U.S. Liquid Government Liabilities and Emerging Market Capital Flows*

Annie Soyean Lee†
Charles Engel‡

This version: March 2025

Abstract

Empirical work finds that flows of investments from the U.S. and other high income countries to emerging markets increase during times of quantitative easing (QE) by the U.S. Federal Reserve, and the reverse movement occurs under quantitative tightening. We offer new evidence to confirm these findings, and then propose a theory based on the liquidity of U.S. government liabilities held by the public. We hypothesize that QE, by increasing liquidity, offers greater flexibility for investors that might be concerned their funds will be tied up when shocks to income or investment opportunities arise. With the assurance that some of their portfolio can be readily sold in liquid markets, rich country investors are more willing to increase investments in illiquid loans to emerging markets. The effect of increasing the liquidity of U.S. government liabilities on investments in EMs may even be stronger during times of greater uncertainty. We find evidence to support our interpretation: QE lowers covered interest parity deviations for the dollar, as our model predicts.

JEL Classification Codes: F32, F41, G15
Keywords: liquidity, capital flows, emerging markets, quantitative easing

*We thank Yeonggyu Yun for his excellent research assistance.
†Email: annie.lee.econ@gmail.com, Johns Hopkins University
‡Email: cengel@ssc.wisc.edu, University of Wisconsin-Madison

1 Introduction

Government bonds issued by the U.S. are safe, liquid, and offer a convenience yield.[1] Especially, short-term T-bills or reserves held at the Federal Reserve appear to be the ultimate prize for investors that require liquidity. Therefore, policymakers and academics have emphasized the importance of liquidity in the market for U.S. government liabilities in facilitating efficient functioning of financial markets.[2] However, the provision of greater liquidity to the markets has implications for the demand for other types of assets including those issued by emerging market firms and governments.

This paper examines how changes in the supply of liquid U.S. debt influence capital flows to emerging markets with a focus on the effects of quantitative easing (QE) and quantitative tightening (QT).[3] We provide empirical evidence on how shifts in the U.S. liquidity policy impact capital flows to emerging markets and propose a theory to account for the empirical findings.

Figure 1 illustrates the effects of QE and QT on capital flows to emerging markets. In June 2013, the chairman of the Federal Reserve, Ben Bernanke, announced that the Fed could begin to scale back its purchases of long-term bonds. The so-called "taper tantrum" ensued. In the figure, we plot the capital flows into 16 emerging markets in 2012-2014.[4] It is apparent that there was a sharp decline in flows immediately following Bernanke's announcement of quantitative tightening. The figure also picks up an acceleration of flows into those countries following the announcement of QE3, the third round of quantitative easing by the Fed, in September 2012.

The framework in which we rationalize these empirical regularities is one in which *some* U.S. government liabilities are very liquid in the sense that they are traded in deep markets and can easily be sold on secondary markets. In particular, short-term Treasury bills and reserves held at the Fed are very liquid government liabilities, while longer term bonds may be less liquid. We investigate the consequences of changing the composition of government debt issuance as the U.S. government's portfolio of debt shifts from longer term, less liquid debt to shorter term, more liquid debt. We are concerned about the effects on loan availability to emerging markets. Because the U.S. is a borrower on global markets, it competes with the emerging market countries (EMs) for loans from the rest of the world (ROW). We, therefore, want to understand the effect of a shift in the composition of the U.S. debt per se, holding the total debt issuance constant.

In the model, household lenders in the U.S. and ROW decide on a portfolio of loans – short-term liquid U.S. bills, long-term less liquid U.S. bonds, and loans to EMs – before the realization of

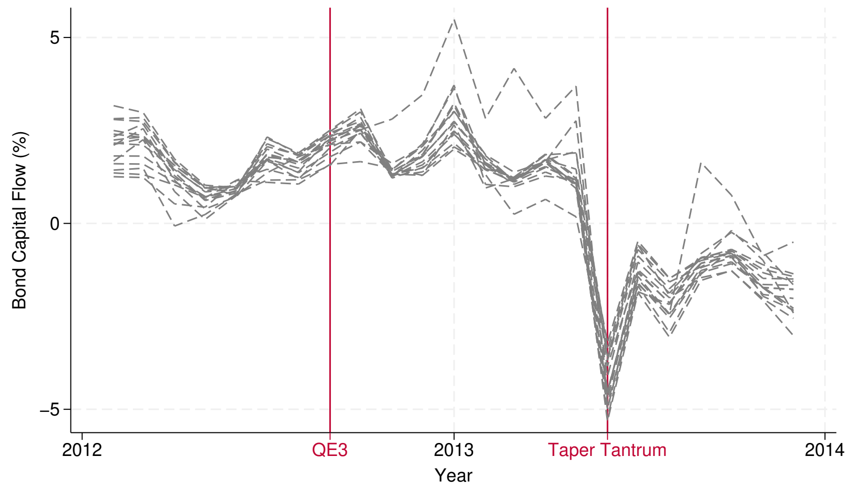
[1] See Krishnamurthy and Vissing-Jorgensen (2011), Krishnamurthy and Vissing-Jorgensen (2012), Greenwood et al. (2015), Nagel (2016), Diamond and Van Tassel (2021), He et al. (2019), Jiang et al. (2021) and Gorton and Ordonez (2022).

[2] See Duffie (2023), Copeland et al. (2021), Acharya and Rajan (2022), Acharya et al. (2023), Diamond et al. (2023) and Afonso et al. (2022).

[3] A discussion on how QE and QT influence the liquidity of U.S. government liabilities follows later in the introduction.

[4] See Section 2 for details on the data.

Figure 1: Quantitative Easing and Tightening in the U.S. and Capital Flows to Emerging Markets



Notes: Each line shows monthly bond fund flows as a ratio of the bond fund allocation for 16 emerging market countries. The data on monthly bond fund flows are from the Emerging Portfolio Fund Research dataset.

their uncertain income or investment opportunities. When uncertainty is resolved, they can adjust their portfolio by trading with other households that have different outcomes. If a household/lender finds its income is higher than expected, or it has less need for funds for investment in real assets, it can buy liquid bonds from households whose income is lower than expected or who have greater investment opportunities. That is, there is a secondary market in liquid bonds that operates after the resolution of uncertainty, but no such market exists for the other two types of loans. In the data, while all U.S. government debt appears to earn a convenience yield or liquidity yield relative to privately issued debt that is equally riskless or relative to government debt of other countries, the market considers short-term U.S. government debt to be more liquid than long-term debt. Our model captures the differing liquidity profile of loans by allowing some debt to be traded on secondary markets, while other government obligations are not.[5]

In our model, liquidity is valued because it provides flexibility as in the classic works of Hahn (1990) and Jones and Ostroy (1984). The essence of our argument is that when a greater volume of liquid assets become available, agents are willing to save more because they are not as concerned with being locked into illiquid investments. They can hold a larger portfolio of assets - more liquid and more illiquid assets - and be assured that they can sell a sufficient amount of the liquid assets when funds are needed for consumption or investment. The increased supply of liquid assets under QE does not just push down their price and lead investors to switch away from other assets to short-term U.S. government liabilities. It also increases overall lending, including in the form of less liquid loans to emerging markets.

[5] In the model, EMs have no need for the liquid bonds since their income path is known at the time of the initial portfolio choice, and, in fact, we are assuming that the time discount factor of EMs is low such that EMs always want to be borrowers and therefore have no demand for U.S. government bonds of either type.

It is sometimes said that capital flows to emerging markets in a “search for yield”. Our model is not an alternative theory to search-for-yield, but rather an explanation of it. Investors always want higher yield, holding all else constant. What would make them search for more yield? It must be that there has been a change in some other characteristic that influences their asset demand - a change in risk, or a change in their balance sheet constraints, or a change in liquidity. Our empirical evidence suggests that a strong motive is the latter. When the supply of liquid assets increases, the marginal benefit of holding liquid assets declines, and investors escalate their search for yield.

We have empirically examined the effects of Federal Reserve quantitative easing (and subsequent quantitative tightening) on capital flows to emerging markets. In our baseline estimation, we have treated T-bills and reserves as imperfect substitutes, and under an alternative specification have grouped them together as equally liquid assets. The empirical results are qualitatively the same under the two groupings. We examine Fed purchases and sales of Treasury bonds. These are actions that do not materially affect the overall debt of the consolidated government but change the liquidity of U.S. government obligations held by the public.[6] We make use of weekly data on bond flows to emerging markets from the Emerging Portfolio Fund Research (EPFR) dataset. We find that in weeks in which the Fed makes large purchases (sales) of longer-term Treasuries, there is a subsequent increase (decrease) in U.S. funds flowing to EMs. This effect is statistically significant out to a horizon of at least 52 weeks. This effect is robust to controls for U.S. conditions (VIX, returns on 10-year U.S. Treasury bonds, changes in the S&P 500 index) as well as recipient-country specific controls (money market rates, change in industrial production, change in the exchange rate relative to the dollar, year-on-year CPI inflation and reserves/GDP.)[7] We see these responses both in flows into and out of emerging markets, and in the wealth invested in EMs (which includes valuation changes.) We find similar effects in response to news about QE and QT rather than actual purchases and sales of long-term Treasury bonds.

We then show that the convenience yield or return to liquidity on U.S. Treasury bonds falls as the supply of liquidity increases during quantitative easing, and the reverse occurs during quantitative tightening, consistent with the prediction of our model. We measure the convenience yield as the “Treasury basis”, or the deviation from covered interest parity for government bonds of the U.S. relative to other major currencies. The data support the hypothesis that QE (QT) increases (decreases) the supply of liquid assets to markets, thereby lowering (raising) the convenience yield on short-term Treasuries. In turn, we use the relationship between QE/QT and the convenience yield as a first stage regression, in which the Fed intervention is an instrument for the covered interest parity deviation. Then, the second stage regression finds that a decrease (increase) in the convenience yield after QE (QT) does provoke greater capital flows to emerging markets.

[6]We ignore the fiscal effects that arise because as interest rates on longer term debt differ from shorter term debt.

[7]The analysis is at the weekly frequency, and U.S. variables are observed weekly, but most recipient-country specific controls are avaliable at the monthly frequency.

