - 2014 | Yes |

Table 2: Summary Statistics of *USDebt* Portfolios

This table reports, for each portfolio, the average one-month log excess returns $rx_{t+1}$ and one-month nominal interest rate differentials implied by log forward premia, $f_t - s_t$. Log excess returns are computed as $rx_{t+1} = f_t - s_t - \triangle s_{t+1}$ and expressed in the U.S. dollars. All moments are annualized and reported in percentage points. The portfolios are constructed by sorting currencies into four groups every beginning of each year based on their USD-net-external-debt-to-GDP ratios (*USDebt*) in the previous year. *DCDebt* stands for domestic-currency-net-external-debt-to-GDP ratios. The GDP per capita is expressed in thousands of U.S. dollars. The GDP per capita growth is reported in percentage points. The share of young population is the share of population under the age of 50. The young dependency ratio is the number of population under the age of 25 over that of from the age of 25 to 50. Currencies in the sample are the currencies of OECD countries with flexible exchange rates. The sample period is from January 1994 to December 2014 for 252 monthly observations and 21 annual observations.

| | Lowest *USDebt* | Port 2 | Port 3 | Highest *USDebt* | Average | *USDebt*-HML |
|---|---|---|---|---|---|---|
| $rx_{t+1}$ | -0.18 | 1.40 | 3.05 | 5.28 | 2.39 | 5.46 |
| $fp_t$ | -0.15 | 1.74 | 2.66 | 5.76 | 2.50 | 5.91 |
| $\triangle s_{t+1}$ | 0.03 | 0.34 | -0.39 | 0.48 | 0.12 | 0.45 |
| Standard deviation | 6.43 | 6.69 | 6.61 | 8.08 | 6.02 | 6.99 |
| Sharpe ratio | -0.03 | 0.21 | 0.46 | 0.65 | 0.40 | 0.78 |
| $USDebt_t$ | -0.07 | 0.08 | 0.15 | 0.26 | 0.11 | 0.32 |
| $DCDebt_t$ | 0.05 | 0.02 | 0.09 | 0.06 | 0.05 | 0.01 |
| GDP per capita$_t$ | 36.5 | 28.8 | 26.4 | 18.6 | 27.6 | -17.9 |
| GDP-per-capita growth$_t$ | 4.24 | 4.51 | 5.72 | 6.11 | 5.14 | 1.60 |
| Share of young population$_t$ | 0.67 | 0.69 | 0.73 | 0.75 | 0.71 | 0.08 |
| Young dependency ratio$_t$ | 0.68 | 0.74 | 0.88 | 0.93 | 0.80 | 0.25 |
| Chin-Ito capital openness index$_t$ | 0.90 | 0.81 | 0.88 | 0.80 | 0.84 | -0.10 |

Table 3: Summary Statistics of U.S. Monetary Policy Shocks

This table shows the summary statistics of the U.S. monetary policy shocks based on the 30-minute changes in fed funds futures, and the summary statistics of the one-day changes in the three-month and one-year Treasury yield bracketing the scheduled FOMC press release. The sample period is from January 1994 to December 2007 for a total of 112 events based on 8 scheduled FOMC meetings per year. The fed funds rate based U.S. monetary policy shocks are from Weber and Gorodnichenko (2015). The Treasury-yield data are from the Federal Reserve Board.

| Instrument | Fed funds | 3M Treasury | 1Y Treasury |
|---|---|---|---|
| Mean | -.5 | -1.9 | -1.2 |
| Median | .0 | -1.0 | -1.0 |
| Standard deviation | 5.9 | 5.3 | 5.7 |
| Min | -22.6 | -19.0 | -19.0 |
| Max | 16.3 | 12.0 | 14.0 |
| Correlations | | .7 | .5 |
| Number of observations | 112 | | |

Table 4: Responses of Exchange Rates to U.S. Monetary Shocks

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt} Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$, $USDGrossDebtLb_{i,t-1}$ is the USD-gross-external-debt-liabilities-to-GDP ratio, and $USDGrossDebtAs_{i,t-1}$ is the USD-gross-external-debt-assets-to-GDP ratio. *NonUSD* denotes external debt denominated in non-USD currencies. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) |
|---|---|---|---|
| $\mu_t$ | 2.17*** | 1.66** | 1.30 |
| | (0.64) | (0.66) | (0.87) |
| $USDDebt_{i,t-1} \times \mu_t$ | 7.52*** | 6.39*** | |
| | (2.81) | (2.05) | |
| $NonUSDDebt_{i,t-1} \times \mu_t$ | | 2.92* | |
| | | (1.51) | |
| $USDGrossDebtLb_{i,t-1} \times \mu_t$ | | | 7.17** |
| | | | (2.87) |
| $USDGrossDebtAs_{i,t-1} \times \mu_t$ | | | -7.05*** |
| | | | (1.69) |
| $NonUSDGrossDebtLb_{i,t-1} \times \mu_t$ | | | 2.14 |
| | | | (1.48) |
| $NonUSDGrossDebtAs_{i,t-1} \times \mu_t$ | | | -0.42 |
| | | | (2.36) |
| $USDDebt_{i,t-1}$ | -0.16 | -0.16 | |
| | (0.14) | (0.13) | |
| $NonUSDDebt_{i,t-1}$ | | 0.03 | |
| | | (0.07) | |
| $USDGrossDebtLb_{i,t-1}$ | | | -0.49** |
| | | | (0.21) |
| $USDGrossDebtAs_{i,t-1}$ | | | 0.19 |
| | | | (0.13) |
| $NonUSDGrossDebtLb_{i,t-1}$ | | | 0.09 |
| | | | (0.06) |
| $NonUSDGrossDebtAs_{i,t-1}$ | | | -0.12 |
| | | | (0.08) |
| Constant | -0.02 | -0.02 | 0.05 |
| | (0.05) | (0.05) | (0.06) |
| Observations | 1,312 | 1,312 | 1,312 |
| $R^2$ | 0.05 | 0.06 | 0.06 |
| Number of countries | 18 | 18 | 18 |

Table 5: Responses of Exchange Rates to U.S. Monetary Shocks

This table shows the regression results of the following specification:

$$\begin{aligned}\triangle s_{i,t} = \alpha + \beta_\mu \mu_t + \beta_{\overline{Debt}}\left[\overline{USDebt}_i \times \mu_t\right] + \beta_{\hat{Debt}}\left[(USDebt_{i,t} - \overline{USDebt}_i) \times \mu_t\right] \\ + \gamma_{\overline{Debt}} \overline{USDebt}_i + \gamma_{\hat{Debt}} (USDebt_{i,t} - \overline{USDebt}_i) + \varepsilon_{i,t},\end{aligned}$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, $\overline{USDebt}_i$ is the average USD-net-external-debt-to-GDP ratio of country $i$ over the sample period, and $(USDebt_{i,t} - \overline{USDebt}_i)$ is the deviation of $USDebt_{i,t}$ from its average. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) |
|---|---|
| $\mu_t$ | 2.17*** |
| | (0.69) |
| $\overline{USDebt}_i \times \mu_t$ | 7.39** |
| | (3.45) |
| $(USDebt_{i,t} - \overline{USDebt}_i) \times \mu_t$ | 7.00** |
| | (3.35) |
| $\overline{USDebt}_i$ | -0.05 |
| | (0.20) |
| $(USDebt_{i,t} - \overline{USDebt}_i)$ | -0.42* |
| | (0.22) |
| Constant | -0.03 |
| | (0.05) |
| Observations | 1,312 |
| $R^2$ | 0.05 |
| Number of countries | 18 |

Table 6: Responses of Exchange Rates to U.S. Monetary Shocks (Asymmetric Effects of Expansionary and Contractionary Shocks)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_\mu \mu_t + \beta_{+,\mu}\left[D_{+,t} \times \mu_t\right] + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \beta_{+,Debt}\left[Debt_{i,t-1} \times D_{+,t} \times \mu_t\right]$$
$$+ \gamma_{Debt} Debt_{i,t-1} + \gamma_+ D_{+,t} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, $D_{+,t}$ is a dummy variable equal to one if $\mu_t > 0$ and zero otherwise, $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. The sample is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $\mu_t$ | 2.17*** | 1.44 | 1.93*** | 1.46 | 1.96** | 1.62 |
| | (0.64) | (0.90) | (0.65) | (0.90) | (0.89) | (1.10) |
| $D_{+,t} \times \mu_t$ | | 0.55 | | -0.47 | | -0.35 |
| | | (2.34) | | (2.71) | | (3.43) |
| $USDDebt_{i,t-1} \times \mu_t$ | 7.52*** | 10.85*** | 8.49*** | 10.58*** | 7.48** | 8.13** |
| | (2.81) | (3.23) | (2.74) | (3.26) | (3.55) | (3.88) |
| $USDDebt_{i,t-1} \times D_{+,t} \times \mu_t$ | | -10.45* | | -7.20 | | -1.94 |
| | | (5.77) | | (5.99) | | (11.99) |
| $USDDebt_{i,t-1}$ | -0.16 | -0.00 | -0.13 | -0.03 | -0.10 | -0.08 |
| | (0.14) | (0.17) | (0.13) | (0.17) | (0.21) | (0.26) |
| $D_{+,t}$ | | 0.10 | | 0.12 | | 0.09 |
| | | (0.16) | | (0.16) | | (0.15) |
| Constant | -0.02 | -0.07 | -0.02 | -0.06 | -0.02 | -0.05 |
| | (0.05) | (0.08) | (0.05) | (0.08) | (0.06) | (0.08) |
| Observations | 1,312 | 1,312 | 1,305 | 1,305 | 899 | 899 |
| $R^2$ | 0.05 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 |
| Number of countries | 18 | 18 | 18 | 18 | 9 | 9 |
| Excluding the event of Feb 4, 1994 | No | No | Yes | Yes | Yes | Yes |