QE, QT and Liquidity Composition

Under quantitative easing, the Federal Reserve buys less liquid debt of the government – medium- and long-term Treasury bonds and agency debt. It creates reserves held at the Fed. As Rogoff (2017, Ch. 8) argues, "pure" quantitative easing – where the Fed buys long-term Treasury bonds in exchange for money which creates reserves – is equivalent to changing the maturity and *liquidity* of U.S. government debt without changing the quantity outstanding. Since reserves pay interest (and in recent years, the interest rate on reserves has usually been nearly identical to the interest rate on 30-day Treasury bills), the Fed is in essence swapping short-term debt for long-term debt. The Fed's balance sheet is part of the consolidated U.S. government balance sheet – where the interest the Fed earns on its government bond portfolio is repatriated to the general Treasury account – quantitative easing effectively alters the maturity structure of the outstanding Treasury debt held by the investors. In fact, Nagel (2016) refers to short-term T-bills as "near-money assets", implying that short-term T-bills and reserves are close substitutes. Reserves and short-term Treasury bills are prized for their high liquidity, as recent events such as the March 2020 "dash for cash" have verified.[8]

Table 1 presents a highly simplified and stylized representation of the Federal Reserve balance sheet. Quantitative easing involves a purchase of Treasury notes (medium-term bonds) and Treasury bonds (long-term bonds) from the financial sector. On the balance sheet, this shows up as an increase in "Medium-Term Notes and Long-Term Bonds" on the asset side, balanced by an equal increase in Reserves on the liability side. Quantitative tightening has the opposite effect. QE increases liquidity because it increases reserves, a liability of the Fed and a liquid asset held by the investors (specifically, banks in the Federal Reserve system.) When the Fed injects liquidity into financial markets through QE by purchasing Treasury notes or bonds, the total amount of reserves plus Treasury bills in financial markets - which is our notion of *liquid* U.S. government assets held by the investors - rises, whereas the total amount of Treasury notes and bonds held by investors falls. Therefore, QE shifts the liquidity composition of U.S. government debt held by the investors. While the direct effect of QE is to increase the amount of reserves held by the banking system, ultimately this action affects total holdings of liquid U.S. government liabilities held by other actors in the private sector. For example, as a bank ends up with more reserves after QE, it might sell some of its T-bill holdings, thereby increasing the supply of liquid assets to the non-banking sectors of the economy.[9]

It is important to note that the Fed is not the only government institution that can perform QE. If the Treasury decides to change the mix of its debt issuance from long-term to short-term, it

[8]See Vissing-Jorgensen (2021), Barone et al. (2022) and Cesa-Bianchi and Eguren Martin (2021).

[9]QE and QT do not generally involve buying or selling T-bills. If the Fed does buy or sell T-bills, this would have little effect on liquidity, since it is swapping one liquid asset held by the public (T-bills) for another liquid asset (reserves.)

Table 1: Stylized Federal Reserve Balance Sheet

Assets	**Liabilities**
Short-term Government Bills	Currency
Medium-Term Notes and Long-Term Bonds	Reserves

increases the liquidity held by the public. As Rogoff (2017) argues, both QE and changing the tenor of Treasury debt issuance effectively achieve the same result — exchanging liquid short-term liabilities (such as reserves or T-bills) for long-term bonds. Miran and Roubini (2024) in fact refer to the shortening of the yield profile of Treasury debt in 2024 as "stealth QE." This alternative perspective is aligned with how our model portraits QE as a shift of the U.S. government debt issuance from less-liquid to more-liquid Treasuries.

Review of Literature

Our study is, therefore, related to work that has investigated the impact of quantitative easing/tightening (QE/QT) on reserves and bank lending. Many have centered on the ways in which domestic lending has been influenced.[10] Others have examined its impact on emerging markets. Some have studied high-frequency responses of financial variables in EMs to announcements of Fed policies. Another strand of research has employed structural vector autoregressions to look at macroeconomic impacts of these policies on EMs. The latter includes a number of papers that have investigated the effects on capital flows to a broad set of emerging markets. A common finding of this work is that quantitative easing increases flows to EMs. In section 2 we present some additional evidence using high-frequency responses of capital flows to QE and QT. Then, in section 3, we present new evidence that links these flows to liquidity provision by the Fed.

Lim et al. (2014) finds large effects of QE on quarterly capital inflows to 60 emerging markets and developing countries in the 2000-2013 period. Ahmed and Zlate (2014) use regression analysis for 12 emerging markets from 2002-2013 and find that large-scale asset purchases by the Federal Reserve lead to higher quarterly capital inflows to these countries. Tillmann (2016) estimates a VAR in which surprise QE shocks are identified and finds a strong impact on U.S. quarterly capital flows to emerging markets in Asia and Latin America in the 2007-2013 period. Duca et al. (2016) find that quarterly corporate bond issuance in 18 emerging markets increases following QE in the 2001-2013 period. Anaya et al. (2017) use a large-scale structural global VAR, which identifies QE shocks using Fed balance sheet data, and find a significant impact on U.S. monthly capital flows to 19 emerging markets in the 2004-2018 period. Bhattarai et al. (2021) estimate a structural VAR for the US, then use the identified QE shocks from that VAR to examine the impact on macro variables for thirteen emerging markets in 2008-2014. They find a large and persistent effect of QE in raising

[10] Diamond et al. (2023), Kandrac et al. (2021), Kandrac and Schlusche (2021), Li et al. (2019), Rodnyansky and Darmouni (2017), Chakraborty et al. (2020) and Acharya and Dogra (2022).

monthly capital inflows into these markets. Chari et al. (2021) use high-frequency identification to obtain a measure of unconventional US monetary policy surprises. Then using monthly data from the U.S. Department of Treasury International Capital (TIC) System, they examine the effects of surprises in the periods of QE and QT, and the pre-crisis period in the 1994-2008 span on fifteen emerging markets, confirming findings in the other studies cited here. Georgiadis and Jarocinski (2023) use high-frequency changes in asset prices to identify the effects of different unconventional US monetary policy shocks, and find that QE triggers quarterly capital inflows to an aggregate of EMs in the 1996-2019 interval.

Kolasa and Wesołowski (2020) build a calibrated structural model to explain how QE in the US might lead to flows into purchases of EM's sovereign bonds. As returns on US assets decline due to QE, investors find potential returns on EM sovereign bonds more attractive. Their analysis, which centers on default risk, complements our focus on liquidity. Kim (2023) builds a money-search model in which QE in a country such as the US, whose assets serve as collateral, can lead to capital flows to EMs.

The empirical study closest to ours is Fratzscher et al. (2018). Using the high frequency capital flow data from 2008 to 2012 on portfolio flows from EPFR, the study assesses the effects of QE announcements on capital flows. Relative to this work, we look at *actual* large purchases or sales of Treasury assets by the Federal Reserve, together with the response to announcements, and find more immediate and significant effects. As we detail next, we look at the dynamics of capital flows to EMs, and find that the effects of these operations on capital flows to EMs are quite persistent. Our study uses a longer time span that includes periods of quantitative tightening as well as large scale asset purchases.

Related are a large number of papers that examine spillovers of U.S. monetary policy more generally (that is, not specifically spillovers from quantitative easing or tightening) to emerging markets, including Rey (2016), Bruno and Shin (2015), Passari and Rey (2015), Aizenman et al. (2016), Georgiadis (2016), Kalemli-Ozcan (2019), Obstfeld et al. (2019), Iacoviello and Navarro (2019), Albagli et al. (2019), Miranda-Agrippino and Rey (2020), Avdjiev et al. (2020), Degasperi et al. (2020), Ca'Zorzi et al. (2020), Bräuning and Ivashina (2020), Ciminelli et al. (2022), Hoek et al. (2022), Obstfeld and Zhou (2022), and De Leo et al. (2024).

Our evidence relating quantitative easing and tightening to the covered interest parity deviation, and the regressions that show that c.i.p. deviations lead to capital flows to emerging markets are new to the literature, as far as we are aware.

Section 2 presents empirical evidence to support the claim that quantitative easing leads to increased capital flows to emerging markets. We show in section 3 the evidence on covered interest parity deviations that accords with our model. Section 4 presents a model that helps explain this phenomenon, while section 5 examines the model quantitatively. Section 6 concludes.

2 Liquidity of U.S. Government Liabilities and Capital Flows

Our empirical approach considers quantitative easing as an alteration of the maturity of government debt held by the investors. When the Federal Reserve buys long-term bonds, the Fed pays with money, increasing reserves of the banking system. QE changes the liquidity composition of government debt in financial markets - the investors hold less long-term Treasury obligations and more short-term debt in the form of reserves. We are interested in how the shift in the liquidity composition of government debt has affected capital inflows to other countries.

2.1 Data Sources

We employ weekly bond flows data from the EPFR dataset. The EPFR dataset collects data on individual fund flows and fund allocations, and aggregates them to flows into and out of specific countries and sectors. The weekly capital flows and fund allocations are reported every Wednesday. Flows cover the total flows occurring over the past week. "Allocations" are their values as of every Wednesday. Both flows and allocations are reported in units of the U.S. dollar.[11] Weekly capital flows cover mutual fund investors and exchange traded fund investors. We employ weekly bond flows and allocations at the country level.

With this data, we analyze how the weekly capital bond inflows to countries change following a sharp increase in the Fed's holding of U.S. Treasury securities. The country sample includes 16 emerging market countries: Brazil, Chile, China, Colombia, Hungary, India, Korea, Mexico, Malaysia, Israel, Peru, Philippines, Poland, Russia, Thailand, and Turkey. The sample period is from 01/01/2006—12/31/2018.[12]

Our identification of the dynamic effects on capital inflows to emerging markets after a large purchase of government bonds by the Fed relies on high frequency capital flow data. The EPFR is the most suited to our analysis given that the capital flow data are available at high frequency compared to other datasets such as the data from the U.S. TIC System or each country's balance of payments statistics. The investor coverage of the dataset is incomplete compared to the balance of payments data; nonetheless, the EPFR dataset is highly representative in capturing the aggregate flow data from the balance of payments data (see, for instance, Jotikasthira et al. (2012).)

We also explore the capital flow dynamics to emerging markets after QE and QT announcements. We collect QE announcement dates from Fratzscher et al. (2018) and QT announcement dates from Du et al. (2024). QE and QT announcement dates that we employ are summarized in Table 4 in the Appendix.[13]

[11] We deflate allocations and flows such that they are in constant 2015 USD.

[12] The weekly capital flow data from EPFR are available from May 2003.

[13] We employ a subset of QE announcements used by Fratzscher et al. (2018), which deliver a positive message about an introduction or expansion of QE.

2.2 Capital Flow Dynamics

We first flag weeks when the weekly log changes in the Fed's outright holding of U.S. Treasury securities is larger than 1.302%, which corresponds to the 95th percentile of the empirical distribution of weekly log changes in the Fed's outright holding of U.S. Treasury securities in 12/18/2002-12/28/2022.[14]

We estimate the following weekly panel local linear projections (Jordà (2005)):

$$ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1}) = \alpha_{i,k} + \beta_k D_t + u_{i,k,t}, \quad (1)$$

$$\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}} = \alpha_{i,k} + \beta_k D_t + u_{i,k,t}. \quad (2)$$

Here, $BondFundAllocation_{i,t}$ refers to the total foreign holdings of bonds of country *i* at weekly date t in the EPFR data, so the change in that variable includes new allocations plus capital gains or losses. $BondFundFlow_{i,t}$ is the flow of funds into country *i* over the past one week prior to weekly date t. D_t is a dummy variable that is equal to one, when, on the weekly date *t*, the Fed's holding of U.S. Treasury securities increases more than 1.302% over one week and zero otherwise. Regression 1 measures how global bond fund allocations to each country i are affected k weeks after, compared to the bond funds allocation one week before, after the Fed's large purchase of U.S. Treasury securities. In regression 2, we look at how each week's bond fund flow change*s* over k weeks, as a ratio of the bond funds allocation one week before, after a large increase in the Fed's purchase of Treasuries. The coefficients of interest are β_k for $k = 0, \ldots, 52$. We include country fixed effects in both specifications.[15]

Figures 2 and 3 show similar patterns. In Figure 2, we see that the bond fund allocation increases by around 20% after a large purchase at the peak. In Figure 3, weekly capital inflows (as a ratio of the fund allocation before the large increase) increase by 0.4 percentage points per week at the peak.

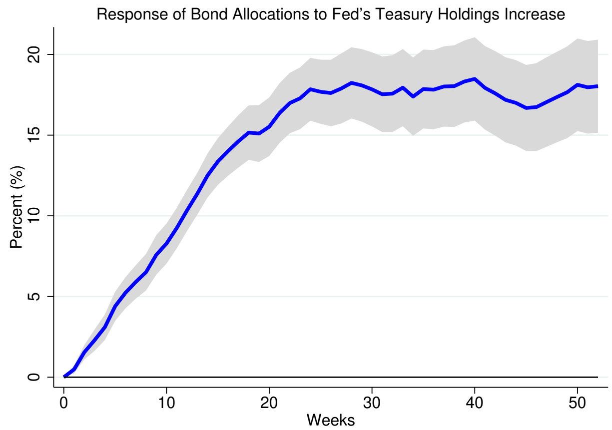
We perform additional robustness exercises. First, we flag weeks only when there is a large increase in the Fed's holdings of U.S. Treasury securities **that are not U.S. Treasury bills**. In this specification, we treat reserves and U.S. Treasury bills as perfect substitutes. We create a new dummy that is equal to one, when, on the weekly date *t*, the Fed's holding of U.S. Treasury securities excluding U.S. Treasury bills increases more than 1.331% over one week and zero otherwise.

Second, we add global and country-level control variables to the regressions (1) and (2). Global variables at the weekly frequency include log of the VIX index, the 10-year Treasury bond yield, and changes in the log of the S&P500 index. We also control for the week-over-week changes in

[14]The first observation is on 12/18/2002, and every Wednesday, the Fed reports its holdings of U.S. Treasury securities.

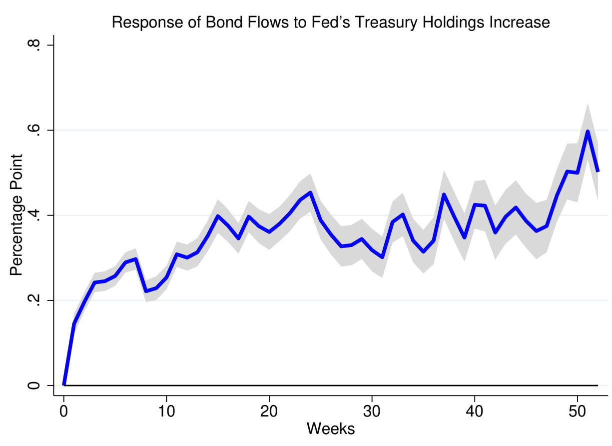
[15]We exclude the top 1% and bottom 1% of the dependent variable in estimation.

Figure 2: Effect of Large Increase in Fed's Holding of U.S. Treasuries on Bond Fund Allocations



Notes: The dependent variable is, $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$. The response shows how the bond funds allocations have changed over 52 weeks after the Fed's large purchase of the U.S. Treasuries. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

Figure 3: Effect of Large Increase in Fed's Holding of U.S. Treasuries on Bond Fund Flows



Notes: The dependent variable is, $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$. The response shows how weekly bond fund flows have changed over 52 weeks after the Fed's large purchase of the U.S. Treasuries. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

the log of bilateral nominal exchange rates against the U.S. dollar to show that the results are not driven by the exchange rate fluctuations. Other country-level controls are mostly at the monthly frequency: money market rates, month-over-month log changes in industrial production index, and year-over-year CPI inflation. Central banks' reserves as a fraction of GDP is also included but only available at the quarterly frequency.[16]

Third, we define a new shock variable that is 1 when the Fed's holding of U.S. Treasury securities increases more than 1.302% over one week, -1 when the Fed's holding of U.S. Treasury securities decreases more than 0.519% over one week, and zero otherwise. 1.302% and -0.519% correspond to 95th and 5th percentile of the weekly changes in the Fed's holding of U.S. Treasuries. This measure then allows for both a large increase and decrease in Fed's holding of U.S. Treasuries.

Figure 4 shows that results do not change when we flag only the dates with abnormally higher increase in Fed's holding of U.S. *long-term* Treasuries. The results change very little when we use an alternative measure. Figure 5 shows the results are robust to controlling for global and country-level variables.

Figure 6 shows the results where D_t is equal to one, when, on the weekly date *t*, the Fed's holding of U.S. Treasury securities increases more than its 95th percentile value over one week, negative one when its change is less than its 5th percentile value over one week and zero otherwise. Now, the dummy variable captures not only a large purchase of U.S. Treasury securities by the Fed but also *its reversal*. The results are intact regardless of whether we only capture quantitative easing or both quantitative easing and tightening.[17]

We then explore the dynamic effects of QE and QT announcement on capital inflows to emerging markets. We estimate weekly panel local linear projections of Equation 3:

$$y_{i,t+k} = \alpha_{i,k} + \gamma_k QE_t + \theta_k QT_t + u_{i,k,t}, \tag{3}$$

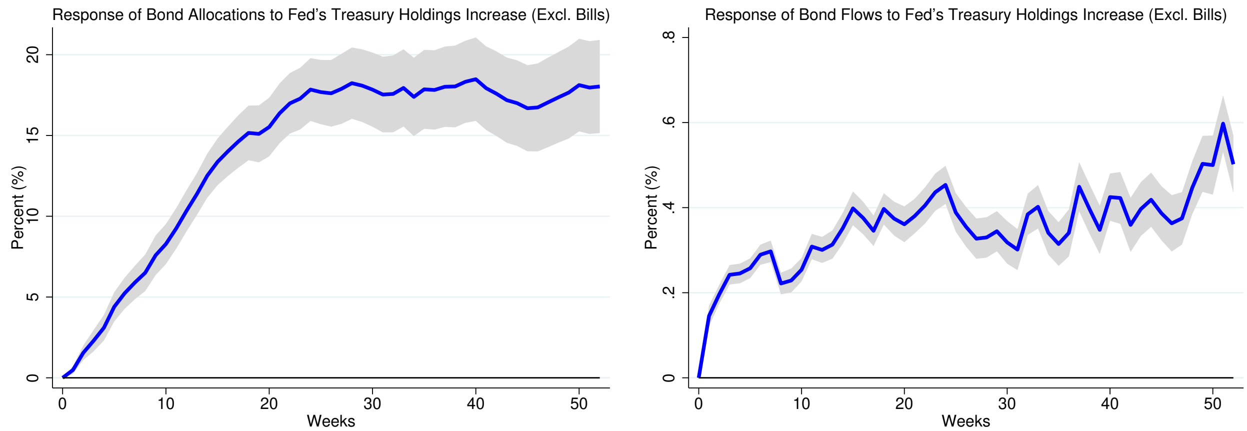
where the dependent variables $y_{i,t+k}$ are (i) $ln(\frac{BondFundAllocation_{i,t+k}}{BondFundAllocation_{i,t-1}})$ and (ii) $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$. The dummy variables, QE_t and QT_t, are defined such that they are equal to one when, on the weekly date *t*, there was a QE and QT announcement, respectively, and zero otherwise. The sample period is 2006 – 2018. We include country fixed effects. The coefficients of interest are γ_k and θ_k for $k = 0, \ldots, 52$.

Figures 7 and 8 show the estimated dynamic effects of QE and QT announcements on capital inflows to emerging markets. We clearly see that bond fund allocations to EMs do not react to QE nor QT news immediately and change sluggishly. Shown in Figures 7 and 8, we could see a positive effect on capital flows, around 10 weeks after QE announcement, and the negative effect

[16] For example, when data is available only monthly, in the regressions, we give each weekly observation the monthly value of the variable.

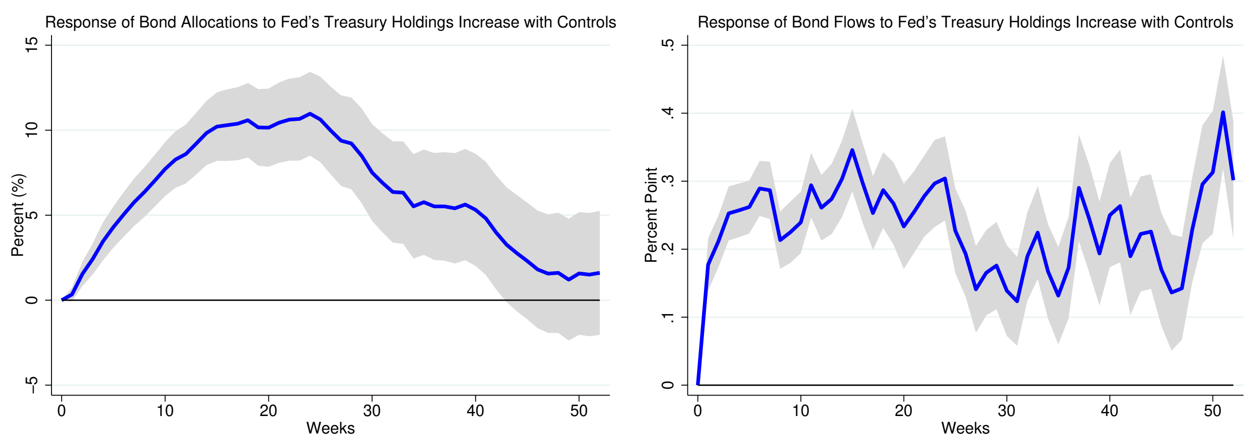
[17] We also have re-estimated Equations 1 and 2 with a dummy variable equal to one, when, on weekly date t, the Fed's holding of U.S. Treasuries *decreases* more than 0.519%. We see that capital inflows to EMs *decrease* after a large sale of U.S. Treasuries by the Fed, shown in Figure 19 in the Appendix.