Table 7: Responses of Exchange Rates to U.S. Monetary Shocks (with Emerging Countries)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt} Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. $NonUSD$ denotes external debt denominated in non-USD currencies. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\mu_t$ | 1.66** | 1.98*** | 2.20* | 2.66* |
| | (0.66) | (0.69) | (1.21) | (1.35) |
| $USDDebt_{i,t-1} \times \mu_t$ | 6.39*** | 3.06 | 9.66*** | 8.13** |
| | (2.05) | (2.60) | (3.37) | (3.75) |
| $NonUSDDebt_{i,t-1} \times \mu_t$ | 2.92* | 2.41* | 3.09** | 2.21 |
| | (1.51) | (1.21) | (1.33) | (1.31) |
| $USDDebt_{i,t-1}$ | -0.16 | -0.10 | -0.24 | -0.15 |
| | (0.13) | (0.16) | (0.20) | (0.21) |
| $NonUSDDebt_{i,t-1}$ | 0.03 | 0.03 | 0.15* | 0.12 |
| | (0.07) | (0.07) | (0.08) | (0.09) |
| Constant | -0.02 | -0.03 | -0.05 | -0.03 |
| | (0.05) | (0.05) | (0.06) | (0.07) |
| Observations | 1,312 | 1,616 | 1,312 | 1,616 |
| $R^2$ | 0.06 | 0.04 | 0.06 | 0.05 |
| Number of countries | 18 | 22 | 18 | 22 |
| Event window | One-day | One-day | Two-day | Two-day |
| Sample | OECD | OECD + EM | OECD | OECD + EM |

Table 8: Responses of Exchange Rates to U.S. Monetary Shocks (Financial Variables Robustness Checks)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt} Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\mu_t$ | 2.18*** | 2.11*** | 2.31*** | 2.71** |
| | (0.69) | (0.68) | (0.67) | (1.05) |
| $USDDebt_{i,t-1} \times \mu_t$ | 6.90** | 6.74** | 8.42*** | |
| | (2.70) | (2.67) | (2.86) | |
| $E_{t-1}\left[\triangle ff_t\right]$ | 0.01 | | | |
| | (0.27) | | | |
| $USDDebt_{i,t-1} \times E_{t-1}\left[\triangle ff_t\right]$ | 0.70 | | | |
| | (0.60) | | | |
| $1M\,forward\,premia_{i,t-1} \times \mu_t$ | | 1.68 | | |
| | | (1.26) | | |
| $\triangle 1M\,forward\,premia_{i,t-1} \times \mu_t$ | | | -14.83 | |
| | | | (14.35) | |
| $TradeCentrality_{i,t-1} \times \mu_t$ | | | | -0.19 |
| | | | | (4.30) |
| Constant | -0.02 | -0.03 | -0.02 | 0.24 |
| | (0.05) | (0.05) | (0.05) | (0.31) |
| Observations | 1,312 | 1,206 | 1,206 | 1,168 |
| $R^2$ | 0.05 | 0.06 | 0.06 | 0.04 |
| Number of countries | 18 | 18 | 18 | 14 |

Table 9: Responses of Exchange Rates to U.S. Monetary Shocks (Financial Variables Robustness Checks)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt} Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (5) | (6) | (7) |
|---|---|---|---|
| $\mu_t$ | 3.18*** | 0.87 | 2.51*** |
| | (0.72) | (1.02) | (0.58) |
| $USDDebt_{i,t-1} \times \mu_t$ | | 9.05*** | 6.59** |
| | | (2.52) | (2.76) |
| $TradeCentrality_{i,t-1} \times \mu_t$ | | 9.06* | |
| | | (4.23) | |
| $GDPShare_{i,t-1} \times \mu_t$ | -2.71** | | -1.68* |
| | (1.23) | | (0.93) |
| Constant | -0.04 | -0.02 | 0.38 |
| | (0.05) | (0.05) | (0.36) |
| Observations | 1,312 | 1,312 | 1,168 |
| $R^2$ | 0.04 | 0.05 | 0.05 |
| Number of countries | 18 | 18 | 14 |

Table 10: Responses of Exchange Rates to U.S. Monetary Shocks (Macro Variables Robustness Checks)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt}Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\mu_t$ | 2.25*** | 2.27*** | 1.71 | 2.09*** |
| | (0.67) | (0.69) | (1.18) | (0.59) |
| $USDDebt_{i,t-1} \times \mu_t$ | 6.70*** | 8.57*** | 7.64** | 8.04** |
| | (2.44) | (2.87) | (2.93) | (3.12) |
| $NetExport_{i,t-1} \times \mu_t$ | -5.04 | | | |
| | (5.63) | | | |
| $USDNetExport_{i,t-1} \times \mu_t$ | | 2.82 | | |
| | | (2.60) | | |
| $USDExport_{i,t-1} \times \mu_t$ | | | 2.11 | |
| | | | (2.62) | |
| $USDImport_{i,t-1} \times \mu_t$ | | | 2.84 | |
| | | | (6.77) | |
| $OilNetExport_{i,t-1} \times \mu_t$ | | | | 1.01** |
| | | | | (0.50) |
| Constant | -0.02 | -0.02 | 0.02 | -0.02 |
| | (0.05) | (0.06) | (0.07) | (0.05) |
| Observations | 1,240 | 896 | 896 | 1,232 |
| $R^2$ | 0.05 | 0.05 | 0.05 | 0.05 |
| Number of countries | 18 | 14 | 14 | 18 |

Table 11: Responses of Exchange Rates to U.S. Monetary Shocks (Macro Variables Robustness Checks)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt} Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $USD\,Debt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (5) | (6) | (7) | (8) |
|---|---|---|---|---|
| $\mu_t$ | 1.97** | 2.11*** | 2.15*** | 2.06** |
| | (0.68) | (0.70) | (0.65) | (0.75) |
| $USD\,Debt_{i,t-1} \times \mu_t$ | 6.47** | 6.77** | 6.65** | 5.34*** |
| | (2.59) | (2.67) | (2.53) | (1.75) |
| $Domestic\,Debt_{i,t-1} \times \mu_t$ | 0.76 | | | 0.53 |
| | (0.66) | | | (0.77) |
| $Dom\,Gov\,Debt_{i,t-1} \times \mu_t$ | | 0.61 | | |
| | | (1.35) | | |
| $Dom\,NonFC\,Debt_{i,t-1} \times \mu_t$ | | | 1.41 | |
| | | | (2.75) | |
| $USDebt \times Domestic\,Debt \times \mu_t$ | | | | 4.39** |
| | | | | (1.96) |
| Constant | 0.07 | 0.06 | 0.06 | 0.07 |
| | (0.06) | (0.07) | (0.06) | (0.06) |
| Observations | 1,200 | 1,200 | 1,200 | 1,200 |
| $R^2$ | .06 | .06 | .06 | .06 |
| Number of countries | 17 | 17 | 17 | 17 |

Table 12: Responses of Exchange Rates to U.S. Monetary Shocks (by Sector)

This table shows the regression results of the following specification:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{SectorJDebt}\left[SectorJDebt_{i,t-1} \times \mu_t\right] + \gamma_{SectorJDebt}SectorJDebt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day window bracketing the FOMC press release, positive $\triangle s_{i,t}$ denotes USD appreciation, $\mu_t$ is the fed funds futures based U.S. monetary policy shock, $\mu_t > 0$ denotes a contractionary shock, and $SectorJDebt_{i,t-1}$ is the net-external-debt-to-GDP ratio of sector $J$ in country $i$ in the year prior to event $t$. There are 3 sectors: banking, public, and other sector. Public-sector debt is the sum of the government and central bank position. The sample period is from January 1994 to December 2007 for a total of 112 events. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) |
|---|---|---|
| $\mu_t$ | 1.61** | 1.61** |
| | (0.65) | (0.70) |
| $BankDebt_{t-1} \times \mu_t$ | 6.05*** | 5.80*** |
| | (1.77) | (1.35) |
| $OtherSDebt_{t-1} \times \mu_t$ | 4.98** | 4.86* |
| | (2.34) | (2.38) |
| $PublicDebt_{t-1} \times \mu_t$ | -1.71 | -1.76 |
| | (2.71) | (2.84) |
| $BankDebt_{t-1}$ | -0.06 | -0.28 |
| | (0.10) | (0.17) |
| $OtherSDebt_{t-1}$ | 0.11 | -0.24 |
| | (0.20) | (0.23) |
| $PublicDebt_{t-1}$ | -0.01 | 0.05 |
| | (0.10) | (0.20) |
| Constant | -0.04 | -0.01 |
| | (0.05) | (0.06) |
| Observations | 1,200 | 478 |
| $R^2$ | 0.06 | 0.17 |
| Number of countries | 17 | 17 |
| $\lvert\mu_t\rvert > 2$ basis-point | No | Yes |

Table 13: Responses of Exchange Rates to Monetary Shocks of the BOJ and ECB

This table shows the regression results of the following specification applied to the Bank of Japan (BOJ) and European Central Bank (ECB) monetary policy announcement days, separately:

$$\triangle s_{i,t} = \alpha + \beta_{\mu}\mu_t + \beta_{Debt}\left[Debt_{i,t-1} \times \mu_t\right] + \gamma_{Debt}Debt_{i,t-1} + \varepsilon_{i,t},$$

where $\triangle s_{i,t}$ is the percentage change in the exchange rate in a one-day or two-day window bracketing the central bank's monetary policy announcement, positive $\triangle s_{i,t}$ denotes central bank's currency appreciation, $\mu_t$ is the one-day change in the two-year Japanese government bond yield for the BOJ events and German government bond yield for the ECB events, $CBDebt_{i,t-1}$ is the net external debt denominated in the respective central bank's currency, as a ratio to GDP, of country $i$ in the year prior to event $t$ and $NonCB$ denotes net external debt denominated in any currencies other than the central bank's. $\mu_t$ is normalized by one standard deviation of the one-day changes in the bond yield on the event days of the respective central banks. Sample period I is from January 1999 to December 2007. Sample period II is from January 1999 to December 2014. The currencies in sample are the OECD and EM currencies with flexible exchange rates. Standard errors are clustered at the event level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | BOJ | | | | ECB | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\mu_t$ | 0.12* | 0.13 | 0.11* | 0.10 | -0.08 | -0.11 | 0.10*** | 0.15** |
| | (0.07) | (0.11) | (0.07) | (0.12) | (0.05) | (0.08) | (0.04) | (0.06) |
| $CBDebt_{i,t-1} \times \mu_t$ | 0.78* | 1.90*** | 0.67 | 1.68*** | 0.11 | -0.01 | 0.07*** | 0.07* |
| | (0.42) | (0.51) | (0.48) | (0.59) | (0.12) | (0.18) | (0.02) | (0.04) |
| $NonCBDebt_{i,t-1} \times \mu_t$ | -0.05 | -0.15 | -0.04 | -0.09 | -0.03 | 0.10 | -0.27*** | -0.31* |
| | (0.07) | (0.10) | (0.04) | (0.07) | (0.14) | (0.20) | (0.08) | (0.18) |
| $CBDebt_{i,t-1}$ | 1.79*** | 2.00** | 0.87 | 0.92 | -0.07 | 0.08 | 0.01 | 0.06 |
| | (0.61) | (0.84) | (0.59) | (0.90) | (0.10) | (0.12) | (0.02) | (0.04) |
| $NonCBDebt_{i,t-1}$ | -0.11** | -0.14* | 0.00 | -0.01 | -0.18* | -0.31* | -0.10 | -0.22* |
| | (0.05) | (0.07) | (0.03) | (0.04) | (0.11) | (0.15) | (0.08) | (0.11) |
| Constant | -0.12* | -0.12 | -0.03 | -0.00 | 0.06 | 0.07 | 0.02 | -0.00 |
| | (0.06) | (0.08) | (0.07) | (0.10) | (0.04) | (0.06) | (0.03) | (0.05) |
| Observations | 2,118 | 2,118 | 4,096 | 4,096 | 1,932 | 1,932 | 3,547 | 3,547 |
| $R^2$ | 0.04 | 0.04 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Number of countries | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| Event window | 1 day | 2 day | 1 day | 2 day | 1 day | 2 day | 1 day | 2 day |
| Sample period | I | I | II | II | I | I | II | II |

Table 14: Summary Statistics of Quarterly Debt Issuance

This table shows the summary statistics of the quarterly debt issuance relative to previous year's GDP (*Debt Issuance*) and one-quarter changes in the quarterly debt issuance ($\triangle$*Debt Issuance*). Both variables are expressed in percentage points. The sample period is from 1994 to 2007. $\mu > 0$ indicates unexpected contractionary U.S. monetary shocks based on the fed funds futures and $\mu < 0$ indicates unexpected expansionary U.S. monetary shocks. High debt countries in the OECD consist of Australia, Canada, Chile, Czech Republic, Hungary, Mexico, New Zealand, Norway, and Turkey. Low debt countries in the OECD consist of Israel, Korea, Poland, and Sweden. The financial centers consist of Germany, European Monetary Union, Japan, and the United Kingdom. The EM countries include Brazil, Colombia, Indonesia, and South Africa.

| Group | All countries | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All $\mu$ | | | $\mu > 0$ | | | $\mu < 0$ | | |
| | N | Mean | Std. dev | N | Mean | Std. dev | N | Mean | Std. dev |
| *Debt Issuance* | 744 | 0.13 | 0.51 | 318 | 0.10 | 0.50 | 390 | 0.15 | 0.51 |
| $\triangle$*Debt Issuance* | 744 | -0.01 | 0.70 | 318 | -0.04 | 0.73 | 390 | 0.01 | 0.70 |
| *USDebt* | 744 | 0.12 | 0.13 | 318 | 0.13 | 0.13 | 390 | 0.11 | 0.13 |
| | High debt countries in the OECD | | | | | | | | |
| | All $\mu$ | | | $\mu > 0$ | | | $\mu < 0$ | | |
| | N | Mean | Std. dev | N | Mean | Std. dev | N | Mean | Std. dev |
| *Debt Issuance* | 332 | 0.20 | 0.60 | 142 | 0.17 | 0.59 | 174 | 0.23 | 0.63 |
| $\triangle$*Debt Issuance* | 332 | 0.01 | 0.82 | 142 | -0.01 | 0.79 | 174 | 0.03 | 0.88 |
| *USDebt* | 332 | 0.18 | 0.06 | 142 | 0.19 | 0.07 | 174 | 0.18 | 0.06 |
| | Low debt countries in the OECD | | | | | | | | |
| | All $\mu$ | | | $\mu > 0$ | | | $\mu < 0$ | | |
| | N | Mean | Std. dev | N | Mean | Std. dev | N | Mean | Std. dev |
| *Debt Issuance* | 264 | 0.09 | 0.41 | 106 | 0.08 | 0.42 | 143 | 0.08 | 0.40 |
| $\triangle$*Debt Issuance* | 264 | -0.03 | 0.62 | 106 | -0.06 | 0.75 | 143 | -0.03 | 0.51 |
| *USDebt* | 264 | -0.01 | 0.12 | 106 | 0.00 | 0.11 | 143 | -0.01 | 0.12 |
| | Emerging Market countries | | | | | | | | |
| | All $\mu$ | | | $\mu > 0$ | | | $\mu < 0$ | | |
| | N | Mean | Std. dev | N | Mean | Std. dev | N | Mean | Std. dev |
| *Debt Issuance* | 148 | 0.06 | 0.37 | 70 | 0.00 | 0.41 | 73 | 0.11 | 0.34 |
| $\triangle$*Debt Issuance* | 148 | 0.00 | 0.53 | 70 | -0.08 | 0.55 | 73 | 0.07 | 0.50 |
| *USDebt* | 148 | 0.20 | 0.10 | 70 | 0.21 | 0.11 | 73 | 0.19 | 0.10 |
| | Financial centers | | | | | | | | |
| | All $\mu$ | | | $\mu > 0$ | | | $\mu < 0$ | | |
| | N | Mean | Std. dev | N | Mean | Std. dev | N | Mean | Std. dev |
| *Debt Issuance* | 108 | 0.13 | 0.30 | 40 | 0.11 | 0.30 | 61 | 0.14 | 0.31 |
| $\triangle$*Debt Issuance* | 108 | 0.00 | 0.29 | 40 | -0.05 | 0.26 | 61 | 0.02 | 0.31 |
| *USDebt* | 108 | -0.11 | 0.10 | 40 | -0.12 | 0.09 | 61 | -0.11 | 0.10 |

Table 15: Responses of External Debt Issuance to U.S. Monetary Shocks

This table reports the OLS estimates of specification 3:

$$\triangle Debt_{i,t} = \alpha_0 + \beta_\mu \mu_t + \beta_{\mu,Debt} [\mu_t \times Debt_{i,t-1}] + \gamma_{Debt} [Debt_{i,t-1}] + control_{i,t-1} + \varepsilon_{i,t},$$

where one period is a quarter, $\triangle Debt_{i,t}$ is one-quarter change of country *i's* external-debt issuance in period $t$ normalized by the GDP at the end of the previous year of period $t$, $\triangle USDebt_{i,t}$ is that of USD-denominated issuance, $\mu_t$ is the fed funds futures based U.S. monetary policy shocks in period $t$, and $USDebt_{i,t}$ is country *i's* USD-net-external-debt-to-GDP ratio at the end of the previous year of period $t$. $NonUSD$ denotes external debt denominated in non-USD currencies. The baseline control variables are the lagged dependent variables of lag 1 to 4, country fixed effects, and quarter fixed effects. Sample period I is from 1994 to 2007 and sample period II is from 1994 to 2014. Standard errors are heteroscedasticity and four-lag serial-correlation consistent based on Driscoll and Kraay (1997) and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| $\triangle USDebt$ | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\mu_t$ | 0.85 | 0.80 | 0.80 | 1.29** |
| | (0.61) | (0.58) | (0.53) | (0.55) |
| $USDebt_{i,t-1} \times \mu_t$ | -6.05** | -5.81** | -6.29** | -7.32*** |
| | (2.93) | (2.95) | (3.24) | (2.51) |
| $E_{t-1}[\triangle ff_t]$ | | 0.13 | | |
| | | (0.08) | | |
| $USDebt_{i,t-1} \times E_{t-1}[\triangle ff_t]$ | | -0.57 | | |
| | | (0.34) | | |
| $NonUSDDebt_{i,t-1} \times \mu_t$ | | | 0.46 | |
| | | | (1.43) | |
| $USDebt_{i,t-1}$ | -0.73** | -0.67** | -1.04** | -0.42 |
| | (0.30) | (0.31) | (0.45) | (0.28) |
| $NonUSDDebt_{i,t-1}$ | | | 0.64 | |
| | | | (0.47) | |
| Observations | 632 | 632 | 632 | 1,036 |
| Number of countries | 17 | 17 | 17 | 17 |
| Sample period | I | I | I | II |