Figure 4: Dynamics of Capital Flows: Alternative Measure When Flagging Events



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the Fed's large purchase of the *longer-term* U.S. Treasuries. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

Figure 5: Dynamics of Capital Flows: Controlling for Global and Country-level Variables



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the Fed's large purchase of the U.S. Treasuries. We control for global and country-level variables. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

Figure 6: Dynamics of Capital Flows: Capturing Both Quantitative Easing and Tightening

Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the Fed's large *purchase or sale* of the U.S. Treasuries. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

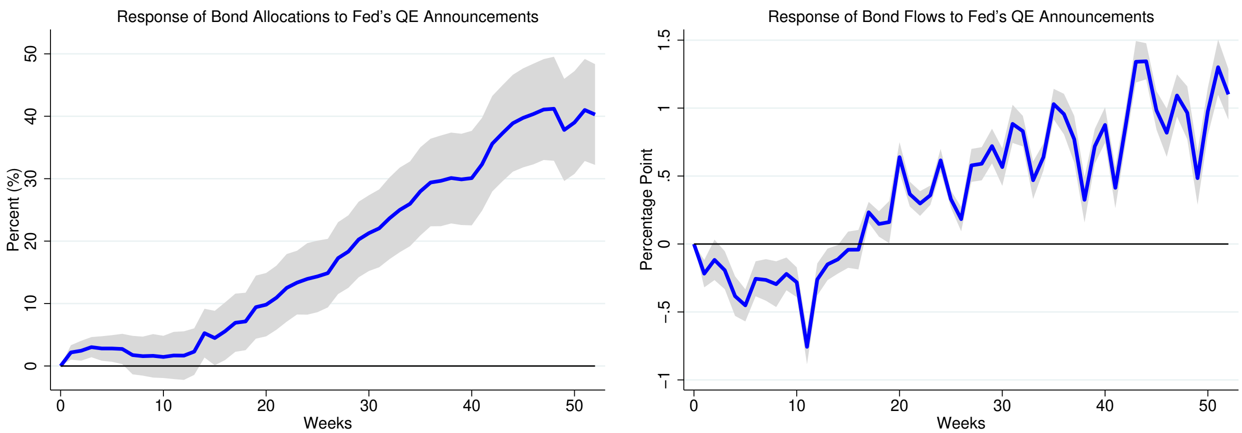
on capital inflows to EMs surfaces around 40 weeks after QT announcements.

In sum, we show that the shift of the liquidity composition of U.S. government towards short-term liquid assets comes with larger capital inflows to emerging markets. At first glance this empirical finding is counterintuitive because quantitative easing supplies the markets with liquid U.S. government assets, which, ceteris paribus, would tend to redirect asset demand toward these U.S. assets and away from investments to other countries. Rationalizing this empirical pattern, we build a simple two-period model that features three different assets with different liquidity profiles and explain how a higher supply of liquid U.S. Treasuries insures investors and leads to more lending to other countries.

3 Liquidity of U.S. Government Liabilities and CIP Deviations

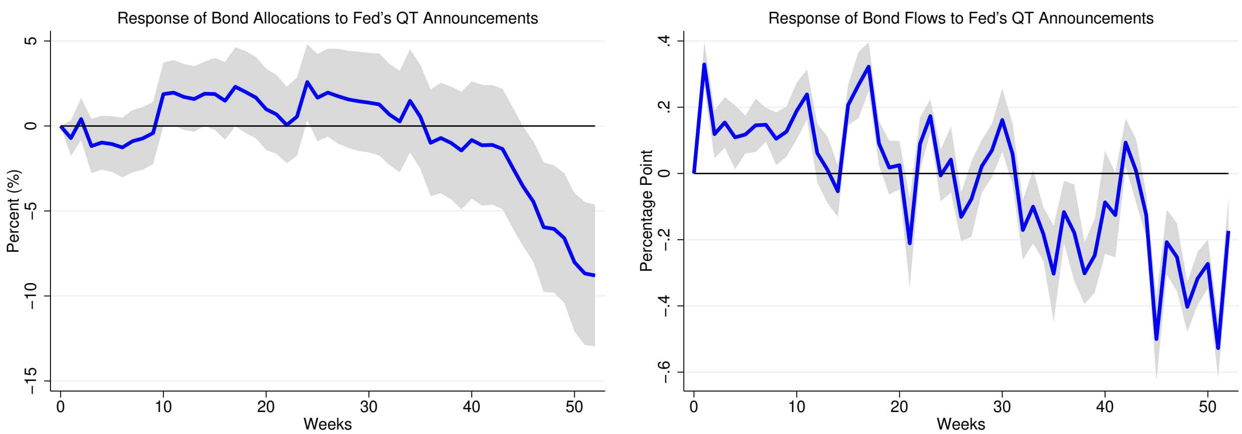
We follow the literature in associating the convenience yield of short-term U.S. Treasury bills with the degree of liquidity these bills provide markets. Our hypothesis is that QE increases the supply of very liquid U.S. government assets to the public, and should reduce the convenience yield on T-bills. QT would have the opposite effect. Recent work that has examined the convenience yield on T-bills, and the Treasury basis, includes Krishnamurthy and Vissing-Jorgensen (2012), Krishnamurthy and Vissing-Jorgensen (2011) Nagel (2016), Vissing-Jorgensen (2021), Jiang et al. (2021), Obstfeld and Zhou (2022), Du et al. (2018), Du and Schreger (2022), Kalemli-Ozcan and Varela (2021), Du et al. (2023), Diamond and Van Tassel (2021), Tabova and Warnock (2021), Engel and Wu (2023), and Cerutti et al. (2021).

Figure 7: Effect of QE Announcements on Capital Flows



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the QE announcements. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

Figure 8: Effect of QT Announcements on Capital Flows



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the QT announcements. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

3.1 Data Sources

We explore how the convenience yields have changed after QE and QT announcements.[18] We measure the convenience yields following Du and Schreger (2016) and Du et al. (2018). We quantify the convenience yield of the U.S. Treasuries and foreign government bonds by measuring the one-year CIP deviations, adjusted by the default risk using credit default swap (CDS) data, $\Phi_{i,t}$:

$$\Phi_{i,t} = (y_{i,t}^{Govt} - CDS_{i,t} - \rho_{i,t}) - (y_{US,t}^{Govt} - CDS_{US,t}),$$

where $y_{i,t}^{Govt}$is the one-year local-currency government bond yield in country i, $\rho_{i,t}$ is the one-year market-implied forward premium for hedging currency i against the U.S. dollar, and $y_{USD,t}^{Govt}$ is the one-year U.S. Treasury bond yield on weekly date t. To account for the probability of government default, we adjust the CIP deviations by subtracting the difference between the emerging market country's one-year CDS premium and that of the U.S.[19] The CIP deviation captures the extent to which investors are willing to accept a lower yield on U.S. Treasuries as investors get non-pecuniary benefits from holding U.S. Treasuries. We employ the same set of emerging market countries: Brazil, Chile, China, Colombia, Hungary, India, Korea, Mexico, Malaysia, Israel, Peru, Philippines, Poland, Russia, Thailand, and Turkey.

3.2 Dynamics of CIP Deviations

We look at the dynamics of one-year CIP deviations following the QE and QT announcements.[20] We estimate the weekly panel local linear projection:

$$\Phi_{i,t+k} = \alpha_{QE,i,k} D_t + \alpha_{QT,i,k}(1 - D_t) + \omega_{k,QE} QE_t + \omega_{k,QT} QT_t + \epsilon_{i,k,t} \tag{4}$$

where $\Phi_{i,t}$ captures the convenience yield of U.S. Treasuries over government bonds of country i on weekly date t in basis points.

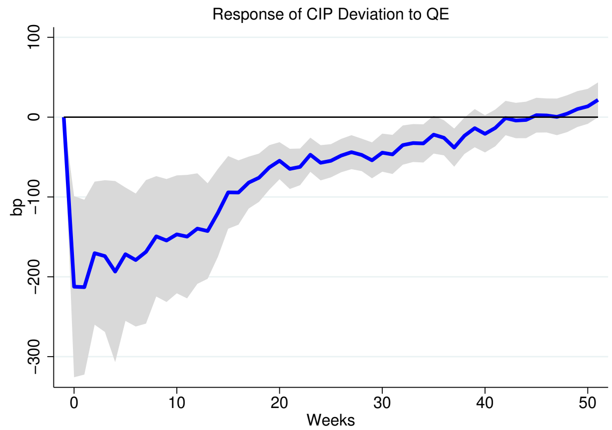
The dummy variable QE_t (QT_t) is equal to one when, on the weekly date *t*, there was a QE (QT) announcement and zero otherwise. Given that market prices react quickly to news, we estimate the dynamic effect of QE and QT announcements over smaller windows to cleanly capture their impact on the liquidity yields. Each period spans two years before the *first* announcement of QE (or QT) and two years after the *last* announcement of QE (or QT): 2006 – 2014 for QE and 2015 – 2019

[18] Given that market prices of government bonds and swaps respond much quickly to the news, we explore the dynamics of CIP deviations after the announcements, not after the actual change in the Fed's holding of U.S. Treasuries.

[19] When CDS data on a weekly date t are missing, we replace them with the annual average for the corresponding year.

[20] We employ one-year CIP deviations as the CDS data are not readily available for those with tenor less than a year. The results are similar with the three-month CIP deviations.

Figure 9: Effect of QE Announcements on CIP Deviations



Notes: The dependent variable is the one-year CIP deviation adjusted by default risk: $\Phi_{i,t} = (y^{Govt}_{i,t} - CDS_{i,t} - \rho_{i,t}) - (y^{Govt}_{US,t} - CDS_{US,t})$,where $y^{Govt}_{i,t}$is the one-year local-currency government bond yield in country i, $\rho_{i,t}$ is the one-year market-implied forward premium for hedging currency i against the U.S. dollar, and $CDS_{i,t}$ is credit default swap premium on country i's government bond on weekly date t. The sample period is from 2005 – 2014. The shaded area represents the 90% confidence interval computed using heteroskedasticity-robust standard errors.