Table 16: Responses of Other-currencies External Debt Issuance to U.S. Monetary Shocks

This table reports the OLS estimates of specification 3:

$$\triangle Debt_{i,t} = \alpha_0 + \beta_\mu \mu_t + \beta_{\mu,Debt}\left[\mu_t \times Debt_{i,t-1}\right] + \gamma_{Debt}\left[Debt_{i,t-1}\right] + control_{i,t-1} + \varepsilon_{i,t},$$

where one period is a quarter, $\triangle Debt_{i,t}$ is one-quarter change of country *i's* external-debt issuance in period $t$ normalized by the GDP at the end of the previous year of period $t$, $\triangle USDebt_{i,t}$ is that of USD-denominated issuance, $\triangle NonUSDDebt_{i,t}$ is that of non-USD-denominated issuance, $\mu_t$ is the fed funds futures based U.S. monetary policy shocks in period $t$, and $USDebt_{i,t}$ is country *i's* USD-net-external-debt-to-GDP ratio at the end of the previous year of period $t$. *NonUSD* denotes external debt denominated in non-USD currencies. The baseline control variables are the lagged dependent variables of lag 1 to 4, country fixed effects, and quarter fixed effects. Sample period I is from 1994 to 2007 and sample period II is from 1994 to 2014. Standard errors are heteroscedasticity and four-lag serial-correlation consistent based on Driscoll and Kraay (1997) and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | $\triangle USDebt$ | | $\triangle NonUSDDebt$ | | $\triangle Debt$ | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\mu_t$ | 0.85 | 0.80 | 1.36*** | 0.50* | 2.37*** | 1.45** |
| | (0.61) | (0.53) | (0.41) | (0.26) | (0.80) | (0.67) |
| $USDebt_{i,t-1} \times \mu_t$ | -6.05** | -6.29** | -5.16*** | -6.66*** | -11.26*** | -12.84*** |
| | (2.91) | (3.22) | (1.80) | (1.46) | (2.81) | (3.19) |
| $NonUSDDebt_{i,t-1} \times \mu_t$ | | 0.46 | | 7.23*** | | 7.50*** |
| | | (1.45) | | (1.39) | | (2.15) |
| $USDebt_{i,t-1}$ | -0.73** | -1.04** | -0.38 | -0.55 | -1.08*** | -1.53** |
| | (0.30) | (0.46) | (0.32) | (0.46) | (0.40) | (0.62) |
| $NonUSDDebt_{i,t-1}$ | | 0.64 | | 0.33 | | 0.92 |
| | | (0.48) | | (0.52) | | (0.63) |
| Observations | 632 | 632 | 632 | 632 | 632 | 632 |
| Number of countries | 17 | 17 | 17 | 17 | 17 | 17 |

Table 17: Responses of International Debt Issuance to U.S. Monetary Shocks (Robustness Check)

This table reports the OLS estimates of specification 3:

$$\triangle Debt_{i,t} = \alpha_0 + \beta_\mu \mu_t + \beta_{\mu,Debt}\left[\mu_t \times Debt_{i,t-1}\right] + \gamma_{Debt}\left[Debt_{i,t-1}\right] + control_{i,t-1} + \varepsilon_{i,t},$$

where one period is a quarter, $\triangle Debt_{i,t}$ is one-quarter change of country *i's* external-debt issuance in period $t$ normalized by the GDP at the end of the previous year of period $t$, $\triangle USDebt_{i,t}$ is that of USD-denominated issuance, $\mu_t$ is the fed funds futures based U.S. monetary policy shocks in period $t$, and $USDebt_{i,t}$ is country *i's* USD-net-external-debt-to-GDP ratio at the end of the previous year of period $t$. The baseline control variables are the lagged dependent variables of lag 1 to 4, country fixed effects, and quarter fixed effects. Sample period I is from 1994 to 2007 and sample period II is from 1994 to 2014. Standard errors are heteroscedasticity and four-lag serial-correlation consistent based on Driscoll and Kraay (1997) and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| $\triangle USDebt$ | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mu_t$ | 1.29** | 0.50 | -5.36 | 1.46** | 1.60** | 1.33** | 1.03 | 1.18 | 1.16* | 1.39 | 0.58 |
| | (0.55) | (0.66) | (4.61) | (0.57) | (0.62) | (0.54) | (0.65) | (0.69) | (0.61) | (0.80) | (0.38) |
| $USDebt_{i,t-1} \times \mu_t$ | -7.32*** | -6.02** | -6.24** | -8.28*** | -8.48** | -7.68*** | -8.29*** | -8.18*** | -8.68** | -7.25** | -6.84*** |
| | (2.51) | (2.67) | (2.49) | (2.55) | (3.27) | (2.47) | (2.82) | (2.77) | (3.84) | (3.37) | (2.31) |
| $GDP\,Share \times \mu_t$ | | 1.60*** | | | | | | | | | |
| | | (0.55) | | | | | | | | | |
| $Centrality \times \mu_t$ | | | 5.79 | | | | | | | | |
| | | | (4.21) | | | | | | | | |
| $NX \times \mu_t$ | | | | 3.16 | | | | | | | |
| | | | | (2.68) | | | | | | | |
| $NX\,USD \times \mu_t$ | | | | | 5.65 | | | | | | |
| | | | | | (3.90) | | | | | | |
| $Oil\,NX \times \mu_t$ | | | | | | 0.20 | | | | | |
| | | | | | | (0.35) | | | | | |
| $Export \times \mu_t$ | | | | | | | 1.43 | | | | |
| | | | | | | | (1.29) | | | | |
| $Import \times \mu_t$ | | | | | | | | 1.02 | | | |
| | | | | | | | | (1.37) | | | |
| $Export\,USD \times \mu_t$ | | | | | | | | | 3.39 | | |
| | | | | | | | | | (3.28) | | |
| $Import\,USD \times \mu_t$ | | | | | | | | | | 1.16 | |
| | | | | | | | | | | (3.44) | |
| $IFI \times \mu_t$ | | | | | | | | | | | 0.36 |
| | | | | | | | | | | | (0.35) |
| Observations | 1,036 | 1,036 | 804 | 1,036 | 504 | 1,036 | 1,036 | 1,036 | 504 | 504 | 1,036 |
| Number of countries | 17 | 17 | 13 | 17 | 12 | 17 | 17 | 17 | 12 | 12 | 17 |

Table 18: Responses of International Debt Issuance to U.S. Monetary Shocks (by Country Groups)

This table reports the OLS estimates of specification 3:

$$\triangle Debt_{i,t} = \alpha_0 + \beta_\mu \mu_t + \beta_{\mu,Debt} \left[\mu_t \times Debt_{i,t-1}\right] + \gamma_{Debt} \left[Debt_{i,t-1}\right] + control_{i,t-1} + \varepsilon_{i,t},$$

where one period is a quarter, $\triangle Debt_{i,t}$ is one-quarter change of country *i's* external-debt issuance in period $t$ normalized by the GDP at the end of the previous year of period $t$, $\triangle USDebt_{i,t}$ is that of USD-denominated issuance, $\mu_t$ is the fed funds futures based U.S. monetary policy shocks in period $t$, and $USDebt_{i,t}$ is country *i's* USD-net-external-debt-to-GDP ratio at the end of the previous year of period $t$. The baseline control variables are the lagged dependent variables of lag 1 to 4, country fixed effects, and quarter fixed effects. Sample period I is from 1994 to 2007 and sample period II is from 1994 to 2014. Standard errors are heteroscedasticity and four-lag serial-correlation consistent based on Driscoll and Kraay (1997) and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| $\triangle USDebt$ | (1) | (2) | (3) |
|---|---|---|---|
| $\mu_t$ | 1.29** | 1.49** | 0.63 |
| | (0.55) | (0.67) | (0.57) |
| $USDebt_{i,t-1} \times \mu_t$ | -7.32*** | -7.61** | -6.11 |
| | (2.51) | (3.13) | (3.82) |
| $USDebt_{i,t-1}$ | -0.42 | -0.78 | -0.21 |
| | (0.28) | (0.61) | (0.19) |
| Observations | 1,036 | 788 | 248 |
| Number of countries | 17 | 13 | 4 |
| Country group | OECD + EM | OECD | EM |

Table 19: Summary Statistics of Exchange Rate Changes around Rare Disasters

This table shows the summary statistics of the percentage exchange rate changes in a three-business-day window $\triangle s\,(3D)$, from *t-1* to *t+2* closing price, and 20-business-day window $\triangle s\,(1M)$, from *t-1* to *t*+19, bracketing the rare disaster events of each currency portfolio. $USDebt_{-1}$ and $Debt_{-1}$ are the USD-net-external-debt-to-GDP and all-currencies-net-external-debt-to-GDP ratios in the year prior to the event. Portfolios 1 and 4 consist of currencies with the lowest and highest $USDDebt_{-1}$, respectively. The rare disaster events are the collapse of Long Term Capital Management in September 1998, the terrorist attack on September 11, 2001, and the bankruptcy filing of Lehman Brothers on September 15, 2008. The exchange rate changes are reported in percentage points.