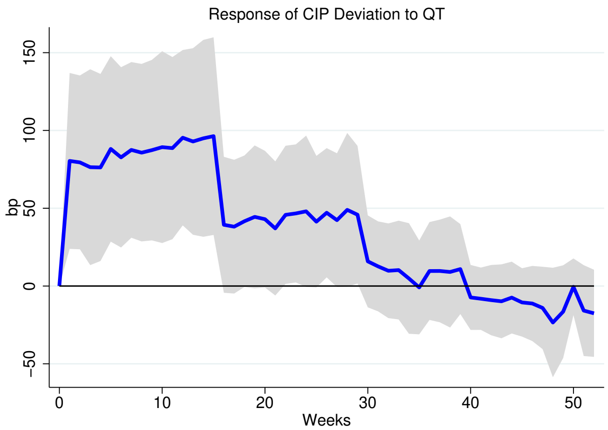
for QT. We define the dummy variable D_t equal to one for the years 2006 – 2014 and zero for 2015 – 2019. As aforementioned, announcement dates are fetched from Fratzscher et al. (2018) and Du et al. (2024), summarized in Table 4 in the Appendix. The coefficients of interest are $\omega_{k,QE}$ and $\omega_{k,QT}$ for $k = 0, \dots, 52$.

Figures 9 and 10 summarize the results. The CIP deviations decrease after the QE announcements, while they increase after the QT announcements. As QE shifts the liquidity composition of U.S. government liabilities towards more liquid short-term assets, the market is flooded with short-term liquidity. Higher short-term liquidity lowers the liquidity and convenience yields. On the flip side, the QT lowers the supply of liquidity in the market, increasing the liquidity return. The quantitative magnitude of a fall in convenience yields after QE announcements is large, on average entailing a two percentage point fall in the convenience yield. The effect of QE on the convenience yield lasts more than 30 weeks. QT announcements in 2017 have come with a much more muted change in convenience yields, around an one percentage point increase in the convenience yield lasting for ten weeks.[21]

In essence, the quantitative easing shifts the liquidity composition of U.S. government liabilities to more short-term liquid assets, decreasing the liquidity return of U.S. Treasuries relative to that of foreign government bonds. We would like to understand, through the lens of our model in Section 4, how this liquidity channel may affect investors' portfolio choices, specifically their lending to the emerging markets.

[21] Recently, Du et al. (2024) show that QT announcements lower the convenience yields on *long-term* U.S. Treasuries over foreign government bonds. We also find a similar pattern with the 10-year CIP deviations.

Figure 10: Effect of QT Announcements on CIP Deviations



Notes: The dependent variable is the one-year CIP deviation $\Phi_{i,t} = (y^{Govt}_{i,t} - CDS_{i,t} - \rho_{i,t}) - (y^{Govt}_{US,t} - CDS_{US,t})$,where $y^{Govt}_{i,t}$is the one-year local-currency government bond yield in country i, $\rho_{i,t}$ is the one-year market-implied forward premium for hedging currency i against the U.S. dollar, and $CDS_{i,t}$ is credit default swap premium on country i's government bond on weekly date t. The sample period is from 2014 – 2019. The shaded area represents the 90% confidence interval computed using heteroskedasticity-robust standard errors.

3.3 CIP Deviations and Capital Flows

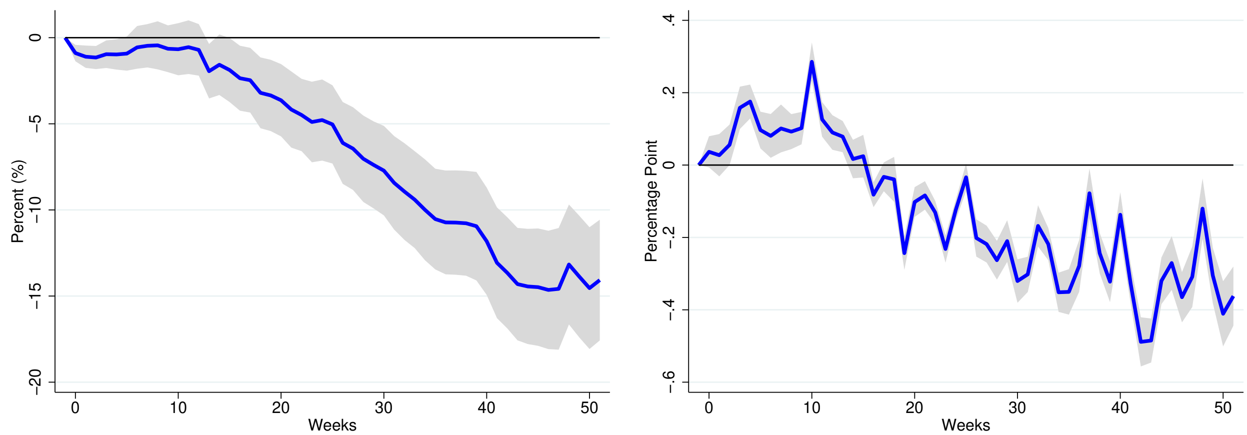
In this section, we explore how the CIP deviations induced by QE and QT announcements affect capital flows to emerging markets. Using the estimates of $\hat{\omega}_{0,QE}$ and $\hat{\omega}_{0,QT}$ on CIP deviations from Equation 4, we compute $100\times\big(\hat{\omega_{0,QE}} \times D_t + \hat{\omega}_{0,QT} \times (1 - D_t)\big) \times$ LiquidityShock$_t$ ($\equiv \hat{\hat{\Phi}}_{i,t}$), where LiquidityShock$_t$ is equal to one when, on weekly date t, there was a QE announcement, negative one when there was a QT announcement, and zero otherwise. D_t equal to one for the years 2006 – 2014 and zero for 2015 – 2019. $\hat{\hat{\Phi}}_{i,t}$ represents the CIP deviations in percentage points induced by QE and QT announcements. Then, with $\hat{\hat{\Phi}}_{i,t}$, we estimate weekly panel local linear projections:

$$y_{i,t+k} = \alpha_{i,k} + \theta_k \hat{\hat{\Phi}}_{i,t} + u_{i,k,t},$$

where the dependent variables $y_{i,t+k}$ are (i) $ln(\frac{BondFundAllocation_{i,t+k}}{BondFundAllocation_{i,t-1}})$ and (ii) $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$. We include country fixed effects. The coefficients of our interest are θ_k for $k = 0, \ldots, 52$.

Figure 11 summarizes the estimation results of the dynamic panel local projections. When CIP deviations decrease after the QE announcements, capital flows to emerging markets increase. A 100 basis point decrease in CIP deviations leads to, on average, a 15% increase in bond fund allocations and a 0.4 percentage point increase in bond fund flows as ratios of bond fund allocations at the pre-announcement level. We clearly observe that a shift in the liquidity yield of U.S. Treasuries vis-a-vis emerging market government bonds, induced by the QE and QT announcements, is followed by capital flowing into and out of emerging markets.

Figure 11: Effect of CIP Deviations on Capital Flows



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The dynamic effects of the CIP deviations induced by QE and QT announcements on capital flows to emerging markets are shown in both figures. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.

4 Model

Our objective in this section is to provide a rationale for why lending to EMs increases with quantitative easing. We build a simple two-period model to illustrate how the changes in the liquidity profile of U.S. Treasuries affects investors' lending to EMs.

We are not interested in, and abstract from, the fiscal implications of the U.S. debt composition. That is, the timing of taxes is not the focus of our study. As the literature has noted, even in a setting with infinitely-lived representative agents, the presence of a liquidity return to government bonds breaks Ricardian equivalence. The particular fiscal policy that is optimal depends on the specifics of how liquidity interacts with private-market decisions, as well as the interdependence of fiscal and monetary policy.[22] The government of our model simply borrows and makes lump-sum transfers, and the driver of U.S. current account deficits is government borrowing.[23]

4.1 Environment

There are two periods, 0 and 1. There are three countries, U.S., ROW and EM, populated by m^a mass of households, where $a = \{\text{US, ROW,EM}\}$. Each country's households may have different time discount factors, β^a, where $a = \{\text{US, ROW,EM}\}$. Each household exhibits constant relative

[22] See Azzimonti and Yared (2019), Bigio et al. (2019), Bassetto and Cui (2018), Bayer et al. (2023), Acharya and Dogra (2022), Krishnamurthy et al. (2018), Berentsen and Waller (2018) and Andolfatto and Martin (2018).

[23] Although there are other reasons for the U.S. current account deficit in these models, Kekre and Lenel (2024) and Jiang et al. (2021) are examples of models in which the seigniorage from issuance of safe assets plays an important role in determining the U.S. deficit.

risk aversion, parametrized by σ. We set up a model with three countries to allow for EMs to be borrowers, but to be consistent with the fact that the U.S. is also a net borrower on international markets. In our set-up, the U.S. is a borrower because of the government. Households in the U.S., under our parameter configuration, are savers and are lenders both to the U.S. government and to EMs. We take the amount of U.S. government debt as exogenously given.

US and ROW Households In the beginning of period 0, U.S. and ROW households do not know their incomes but know that they may have high income with probability p or low income with probability $1-p$. $y_0^{a,k}$ denotes the income at time $t=0$ for country $a=\{\text{US, ROW}\}$ and income type $k=\{H,L\}$, where $y_0^{a,H} > y_0^{a,L}$. In period 1, U.S. and ROW households receive incomes of y_1^a , where $a=\{\text{US, ROW}\}$, regardless of their incomes in period 0.[24] U.S. and ROW households pay lump-sum taxes in periods 0 and 1, T_0^a and T_1^a, where $a=\{\text{US, ROW}\}$.

In the beginning of period 0, before U.S. and ROW households learn their incomes, they decide how much to save in three different types of saving vehicles that offer different levels of liquidity: liquid U.S. Treasury bills $b^a \geq 0$, less-liquid U.S. Treasury bonds $\tilde{b}^a \geq 0$, and illiquid loans ℓ^a to EM for country $a=\{\text{US, ROW}\}$.[25] Then, U.S. and ROW households learn their incomes $y_0^{a,k}$ and adjust their liquid U.S. Treasuries holdings. Liquid Treasuries can be bought and sold between households after their income levels are realized. Each household in country a of income type $k=\{H,L\}$ buy additional liquid Treasuries $b^{a,k}$ at the price $\frac{1}{R_{b,s}}$ (or sell if $b^{a,k}<0$), after its income type k is obtained. The amount that they can sell at this point is restricted by how much the investors hold before the income shock is realized: $b^{a,k} \geq -b^a$.