| | Portfolio | | | | | |
|---|---|---|---|---|---|---|
| **LTCM** | 1 | 2 | 3 | 4 | Average | HML |
| $\triangle s\,(1M)$ | -2.92 | -1.13 | -0.39 | 3.77 | -0.17 | 6.69 |
| $USDDebt_{-1}$ | -0.31 | 0.13 | 0.19 | 0.28 | 0.07 | 0.58 |
| $Debt_{-1}$ | -0.10 | 0.27 | 0.32 | 0.43 | 0.22 | 0.58 |

| | Portfolio | | | | | |
|---|---|---|---|---|---|---|
| **9/11 Terrorist Attack** | 1 | 2 | 3 | 4 | Average | HML |
| $\triangle s\,(2D)$ | -1.97 | -0.07 | 2.20 | 3.03 | 0.80 | 5.00 |
| $\triangle s\,(1M)$ | -0.97 | 0.89 | 3.49 | 7.38 | 2.70 | 8.35 |
| $USDDebt_{-1}$ | -0.44 | 0.13 | 0.21 | 0.49 | 0.10 | 0.94 |
| $Debt_{-1}$ | -0.10 | 0.32 | 0.34 | 0.71 | 0.30 | 0.88 |

| | Portfolio | | | | | |
|---|---|---|---|---|---|---|
| **Lehman Brothers** | 1 | 2 | 3 | 4 | Average | HML |
| $\triangle s\,(2D)$ | 0.10 | 0.74 | 1.53 | 2.16 | 1.13 | 2.06 |
| $\triangle s\,(1M)$ | 3.44 | 8.14 | 10.14 | 11.73 | 8.36 | 8.30 |
| $USDDebt_{-1}$ | -0.39 | 0.10 | 0.14 | 0.39 | 0.06 | 0.78 |
| $Debt_{-1}$ | -0.09 | -0.11 | 0.21 | 0.84 | 0.21 | 0.93 |

Table 20: Summary Statistics of Excess Returns of *USDebt* Portfolios

This table reports, for each portfolio, the average one-month log excess returns $rx_{t+1}$ and one-month nominal interest rate differentials implied by log forward premia, $f_t - s_t$. Log excess returns are computed as $rx_{t+1} = f_t - s_t - \triangle s_{t+1}$. All moments are annualized and reported in percentage points. The portfolios are constructed by sorting currencies into four groups every beginning of each year based on their USD-net-external-debt-to-GDP in the previous year. Currencies in sample are the currencies of OECD countries with flexible exchange regime. The sample period is from January 1994 to December 2014 for 252 observations.

| | Lowest *USDebt* | Port 2 | Port 3 | Highest *USDebt* | Average | *USDebt*-HML |
|---|---|---|---|---|---|---|
| $rx_{t+1}$ | -0.18 | 1.40 | 3.05 | 5.28 | 2.39 | 5.46 |
| $fp_t$ | -0.15 | 1.74 | 2.66 | 5.76 | 2.50 | 5.91 |
| $\triangle s_{t+1}$ | 0.03 | 0.34 | -0.39 | 0.48 | 0.12 | 0.45 |
| Standard deviation | 6.43 | 6.69 | 6.61 | 8.08 | 6.02 | 6.99 |
| Sharpe ratio | -0.03 | 0.21 | 0.46 | 0.65 | 0.40 | 0.78 |
| $USDebt_t$ | -0.07 | 0.08 | 0.15 | 0.26 | 0.11 | 0.32 |

Table 21: Summary Statistics of Two-day Excess Returns of *USDebt* Portfolios around the Scheduled FOMC Announcements

This table reports, for each portfolio, the average two-day excess returns $rx_{t+1}$ in the 48 hours, from day *t-2* closing price to day *t* closing price, bracketing the scheduled FOMC press releases. The two-day excess returns are computed as $rx_{t+1} = (f_t - s_t) \times 2/30 - \triangle s_{t+1}$ where $(f_t - s_t) \times 2/30$ is the one-month interest rate differentials accrued for two days and $\triangle s_{t+1}$ is USD appreciation in the two-day window. All moments are annualized based on 8 events per year and reported in percentage points. The portfolios are constructed by sorting currencies into four groups based on their USD-net-external-debt-to-GDP ratios before each event. Currencies in sample are the OECD currencies with flexible exchange regime. The sample period is from January 1994 to December 2007 for a total of 112 events.

| | Lowest *USDebt* | Port 2 | Port 3 | Highest *USDebt* | Average | *USDebt*-HML |
|---|---|---|---|---|---|---|
| $rx_{t+1}$ | 0.33 | 0.59 | 0.74 | 1.45 | 0.82 | 1.04 |
| $fp_t$ | -0.04 | 0.08 | 0.12 | 0.11 | 0.11 | 0.07 |
| $\triangle s$ | -0.37 | -0.50 | -0.62 | -1.34 | -0.71 | -0.97 |
| Standard deviation | 1.99 | 1.97 | 1.86 | 1.98 | 1.66 | 1.92 |
| Sharpe ratio | 0.17 | 0.30 | 0.40 | 0.73 | 0.49 | 0.54 |
| $USDebt_t$ | -0.08 | 0.08 | 0.14 | 0.22 | 0.09 | 0.30 |

Table 22: Currency Excess Returns and $USDebt$

This table shows the regression results of the following specification:

$$rx_{i,t+1} = \alpha + \beta_{Debt} Debt_{i,t} + control_{i,t} + \varepsilon_{i,t},$$

where the one-month log excess returns $rx_{t+1}$ computed as $f_t - s_{t+1}$, $USDDebt_{i,t-1}$ is USD-net-external-debt-to-GDP ratio of country $i$ in the year prior to event $t$, $NonUSD$ denotes external debt denominated in non-USD currencies, $EURDebt$ and $JPYDebt$ denote net external debt denominated in the euro and Japanese yen, respectively. Sample period I is from 1994 to 2007 and sample period II is from 1994 to 2014. The sample consists of the OECD currencies with flexible exchange rates. Standard errors are clustered at the monthly level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $USDebt_{i,t-1}$ | 1.65*** | 2.88* | 4.28*** | 1.39*** | 5.23** | 4.10** | 1.36** | 5.17*** | 4.16** |
| | (0.50) | (1.51) | (1.43) | (0.53) | (2.16) | (1.83) | (0.53) | (1.89) | (1.78) |
| $NonUSDDebt_{i,t-1}$ | | | | -0.03 | -1.17 | -1.69 | | | |
| | | | | (0.58) | (1.67) | (1.82) | | | |
| $EURDebt_{i,t-1}$ | | | | | | | -0.12 | 0.23 | -0.79 |
| | | | | | | | (0.96) | (1.82) | (1.67) |
| $JPYDebt_{i,t-1}$ | | | | | | | 0.62 | 0.26 | 1.03 |
| | | | | | | | (2.13) | (2.73) | (2.55) |
| Constant | | | | 0.07 | -0.23 | 1.79** | 0.05 | -0.35 | 1.34** |
| | | | | (0.09) | (0.31) | (0.78) | (0.08) | (0.30) | (0.58) |
| Observations | | | | 1,962 | 1,962 | 1,962 | 1,962 | 1,962 | 1,962 |
| R-squared | | | | 0.37 | 0.01 | 0.37 | 0.37 | 0.01 | 0.37 |
| Time FE | Yes | No | Yes | Yes | No | Yes | Yes | No | Yes |
| Country FE | No | Yes | Yes | No | Yes | Yes | No | Yes | Yes |
| Sample period | I | I | I | I | I | I | I | I | I |
| | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) |
| $USDDebt_{i,t-1}$ | 1.17*** | 3.22** | 2.18** | 1.17*** | 3.15** | 2.02* | 1.12*** | 3.07** | 2.11* |
| | (0.43) | (1.35) | (1.11) | (0.42) | (1.37) | (1.12) | (0.43) | (1.35) | (1.09) |
| $FCNDDebt_{i,t-1}$ | | | | 0.26 | -0.51 | -0.65 | | | |
| | | | | (0.43) | (1.11) | (1.19) | | | |
| $EURDebt_{i,t-1}$ | | | | | | | 0.02 | -0.47 | -0.55 |
| | | | | | | | (0.70) | (1.19) | (1.18) |
| $JPYDebt_{i,t-1}$ | | | | | | | 1.07 | 0.74 | -0.06 |
| | | | | | | | (1.80) | (2.14) | (2.05) |
| Constant | | | | 0.02 | -0.11 | 0.79** | 0.02 | -0.15 | 0.74** |
| | | | | (0.07) | (0.26) | (0.35) | (0.06) | (0.23) | (0.32) |
| Observations | | | | 3,042 | 3,042 | 3,042 | 3,042 | 3,042 | 3,042 |
| R-squared | | | | 0.36 | 0.01 | 0.37 | 0.36 | 0.01 | 0.37 |
| Time FE | Yes | No | Yes | Yes | No | Yes | Yes | No | Yes |
| Country FE | No | Yes | Yes | No | Yes | Yes | No | Yes | Yes |
| Sample period | II | II | II | II | II | II | II | II | II |

Table 23: Summary Statistics of Exchange Rate Changes around the U.S. Large Scale Asset Purchases (LSAP) Announcements