Absent other transaction costs, selling liquid bonds in a secondary market has the same consequences as offering these bonds as collateral for short-term loans. After the realization of income shocks, some households want to sell their liquid bills on a secondary market so they can increase consumption (while others, with good income shocks, are willing to buy the bills). Instead of a secondary market, there could be a repo market. The households that want to increase their consumption could borrow directly from the households that are willing to save more, and the T-bills are offered as collateral. In the next period, when it is time to "pay back" the loan, the lending household can simply sell the T-bills they have been holding as collateral. In other words, since the model does not include other financial market frictions, the secondary market and repo market are equivalent. We note this here since in the more complex real world, one aspect of T-bill liquidity is

[24]Here, we have allowed for income uncertainty about shocks to exogenous endowments that occur after the saving decisions are made by households. We can reinterpret shocks to endowments as a varying amount of capital required for production of goods in period 1. Households learn about the technology for production in period 1 after their consumption/saving decision is made in the initial period. They may find that additional investment is required for the project to be productive, which would require redirecting resources from consumption to capital investment. A simple framework with investment is summarized in the Appendix.

[25]The time discount factors of U.S. and ROW households are much higher than EM households such that EM households want to borrow from the U.S. and ROW households.

their collateral value for very short-term loans.[26]

Illiquid Treasuries cannot be sold and bought after income realizations. The difference between liquid and less-liquid Treasuries captures the ease of selling assets when needed. The price of illiquid bonds is $\frac{1}{R_{\tilde{b}}}$.

Illiquid loans to EM households also cannot be sold when the secondary market opens. They also require U.S. and ROW households to pay transaction costs as a function of the size of the amount of loans: $f(\frac{\ell^a}{R_\ell})$, where ℓ^a is the amount of loans extended to EMs, at the price $\frac{1}{R_\ell}$, where $f' > 0$ and $f'' > 0$ for country $a = \{\text{US, ROW}\}$.This formulation for the transaction cost is intended as a reduced form that might represent the cost of searching for acceptable projects to invest in. As the amount lent increases, the cost rises, and at an increasing rate to represent the increasing scarcity of acceptable projects larger loans.

Before learning one's income $y_0^{a,k}$, each household in country a chooses liquid U.S. Treasury bills $b^a \geq 0$, less-liquid U.S. Treasury bonds $\tilde{b}^a \geq 0$, and illiquid loans ℓ^a to EM to maximizes the expected utility from consumptions in periods 0 and 1:

$$\max_{b^a \geq 0, \tilde{b}^a \geq 0, \ell^a} pU^{a,H} + (1-p)U^{a,L} + U(G_0^a, G_1^a), \tag{5}$$

where $U^{a,H}$ and $U^{a,L}$ represent the utilities of households in country a with income type H and L, respectively. $U(G_0^a, G_1^a)$ is utility from public goods consumption, provided by each household's government in periods 0 and 1, and is separable from the utility from consumption for country $a = \{\text{US, ROW}\}$. Hence, it does not affect the optimal household saving choices.

Households choose to increase (or reduce if $b^{a,k} < 0$) their liquid Treasury holdings by $b^{a,k}$ after income realizations to maximize $U^{a,k}$, subject to the constraint,

$$b^{a,k} \geq -b^a,$$

and $U^{a,k}$ is defined as:

$$U^{a,k} = \max_{b^{a,k} \geq -b^a} \frac{(c_0^{a,k})^{1-\sigma}}{1-\sigma} + \beta^a \frac{(c_1^{a,k})^{1-\sigma}}{1-\sigma}, \tag{6}$$

where $c_0^{a,k}$ and $c_1^{a,k}$ are the levels of consumption of income type k after learning their incomes in periods 0 and 1, respectively. The budget constraints (for $k = \{H, L\}$) for consumption in periods 0 and 1 are given as:

$$c_0^{a,k} = y_0^{a,k} - T_0^a - \frac{\ell^a}{R_\ell} - \frac{b^a}{R_b} - \frac{\tilde{b}^a}{R_{\tilde{b}}} - \frac{b^{a,k}}{R_{b,s}} - f(\frac{\ell^a}{R_\ell}), \quad c_1^{a,k} = y_1^a - T_1^a + \ell^a + b^a + \tilde{b}^a + b^{a,k}. \tag{7}$$

[26]See Acharya and Laarits (2023), Gorton et al. (2022), Corsetti et al. (2023), Diamond and Van Tassel (2021), for example.

Before learning one's income, each household in country a saves in liquid U.S. Treasury bills b^a, less-liquid U.S. Treasury bonds $\tilde{b}^a$, and illiquid loans ℓ^a to EMs at the prices $\frac{1}{R_b}$, $\frac{1}{R_{\tilde{b}}}$, and $\frac{1}{R_\ell}$, respectively. Then, the household learns its income type k, receiving after-tax income $y_0^{a,k} - T_0^a$, and one rebalancing its liquid Treasuries by buying ($b^{a,k} > 0$) or selling additionally ($b^{a,k} < 0$) at the price $\frac{1}{R_{b,s}}$, and consumes $c_0^{a,k}$ in period 0. In period 1, each receives its after-tax income $y_1^a - T_1^a$ and the payoffs from its lending: liquid U.S. Treasury billa $b^a + b^{a,k}$, less-liquid U.S. Treasury bonds $\tilde{b}^a$, and illiquid loans ℓ^a.

EM Households

For simplicity, we assume that EM households do not face income uncertainty in period 0 unlike U.S. and ROW households. y_t^{EM} denotes the income at time $t = 0, 1$ for EM households. The time discount factor for EM households is much lower than those of ROW and US households, and this low time discount factor renders EM households to be borrowers from ROW and US households. EM households pay the transaction costs as a function of the total value of loans extended to them: $f(\frac{\ell^{EM}}{R_\ell})$. This cost is symmetric to the lender's cost for making the loan, and is meant to be a reduced-form representation of the two-sided problem of matching borrowers and lenders.

Given that both liquid and less-liquid Treasuries offer higher liquidity to savers, in equilibrium, the interest rates on these Treasuries are lower than that on illiquid loans.[27] EMs would not optimally choose to save in these lower interest-bearing Treasuries, because they borrow via the most illiquid assets in equilibrium. It would be better to reduce borrowing than to borrow at high interest rates and save at low interest rates, so their saving in both liquid and illiquid U.S. Treasuries is zero.

EM households choose the amount of borrowing via illiquid loans ℓ^{EM} to maximize their utility from consumptions in periods 0 and 1:

$$\max_{\ell^{EM}} \frac{(c_0^{EM})^{1-\sigma}}{1-\sigma} + \beta^{EM} \frac{(c_1^{EM})^{1-\sigma}}{1-\sigma}, \tag{8}$$

where c_0^{EM} and c_1^{EM} represent the consumptions in period 0 and 1, respectively. The budget constraints are given as:

$$c_0^{EM} = y_0^{EM} + \frac{\ell^{EM}}{R_\ell} - f(\frac{\ell^{EM}}{R_\ell}), \;\; c_1^{EM} = y_1^{EM} - \ell^{EM}.$$

In period 0, EM households receive endowments of y_0^{EM}, choose how much illiquid loans to take, ℓ^{EM}, at the price $\frac{1}{R_\ell}$, and the transaction costs, $f(\frac{\ell^{EM}}{R_\ell})$, and they consume c_0^{EM}. In period 1, EM households receive the endowment of y_1^{EM}, and pay back their loans ℓ^{EM}.

U.S. Government

The total amount of U.S. government debt is exogenously given as B. The share of liquid U.S. Treasuries in total U.S. Treasuries is exogenous and set as η. We vary η in our experiments to investigate the implication of the liquidity composition for lending to EMs. The U.S. government

[27]We show this hierarchy in the interest rates formally in Proposition 1.

budget constraints in periods 0 and 1 are given as:

$$G_0^{\text{US}} = B(\frac{\eta}{R_b} + \frac{1-\eta}{R_{\tilde{b}}}) + m^{US}T_0^{US} \;\; and \;\; G_1^{US} = -B + m^{US}T_1^{US}.$$

U.S. government spending in period 0, G_0^{US}, is equal to the amount of borrowing in liquid and less-liquid U.S. Treasuries and the lump-sum tax collected from U.S. households, $m^{US}T_0^{US}$. We assume that G_0^{US} varies with η such that T_0^{US} is constant. This assumption allows us to abstract from effects of varying transfers and taxes on government revenues and borrowing as the liquidity composition of the U.S. government bonds. U.S. government spending in period 1, G_1^{US}, is equal to the lump-sum tax collected from U.S., households, $m^{US}T_1^{US}$ after paying back their government debt, B. As the total amount of U.S. government debt B is fixed as well as the lump-sum tax in period 1, T_1^{US}, U.S. government spending in period 1 is also a constant.

ROW Government

The ROW government runs a balanced budget. The budget constraints of the ROW government in periods 0 and 1 are given as:

$$G_0^{\text{ROW}} = m^{ROW}T_0^{ROW} \;\; and \;\; G_1^{ROW} = m^{ROW}T_1^{ROW},$$

where ROW government spending G_t^{ROW} in both periods is equal to the lump-sum tax collected from ROW households, $m^{ROW}T_t^{ROW}$, for $t = 0, 1$. The lump-sum tax collected from the ROW households in both periods is fixed.

4.2 Market Clearing Conditions

The market clearing conditions for liquid Treasuries, illiquid Treasuries, and illiquid loans are given as below:

$$m^{ROW}b^{ROW} + m^{US}b^{US} = \eta B,$$
$$m^{ROW}\tilde{b}^{ROW} + m^{US}\tilde{b}^{US} = (1-\eta)B, \;\; \text{and}$$
$$m^{US}\ell^{US} + m^{ROW}\ell^{ROW} = m^{EM}\ell^{EM}.$$

The market clearing condition for rebalancing liquid Treasuries among households after their income realizations is given as:

$$m^{ROW}(pb^{ROW,H} + (1-p)b^{ROW,L}) + m^{US}(pb^{US,H} + (1-p)b^{US,L}) = 0.$$

4.3 Properties of the Model

In this section, we examine the mechanisms behind the equilibrium determination of interest rates and lending.