This table reports the average two-day and one-week exchange rate changes around the LSAP announcements of countries with the lowest to the highest USD net-external debt-to-GDP ratio. The sample does not include Iceland. Countries are allocated to groups based on their dollar-debt before the announcements. The dates of Quantitative Easing (QE) I announcements are November 25, 2008, December 1, 2008, December 16, 2008, January 28, 2009, and March 18, 2009. The dates of QE II announcements are August 10, 2010, September 21, 2010, and November 3, 2010.

| | QE 1 | | |
|---|---|---|---|
| | Lowest Debt | | Highest Debt |
| Portfolio | 1 | 2 | 3 |
| Two-day $\triangle s$ | -1.13 | -0.58 | -0.95 |
| | (2.62) | (1.85) | (2.81) |
| One-week $\triangle s$ | -0.04 | -0.33 | -0.40 |
| | (2.31) | (1.78) | (2.71) |
| USD Debt | -0.06 | 0.10 | 0.17 |

| | QE 2 | | |
|---|---|---|---|
| | Lowest Debt | | Highest Debt |
| Portfolio | 1 | 2 | 3 |
| Two-day $\triangle s$ | -0.12 | -0.20 | -0.22 |
| | (1.29) | (0.86) | (1.12) |
| One-week $\triangle s$ | 0.01 | -0.26 | -0.39 |
| | (1.68) | (1.18) | (0.98) |
| USD Debt | -0.03 | 0.10 | 0.19 |

# Figures

Figure 6: Exchange-rate Sensitivities to U.S. Monetary Policy Shocks versus Alternative Measures of Dollar-Debt Level

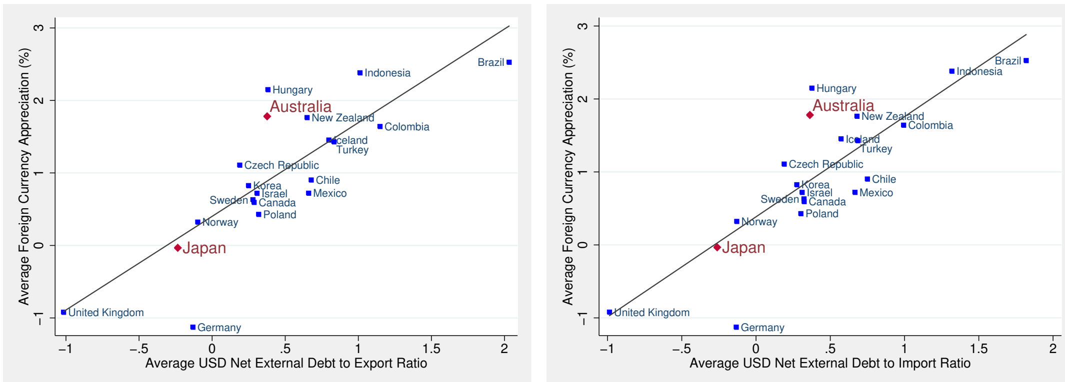



Figure 7: The Average Exchange-rate Movement around Expansionary and Contractionary U.S. Monetary Policy Shocks versus Ex-ante Dollar Debt

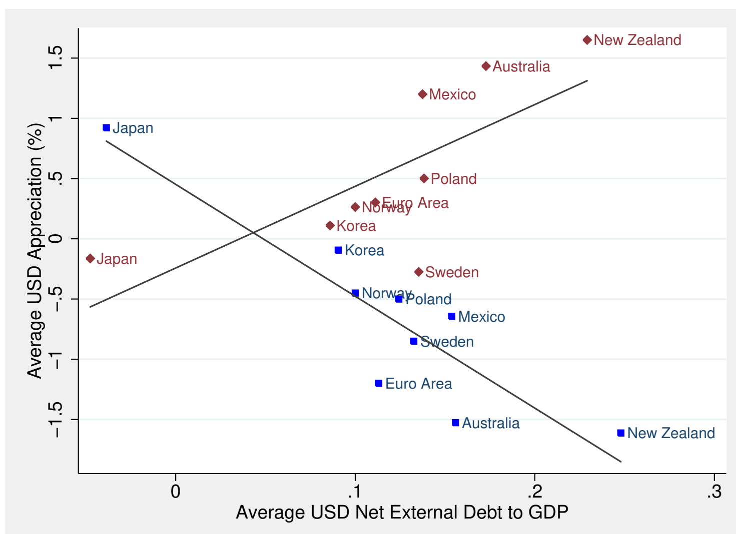
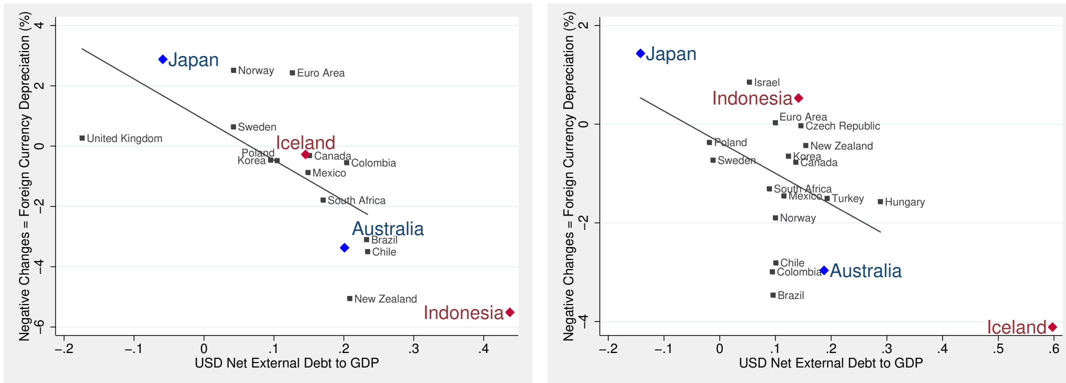
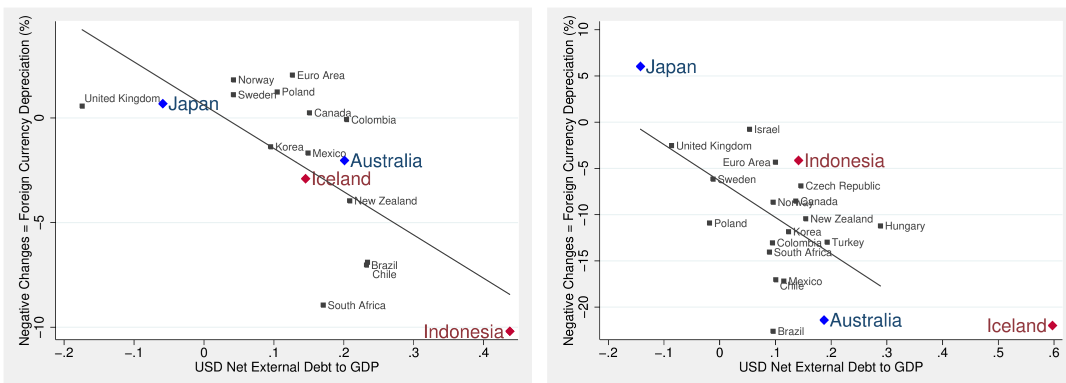


Figure 8: Exchange-Rate Sensitivity to Rare Disasters vs. *USDebt*

(a) Two-day Window




(b) One-month Window




Panel (a) left figure plots the changes in exchange rates from the closing rate on Monday, September 10, 2001, to the closing rate on Monday, September 17, 2001, against foreign countries' ex-ante USD net-external-debt-to-GDP ratios (*USDebt*). The U.S. financial markets are closed from September 11, 2011, and reopen in September 17, 2001. Panel (a) right figure plots the changes in exchange rates from closing rate on Friday, September 12, 2008 to the closing rate on Tuesday, September 16, 2008, against *USDebt*. Lehman Brothers filed for Chapter 11 bankruptcy protection on Monday, September 15, 2008.