Households in country a, after they realize that their income type is k, adjust their holdings of liquid U.S. Treasuries by choosing $b^{a,k}$ subject to the constraint $b^{a,k} > -b^a$ and the budget constraints 7, to maximize their utility shown in Equation 6. The first order condition (F.O.C) with respect to (w.r.t.) $b^{a,k}$ is given as:

$$-\frac{1}{R_{b,s}}(c_0^{a,k})^{-\sigma} + \beta^a(c_1^{a,k})^{-\sigma} + \mu^{a,k} = 0, \tag{9}$$

where we denote the Lagrangian multiplier on $b^{a,k} > -b^a$ as $\mu^{a,k}$.

Savers, at the beginning of period 0, before knowing their incomes, optimally choose their savings in liquid Treasuries $b^a \geq 0$, illiquid Treasuries $\tilde{b}^a \geq 0$, loans to EMs, ℓ^a, subject to the budget constraints 7 of incomes types $k = \{H, L\}$, to maximize their expected utility shown in Equation 5. The first-order conditions w.r.t b^a, w.r.t $\tilde{b}^a$, and w.r.t ℓ^a are, respectively:

$$p\big(-\frac{1}{R_b}(c_0^{a,H})^{-\sigma} + \beta^a(c_1^{a,H})^{-\sigma} + \mu^{a,H}\big) + (1-p)\big(-\frac{1}{R_b}(c_0^{a,L})^{-\sigma} + \beta^a(c_1^{a,L})^{-\sigma} + \mu^{a,L}\big) = 0, \tag{10}$$

$$p\big(-\frac{1}{R_{\tilde{b}}}(c_0^{a,H})^{-\sigma} + \beta^a(c_1^{a,H})^{-\sigma}\big) + (1-p)\big(-\frac{1}{R_{\tilde{b}}}(c_0^{a,L})^{-\sigma} + \beta^a(c_1^{a,L})^{-\sigma}\big) = 0, \text{ and} \tag{11}$$

$$-\big(\frac{1}{R_\ell} + \frac{1}{R_\ell}f'(\frac{\ell^a}{R_\ell})\big)\big(p(c_0^{a,H})^{-\sigma} + (1-p)(c_0^{a,L})^{-\sigma}\big) + p\beta^a(c_1^{a,H})^{-\sigma} + (1-p)\beta^a(c_1^{a,L})^{-\sigma} = 0. \tag{12}$$

Given this environment, we first derive a relationship between the interest rates summarized in Lemma 1. We show that the most liquid assets offer the lowest interest rates, and the interest rate on liquid Treasuries at the issuance is identical to that in the secondary market.

Lemma 1. $R_\ell \geq R_{\tilde{b}} \geq R_b = R_{b,s}$.

Proof. Using Equations 9 and 10, we can see that $R_{b,s} = R_b$. From Equations 11 and 10,

$$\big(\frac{1}{R_b} - \frac{1}{R_{\tilde{b}}}\big)\big(p(c_0^{a,H})^{-\sigma} + (1-p)(c_0^{a,L})^{-\sigma}\big) = p\mu^{a,H} + (1-p)\mu^{a,L} \geq 0$$

which implies that $R_{\tilde{b}} \geq R_b$. Using Equations 11 and 12, we find,

$$\frac{1}{R_{\tilde{b}}} = \frac{1}{R_\ell}(1 + f'(\ell^a))$$

Therefore, as long as $\ell > 0$, $R_\ell > R_{\tilde{b}}$. $\square$

Lenders get benefits other than interest rates from saving in more liquid assets, so they accept lower interest rates on more liquid assets. Lenders pay no transaction costs for both liquid Treasuries and less-liquid Treasuries, and moreover, they can sell liquid Treasuries when their income levels are realized. These perks make the most liquid assets offer the lowest interest rates.

Also, the U.S. and the ROW households face no *unexpected shock*s. Therefore, if the interest rates on the primary and the secondary market differ, each household can be better off by arbitraging between the primary and the secondary market. For instance, if the interest rate was higher in the primary market compared to that in the secondary market, a household could make a positive profit by saving more in liquid Treasuries in the primary market and selling them at a higher price in the secondary market. Therefore, both the interest rate at the issuance and in the secondary market are the same.

We then show the amount of loans to EM is the same across lenders due to the presence of transaction costs.

Lemma 2. $\ell^{US} = \ell^{EU}$.

Proof. Using Equations 11 and 12, we find,

$$\frac{1}{R_{\tilde{b}}} = \frac{1}{R_\ell}(1 + f'(\ell^a))$$

It can be trivially shown that $\ell^{US} = \ell^{EU}$. $\square$

This result arises because of the increasing cost of making loans. In equilibrium, the marginal cost of loans will be equal for both lenders, which then implies they will lend equal amounts.

Lastly, we show that the low income households sell all their liquid U.S. Treasuries in the secondary market when the interest rate on less-liquid Treasuries is higher than that on liquid Treasuries.

Proposition 1. *When the interest rate on less-liquid Treasuries is higher than that on liquid Treasuries, $R_{\tilde{b}} > R_b$, $b^{a,L} + b^a \geq 0$ binds while $b^{a,H} + b^a \geq 0$ does not bind. Low-income households sell all their liquid assets in equilibrium, while high-income households do not.*

Proof. When $R_{\tilde{b}} > R_b = R_{b,s}$, either $\mu^{a,H} > 0$ or $\mu^{a,L} > 0$ or both are positive. We show that $\mu^{a,H} = 0$ and $\mu^{a,L} > 0$ by showing that two other cases are not possible.

Case 1: $\mu^{a,H} > 0$ and $\mu^{a,L} = 0$.

Household budget constraints can be rearranged as $c_0^{a,H} = c_0^{a,L} + (y_0^H - y_0^L) - \frac{b^{a,H} - b^{a,L}}{R_b}$ and $c_1^{a,H} = c_1^{a,L} + (b^{a,H} - b^{a,L})$. And, $b^{a,H} = -b^a < b^{a,L}$ as the constraint only binds for high income households, and it implies that $b^{a,H} - b^{a,L} < 0$. As $y_0^H - y_0^L > 0$ and $b^{a,H} - b^{a,L} < 0$,using Equation 6, we can show that

$$\mu^{a,L} = \frac{1}{R_b}(c_0^{a,L})^{-\sigma} - \beta^a (c_1^{a,L})^{-\sigma} \qquad = 0$$

$$\mu^{a,H} = \frac{1}{R_b}\left(c_0^{a,L} + (y_0^H - y_0^L) - \frac{b^{a,H} - b^{a,L}}{R_b}\right)^{-\sigma} - \beta^a \left(c_1^{a,L} + (b^{a,H} - b^{a,L})\right)^{-\sigma} \quad < \mu^{a,L} = 0$$

Therefore, we cannot have $\mu^{a,H} > 0$.

Case 2: $\mu^{a,H} > 0$ and $\mu^{a,L} > 0$.

The constraints bind for both high and low incomes so $b^{a,H} = -b^a$ and $b^{a,L} = -b^a$. The two equalities cannot hold unless there is a zero supply of liquid Treasuries.

In sum, we conclude the constraint binds for low-income households but does not bind for high-income households. □

Proposition 1 shows that households save in *lower* interest-bearing liquid Treasuries and sell all of them when their income levels turn out to be low. The remainder of their saving/lending is in illiquid Treasuries and loans to EMs. Lenders hold liquid assets, planning to sell them when their income is low in order to smooth consumption across states. These households do not hold more liquid U.S. Treasuries than the amount that they want to sell when their income levels turn out to be low, because they could be better off by lowering their savings in liquid U.S. Treasuries and increasing their savings in less-liquid U.S. Treasuries. When income is realized, high income households buy all the liquid bonds of low income households and earn R_b. The high income households, ex post, wish they had saved more, and are willing to purchase the liquid bonds and earn R_b.

4.4 Liquidity Composition and Capital Flows to EM

We next show analytically how capital flows to EM change as the liquidity profile of the outstanding U.S. Treasuries shifts towards more liquid assets. That is, we want to show how ℓ^{EM}changes when the share of liquid Treasuries in total U.S. government debt η varies.

In doing so, we assume that U.S. and ROW households are identical in that they share the same time discount factors and the same post-tax income profiles. That is, $\beta^{US} = \beta^{ROW}$, and $y_t^{US,k} - T_t^{US} = y_t^{ROW,k} - T_t^{ROW}$for $t = 0, 1$. Without loss of generality, we also assume that $m^{US} + m^{ROW} = m^{EM} = 1$. For simplicity, we further assume that the cost for the U.S. and ROW households of lending to EM is zero, $f(\frac{\ell^{\text{US}}}{R_\ell}) = f(\frac{\ell^{\text{ROW}}}{R_\ell}) = 0$.

U.S. households choose $b^{US,L}$ and $b^{US,H}$, taking b^{US}, $b^{\tilde{US}}$, and ℓ^{US} as given. U.S. households choose $b^{US,k}$ to maximize their utility from consumption shown in Equation 6, given the constraints $b^{US,k} + b^{US} \geq 0$ for $k = \{H, L\}$ and the budget constraints in Equation 7. The F.O.C. w.r.t $b^{US,k}$ are:

$$-\frac{1}{R_{b,s}}(c_0^{US,H})^{-\sigma} + \beta^{US}(c_1^{US,H})^{-\sigma} = 0, \tag{13}$$

$$-\frac{1}{R_{b,s}}(c_0^{US,L})^{-\sigma} + \beta^{US}(c_1^{US,L})^{-\sigma} + \beta^{US}\mu_L^{US} = 0. \tag{14}$$

As we have shown in Proposition 1, the rebalancing constraint does not bind for the high income type: $b^{US,H} + b^{US} > 0$, i.e., $\mu_H^{US} = 0$.