Figure 9: Exchange-Rate Sensitivity to Rare Disasters vs. *USDebt*

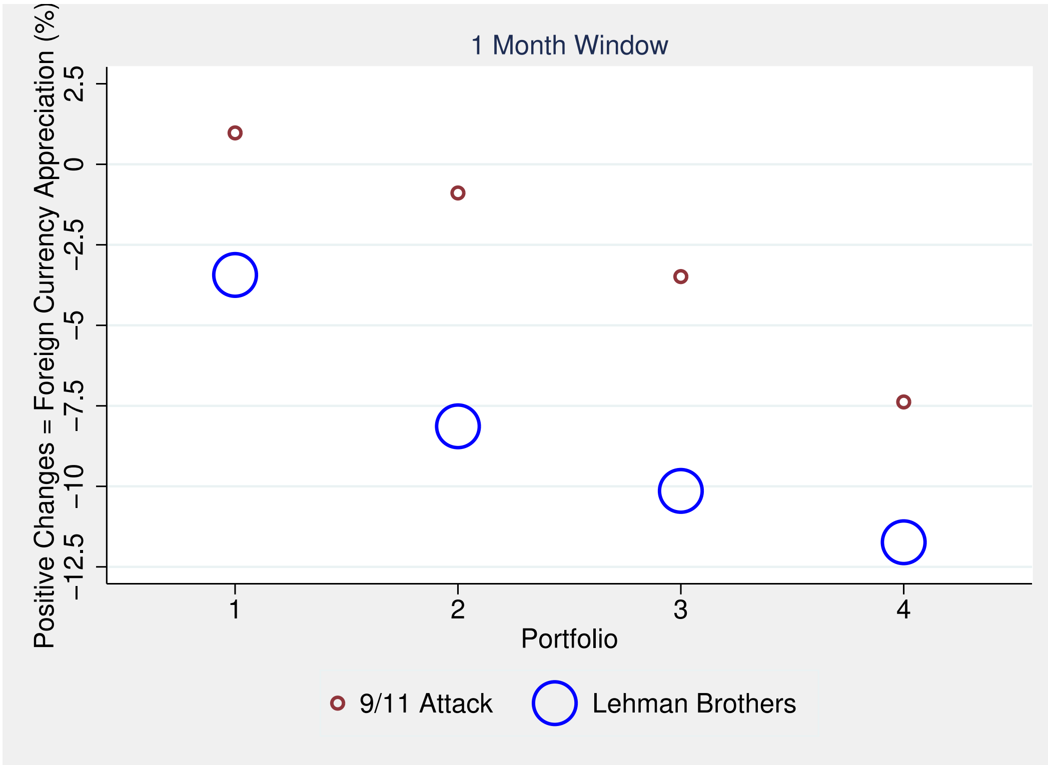


Figure 10: One-month Forward Premia versus *USDebt*

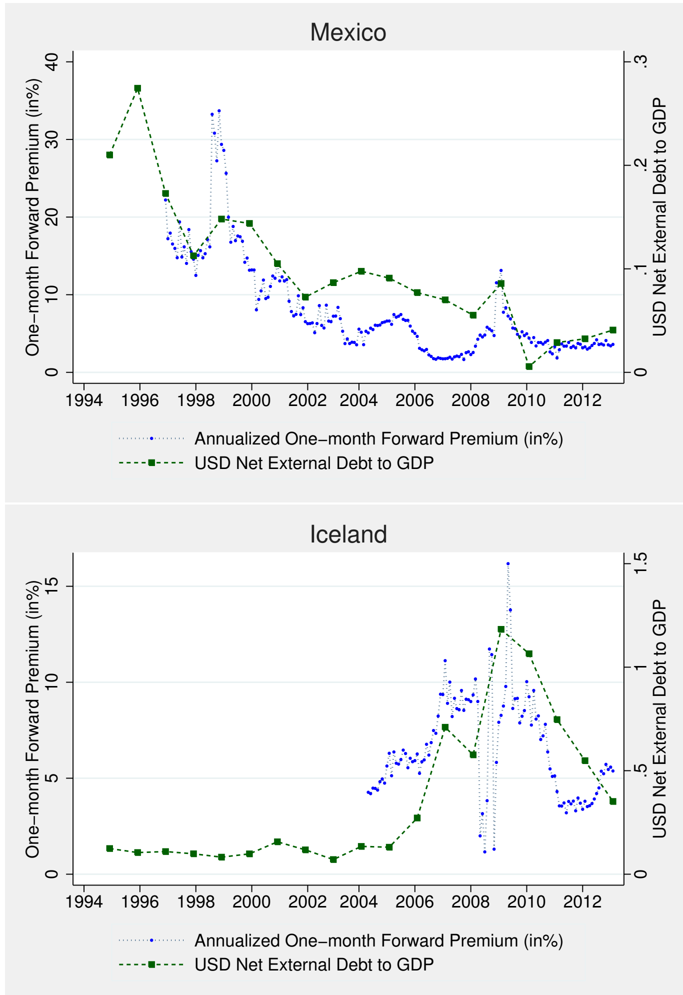
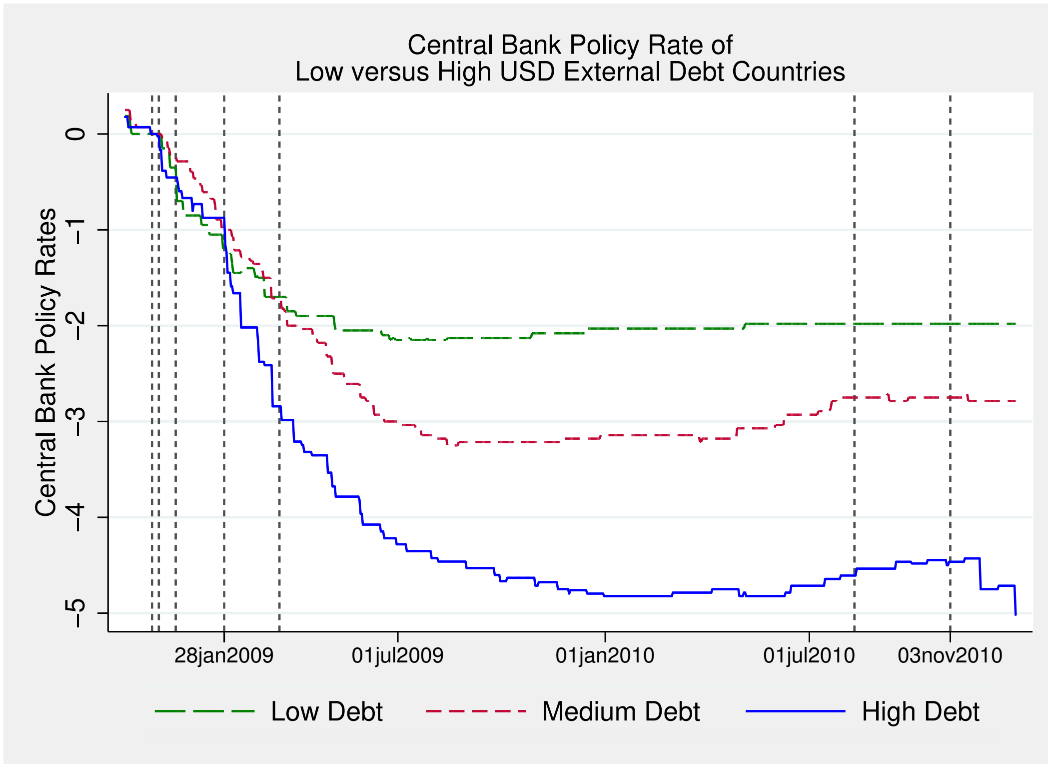


Figure 11: Time Series of Foreign Central Banks' Policy Rates of Low and High-*USDebt* countries during the U.S. Quantitative Easing (QE) I and II




This figure plots foreign central banks' policy rates of low and high-*USDebt* countries from November 1, 2008, to December 30, 2010. The sample does not include Iceland. Countries are allocated to groups based on their *USDebt* in 2007. Policy rates of each portfolio are a simple average of its members'. Central bank policy rates are standardized to zero on November 25, 2008. Each vertical line indicates a QE announcement. The dates of QE I announcements are November 25, 2008, December 1, 2008, December 16, 2008, January 28, 2009, and March 18, 2009. The dates of QE II announcements are August 10, 2010, September 21, 2010, and November 3, 2010.

# Appendix

## Tables

Table 24: Summary Statistics of Two-day Excess Returns of Different *USDebt*, Country Size, and Trade Network Centrality Portfolios around the Scheduled FOMC Press Release

This table reports, for each portfolio, the average two-day excess returns $rx_{t+1}$ in the 48 hours, from day *t-2* closing price to day *t* closing price, bracketing the scheduled FOMC press releases. The two-day excess returns are computed as $rx_{t+1} = (f_t - s_t) \times 2/30 - \triangle s_{t+1}$ where $(f_t - s_t) \times 2/30$ is the one-month interest rate differentials accrued for two days and $\triangle s_{t+1}$ is USD appreciation in the two-day window. All moments are annualized based on 8 events per year and reported in percentage points. The portfolios are constructed by sorting currencies into four groups based on their USD-net-external-debt-to-GDP ratios and GDP share, or USD-net-external-debt-to-GDP ratios and trade network centrality (Richmond 2017) before each event. Currencies in sample are the OECD currencies with flexible exchange regime. The sample period is from January 1994 to December 2007 for a total of 112 events.

(a) Double Sort on *USDebt* and Country Size

| | | Low *USDebt* | High *USDebt* |
|---|---|---|---|
| Big Countries | Two-day *rx* | 0.32 | 1.58 |
| | Standard Deviation | 1.89 | 1.59 |
| | Sharpe Ratio | 0.17 | 0.99 |
| Small Countries | Two-day *rx* | 0.62 | 0.79 |
| | Standard Deviation | 2.11 | 2.35 |
| | Sharpe Ratio | 0.29 | 0.34 |

(b) Double Sort on *USDebt* and Centrality

| | | Low USD Debt | High USD Debt |
|---|---|---|---|
| Central Countries | Two-day *rx* | 0.57 | 0.87 |
| | Standard Deviation | 1.78 | 2.23 |
| | Sharpe Ratio | 0.32 | 0.39 |
| Peripheral Countries | Two-day *rx* | 0.32 | 1.53 |
| | Standard Deviation | 2.06 | 1.90 |
| | Sharpe Ratio | 0.16 | 0.81 |

## External Debt

**Annual debt-to-GDP ratios.** The annual debt-to-GDP ratios are based on debt, GDP, and end-of-year exchange rates data from Lane and Milesi-Ferretti 2007 and Lane and Shambaugh 2010. I adjust the debt-to-GDP ratios of Norway as they exhibit considerable amounts of omission; Lane and Milesi-Ferretti 2007 shows that Norway's cumulative net-external-liabilities omission between 1970 and 2004, as a ratio to GDP, is around 28%. I assume that the omission occurs smoothly between 1970 and 2004 and remains the same after 2004.

## The effect of U.S. Large Scale Asset Purchase (LSAP) on exchange rates and foreign currency interest rates

In this section, I study the effect of the U.S. LSAP on exchange rates and foreign currency interest rates. LSAP is different from the conventional monetary policy tool, which is changing the fed-funds target rate, from at least three perspectives, the size of asset purchases, the securities purchased, and the state of the economy when LSAP was introduced.

I find foreign central banks cut their policy rates after LSAP announcements, and the cut is larger for countries with larger $USDebt$. Figure 11 plots central bank policy rates of three groups of countries based on their USD net-external-debt-to-GDP ratios in 2007. The policy rates are normalized to zero on November 1, 2008. Each vertical line indicates LSAP announcement day. The larger interest rate cut by larger debt countries is especially apparent after the LSAP announcements on January 28, 2009.

Table 23 shows the summary statistics of changes in two-year US treasury yield and exchange rates around LSAP announcements. On average, LSAP announcements are associated with dollar depreciation. Cross sectionally, higher-$USDebt$ currencies experience larger appreciation albeit the pattern is not striking. Foreign central banks' responses to LSAP announcements, as well as, macroeconomic news contained in LSAP might explain the absence of a strong cross-sectional pattern.

## Proof

**Real exchange rate** The definition of real exchange rate is $\varepsilon_{j,t} = P_t^{USD} / \left(P_t^J / s_{j,t}\right)$ where $P_t$ is the nominal price of consumption bundle in the respective currencies. The real exchange rate is obtained by combining price index definition $P_t c_t = P_{T,t}\left(c_{T,t} + p_{N,t} c_{N,t}\right)$, consumption bundle definition $c_t = c_{T,t}^{1/2} c_{N,t}^{1/2}$, Euler equation $c_{N,t} = c_{T,t}/p_{N,t}$, and nominal exchange rate $s_{j,t} = P_{T,t}^J / P_{T,t}^{USD}$.

**U.S. Trader's consumption** By intra-temporal Euler equation, traders spend half their money holding on each good. Because all U.S. households face the same prices, they consume the same bundle. By goods market clearing, the consumption bundle is the same in all periods, $c_{T,t}^{US}/c_{N,t}^{US} = y_{T,t}^{US}/y_{N,t}^{US} = 1$. By the Euler equation $p_{N,t}^{US} = c_{T,t}^{US}/c_{N,t}^{US}$, the non-tradable good real price is also the same in all periods, $p_{N,t}^{US} = 1$. By money market clearing condition (7), $p_{N,t}^{US} = 1$, and equation (14) , we get the traders' consumption in terms of $\mu$.

**Equation 18** The period budget constraint is

$$\frac{1}{s_0^J} P_{T,t}^{DC,J}\left[c_{T,t}^{j} + p_{N,t}c_{N,t}^{j}\right] = \frac{1}{s_0^J} P_{T,t}^{DC,J}\left[y_{T,t}^{J} + p_{N,t}^{J}y_{N,t}^{J}\right] - \left(D_t^{USD,j} - Q_t^{USD}D_{t+1}^{USD,j}\right) - \frac{1}{s_0^J}\left(D_t^{DC,j} - Q_t^{DC,J}D_{t+1}^{DC,j}\right).$$

Substituting the non-tradable good market clearing, we get

$$\frac{1}{s_0^J} P_{T,t}^{DC,J}\left[c_{T,t}^{j}\right] = \frac{1}{s_0^J} P_{T,t}^{DC,J}\left[y_{T,t}^{J}\right] - \left(D_t^{USD,j} - Q_t^{USD}D_{t+1}^{USD,j}\right) - \frac{1}{s_0^J}\left(D_t^{DC,j} - Q_t^{DC,J}D_{t+1}^{DC,j}\right).$$

Substituting the budget constraint, the definition of nominal exchange rate, and dividing both sides with $P_{T,1}^{USD}$, we get

$$c_{T,t}^{j} = y_{T,t}^{J} - \left(\frac{D_t^{USD,j}}{P_{T,t}^{USD}} + \frac{D_t^{DC,j}}{P_{T,t}^{DC}}\right) + \left(\frac{Q_t^{DC,J}}{P_{T,t}^{DC}}D_{t+1}^{DC,j} + \frac{Q_t^{USD}}{P_{T,t}^{USD}}D_{t+1}^{USD,j}\right).$$

Finally, substituting the definition of real interest rate $Q_t = q_t(P_{T,t}/P_{T,t+1})$, the borrowing constraint $D_{t+1}^{USD}/P_{T,1}^{USD} + D_{t+1}^{DC}/P_{T,1}^{DC} \leq \alpha\left(y_{T,1}^{J} + p_{N,1}^{J}y_{N,1}^{J}\right)$, and the assumption that all governments set $P_{T,1} = P_{T,2}$, we arrive at the expression 18.

**Equation 20** Substitute 15 for $dlogP_{T,1}^{USD}$, $-\frac{1}{2}dlog\, c_{T,1}$ for $dlogP_{T,1}^{DC}$, 17 for $dlog\, q_1$, and $dlog\, c_{T,1}$ for $dlog\, p_{N,1}$ in equation (20). Finally, use the binding borrowing constraint equation, $d_1^{USD} + d_1^{DC} = 2\alpha$.

**Equation 22** The binding borrowing constraint implies $d_2 = \alpha\left(y_{T,1} + p_{N,1}y_{N,1}\right)$ and thus $d\left(d_2\right) = \alpha\left(d\log p_{N,1}\right) = \alpha\beta_{\mu}^{j}$. Combined this expression with the expected value of GDP of 2, we arrive to equation (22).

### Expected excess return

$$
\begin{aligned}
Q_0^X &= E_0\left[\frac{u'(c_{T,1})}{u'(c_{T,0})}\left(\frac{P_{T,0}^X}{P_{T,1}^X}\right)\right] \\
log\left(Q_0^X\right) &= logE_0\left[u'(c_{T,1})\left(\frac{P_{T,0}^X}{P_{T,1}^X}\right)\right] - log\left(u'(c_{T,0})\right) \\
&= logE_0\left[u'(c_{T,1})\left(\frac{1}{1+\pi_{T,1}^X}\right)\right] - log\left(u'(c_{T,0})\right) \\
&= logE_0\left[exp\left(log\, u'(c_{T,1}) - log\ \left(1+\pi_{T,1}^X\right)\right)\right] - log\left(u'(c_{T,0})\right)
\end{aligned}
$$

If marginal utilities and inflation are log-normal,

$$
\begin{aligned}
log\left(Q_0^X\right) = {} & E_0\left[log\left(u'(c_{T,1})\right)\right] - E_0\left[log\left(1+\pi_{T,1}^X\right)\right] \\
& + \frac{1}{2}Var\left(log\left(u'(c_{T,1})\right)\right) + \frac{1}{2}Var\left(log\left(1+\pi_{T,1}^X\right)\right) \\
& - Cov\left(log\left(u'(c_{T,1})\right), log\left(1+\pi_{T,1}^X\right)\right) - log\left(u'(c_{T,0})\right)
\end{aligned}
$$

and the expected return is $E_0\left[\left(\frac{P_{T,0}^X}{P_{T,1}^X}\right)/Q_0^X\right] = \frac{1}{Q_0^X}E_0\left[\frac{1}{1+\pi_{T,1}^X}\right]$, and the log expected return is:

$$
\begin{aligned}
-log\left(Q_0^X\right) + logE_0\left[\frac{1}{1+\pi_{T,1}^X}\right] &= -log\left(Q_0^X\right) + logE_0\left[exp\left(-log\left(1+\pi_{T,1}^X\right)\right)\right] \\
&= -log\left(Q_0^X\right) - E_0\left[log\left(1+\pi_{T,1}^X\right)\right] + \frac{1}{2}Var\left(log\left(1+\pi_{T,1}^X\right)\right) \\
&= -E_0\left[log\left(u'(c_{T,1})\right)\right] + \frac{1}{2}Var\left(log\left(u'(c_{T,1})\right)\right) + log\left(u'(c_{T,0})\right) \\
&\quad + Cov\left(log\left(u'(c_{T,1})\right), log\left(1+\pi_{T,1}^X\right)\right)
\end{aligned}
$$

Define $i^X = -log\left(Q_0^X\right)$ and $E_0\left[\pi_{T,1}^X\right] = -logE_0\left[\frac{1}{\Pi_{T,1}^X}\right]$, then, the difference in log expected return is:

$$
\begin{aligned}
i^X - E_0\left[\pi_{T,1}^X\right] - \left(i^{USD} - E_0\left[\pi_{T,1}^{USD}\right]\right) &= \frac{dlog\left(c_{T,1}\right)}{d\mu}\left(\frac{dlog\left(1+\pi_{T,1}^{USD}\right)}{d\mu} - \frac{dlog\left(1+\pi_{T,1}^X\right)}{d\mu}\right)\sigma_\mu^2 \\
&= \beta_\mu^{US}\left(1+\frac{1}{2}\beta_\mu^*\right)\sigma_\mu^2
\end{aligned}
$$

Note that:

$$-log\left(Q_0^X\right)+logE_0\left[\frac{1}{1+\pi_{T,1}^X}\right]+log\left(Q_0^{USD}\right)-logE_0\left[\frac{1}{1+\pi_{T,1}^{USD}}\right]=i^X-i^{USD}+log\left(\frac{E_0\left[\frac{P_{T,0}^X}{P_{T,1}^X}\right]}{E_0\left[\frac{P_{T,0}^{USD}}{P_{T,1}^{USD}}\right]}\right)$$

$$=i^X-i^{USD}-E_0\left[\triangle s_1^X\right]$$