In the beginning of period 0, before the income realizations, U.S. households choose their portfolios of liquid bills b^{US}, less-liquid bonds $\tilde{b}^{US}$, and illiquid loans ℓ^{US}, subject to the budget constraints in Equation 7 to maximize their expected utility shown in Equation 5, while assuming $f(\frac{\ell^{\text{US}}}{R_\ell}) = 0$. The F.O.C. w.r.t b^a, the F.O.C. w.r.t $\tilde{b}^a$, and the F.O.C. w.r.t ℓ^a are summarized below, respectively:

$$p\left(-\frac{1}{R_\ell}(c_0^{US,H})^{-\sigma} + \beta^{US}(c_1^{US,H})^{-\sigma}\right) + (1-p)\left(-\frac{1}{R_\ell}(c_0^{US,L})^{-\sigma} + \beta^{US}(c_1^{US,L})^{-\sigma}\right) = 0 \tag{15}$$

$$-\frac{1}{R_b}\left(p(c_0^{US,H})^{-\sigma} + (1-p)\,(c_0^{US,L})^{-\sigma}\right) + p\beta^{US}(c_1^{US,H})^{-\sigma} + (1-p)\,\beta^{US}\left((c_1^{US,L})^{-\sigma} + \mu_L^{US}\right) = 0 \tag{16}$$

$$p\left(-\frac{1}{R_{\tilde{b}}}(c_0^{US,H})^{-\sigma} + \beta^{US}(c_1^{US,H})^{-\sigma}\right) + (1-p)\left(-\frac{1}{R_{\tilde{b}}}(c_0^{US,L})^{-\sigma} + \beta^{US}(c_1^{US,L})^{-\sigma}\right) = 0 \tag{17}$$

EM households choose how much to borrow from the U.S to maximize utility from consumptions in periods 0 and 1. The F.O.C. w.r.t. ℓ^{EM} is:

$$\frac{1}{R_\ell}(c_0^{EM})^{-\sigma} - \beta^{EM}(c_1^{EM})^{-\sigma} - \frac{1}{R_\ell}f'\left(\frac{\ell^{EM}}{R_\ell}\right)(c_0^{EM})^{-\sigma} = 0. \tag{18}$$

Given that the ROW household decisions are identical to those of the U.S. households, the market clearing conditions now become:

$$b^{US} = \eta B, \tilde{b}^{US} = (1-\eta)B, \text{ and } \ell^{US}{=}\ell^{EM}{=}\ \ell.$$

We show that U.S. households extend more loans to EMs when the total amount of U.S. Treasuries are more tilted towards more liquid short-term Treasury Bills.

Proposition 2. *Define $x = \frac{\ell}{R_\ell}$. Assuming $R_\ell + x\frac{dR_\ell}{dx} > 0$, U.S. households extend more loans to EMs when the liquidity composition of U.S. government debt shifts to more liquid short-term assets.*

That is, $\frac{dx}{d\eta} > 0$.

Proof. See the Appendix. □

Holding total U.S. government debt constant, U.S. (and RoW) households increase their lending to EMs as the liquidity composition of U.S. Treasuries moves toward more liquid assets. The saver households lend more to EM households as the lenders have more "insurance" against the possibility of having low income. They can sell their liquid Treasuries in the secondary market if facing lower income, in contrast to being locked in to illiquid assets. Therefore, lender households have a source of wealth to draw on when their incomes turn out to be low (or investment opportunities arise) since they can adjust their savings in liquid Treasuries.

5 Numerical Analysis

Our aim in this section is to perform a qualitative analysis for the general model that cannot be solved analytically: to explore the effects of increasing liquidity on interest rates, flows to emerging markets, and welfare, and to examine how the relationship between liquidity and flows to emerging markets is affected by income uncertainty. We estimate parameters for the model presented in Section 4.1 to match some key moments from 1980 to 2019, which pertain to the U.S external balance and the interest rates across assets with different liquidity profiles. Section 5.2 presents the numerical results.

5.1 Calibration

One period in the model is one year. Our tack is to translate the two-period model into an infinite-horizon model by assuming shocks occur in the first period (year), and no further shocks occur in subsequent periods so that period 2 is the steady state. We choose parameters in the model to match moments in the data: the average ratio of the U.S. current account balance to the U.S. GDP, the average U.S. saving rate, the average share of foreign investors' holdings of U.S. Treasuries, the average short-term and long-term interest rates on U.S. Treasuries, and the average interest rate on EM securities. The two period model is not well-suited for a full quantitative dynamic analysis, but our calibrated model is useful in assessing the quantitative impact effects of QE/QT

We assume that high and low after-tax income levels in period 0 ($y_0^{a,H} - T_0^a$ and $y_0^{a,L} - T_0^a$) obtained by the households of country a are $\Delta^a \times 100\%$ higher and lower, respectively, than the average period 0 after-tax income of country a, y_0^a. That is, $y_0^{a,H} - T_0^a = (y_0^a - T_0^a)(1 + \Delta^a)$, and $y_0^{a,L} - T_0^a = (y_0^a - T_0^a)(1 - \Delta^a)$, where $a = \{\text{US, RoW}\}$. We set the probability of high income to 0.5. The average incomes in period 0 for the U.S. and the RoW households then are normalized to one, i.e., $y_0^a - T_0^a = 1$. The period 1 after-tax income for households in the U.S. and the RoW is also set to one, assuming zero growth rates of incomes. EM households have a constant income across two periods, normalized to one. Assuming the same average incomes for both periods and across households, time discount factors govern how much each household wants to lend or borrow.[28] The functional form of the transaction cost of extending illiquid loans is $f(x) = \alpha\frac{x^\nu}{\nu}$, where α and ν are set to one and two, respectively. We compute the ratio of U.S. T-Bills held by public to the total marketable U.S. public debt, both of which are collected from from the U.S. Treasury Monthly Statement of the Public Debt (MSPD). η is set to 0.196, the value of this ratio in 2001 – 2022.

The rest of the parameter values are estimated by the simulated methods of moments. We target six moments. The first two moments are the average short-term and long-term interest rates of U.S. Treasuries, computed with monthly observations of 3-month and 10-year Treasury annual yields, respectively, in 1980-2018. The third moment is the average interest rate on EM securities, measured by the average of monthly ICE BofA emerging markets corporate plus index effective yields from December 1998 – 2019. The interest rate data are all from the FRED database. The fourth and the fifth moments are the average quarterly U.S. current account balance as a ratio of the U.S. quarterly GDP and the average monthly U.S. household saving rate from 1980 to 2018; both series are collected from the FRED database. Lastly, we compute the average share of foreign holdings of U.S. Treasuries in the total marketable U.S. Treasuries from December 2011 - 2019. The data are fetched from the the U.S. MSPD. In sum, the six targeted moments are: (i) the mean interest rate on the U.S. short-term Treasuries (3.98%), (ii) the mean interest rate on the U.S. long-term Treasuries (6.03%), (iii) the mean interest rate on EM securities (9.89%), (iv) U.S. Current Account/GDP (-3%), (v) U.S. household saving rate (7.3%), and (vi) share of foreign holdings of the U.S. Treasuries (46%). We estimate time discount factors for three countries, the total supply of U.S. Treasuries B, and income fluctuations of lender households, $\Delta(= \Delta^{US} = \Delta^{RoW})$, and the constant relative risk aversion parameter γ to match moments (i) – (vi).

Although six parameters are jointly determined to match six moments, we can still offer a heuristic description of how each parameter is mostly inferred from an empirical moment. The time discount factor of EM households governs how much they want to front-load their consumption and hence the amount of borrowing and its interest rate, i.e., the interest rate on EM securities. The relative size of the discount factors of the U.S. and the RoW households to that of the EM households helps us to match the U.S. current account. The relative size of the time discount factor of the RoW and to the US captures how much they want to save for the next period, disciplining share of foreign holdings of U.S. Treasuries. The total supply of Treasuries governs both the short-term and long-term interest rates of Treasuries while the size of income fluctuations affects saver

[28] We could assume positive growth rates of incomes for all countries with a higher growth rate for EM. In the two period model, the difference in the size of the annual growth rates of GDP is not enough to generate the quantitatively sizable motive to borrow and lend from each other. Therefore, we assume zero growth rates of incomes over one period for all countries but calibrate time discount factors to match the key moments. The alternative specification, imposing the same discount factor for EM households as that of EU households while assuming a positive growth rate of endowments for EM households, produces qualitatively the same results, and the results are available upon request.

Table 2: Parameter Values

Parameters	Values	Descriptions
Normalized/Arbitrarily Chosen		
$y_t^a - T_t^a$	1	Average Incomes in Periods 0 and 1
p	0.5	Probability of high-income households
ν	2	Transaction Costs of Illiquid Loans: $f(x) = \alpha \frac{x^\nu}{\nu}$
α	1	Transaction Costs of Illiquid Loans: $f(x) = \alpha \frac{x^\nu}{\nu}$
η	0.196	Share of US T-Bills in Marketable Treasuries
Estimated Parameters from Moment Matching		
β^{US}	1.0000	Time discount factor of US
β^{RoW}	0.9957	Time discount factor of RoW
B	0.1107	Supply of US Treasury bonds
β^{EM}	0.8435	Time discount factor of EM
Δ^{US}=$\Delta^{RoW} = \Delta$	0.0858	Income fluctuation of lenders
σ	0.4289	Relative risk aversion

Notes: The upper panel summarizes the parameters normalized or arbitrarily chosen. The lower panel summarizes the calibrated parameters by the simulated methods of moments.

households' desire to hold more liquid U.S. Treasuries, pinning down the difference in the short-term and long-term interest rates on U.S. Treasuries. The relative risk aversion of households regulates the saving rate.

We summarize the parameter values in Table 2, and the targeted moments in Table 3.

5.2 Numerical Results

With these parameters, we numerically solve the model summarized in Section 4.1. Especially, we are interested in how the equilibrium interest rates, loans to EMs and the welfare of households in each country vary with the share of liquid bonds in the U.S. Treasuries. Figures 12 - 15 depict the equilibrium outcomes against η, where an η fraction of total amount of U.S. Treasuries is liquid.

In Figure 12, as η increases, the supply of U.S. liquid Treasuries goes up, while that of U.S. illiquid Treasuries goes down. The increase in the liquidity composition of U.S. Treasuries increases the interest rate on liquid U.S. government bonds, while lowering that on illiquid U.S. government bonds. As the volume of liquidity increases, the liquidity "return" declines, narrowing the gap between the yield on liquid bonds and other bonds, consistent with what we have seen in Section 3.2, where the CIP deviations of U.S. short-term Treasuries fall after QE announcements.

Since liquid bonds offer flexibility if the investor has lower income (or greater investment opportunities), U.S. and ROW households are willing to save more and lend more to EMs, shown in Figure 13. Figure 12 shows the interest rate on these loans falls as their demand increases.

Consequently, EM households benefit more as the liquidity composition of U.S. Treasuries shifts to more liquid assets, and therefore, their welfare increases with higher η, shown in Figure

Table 3: Targeted Moments

	Sample Period	Data Moments	Model Moments
Interest rate on US short-term Treasuries	1981 – 2019	3.98%	3.86%
Interest rate on US long-term Treasuries	1980 – 2019	6.03%	7.15%
Interest rate on EM bonds	1998m12 –- 2019	9.89%	9.40%
US Current Account/GDP	1980 – 2019	– 3%	– 3%
US household saving rate	1980 – 2019	7.3%	7.5%
Share of foreign holdings of US Treasuries	2011m12 – 2019	46%	47%

Notes: We compute the historical average of variables of our interest from 1980 to 2019 if the data are available. The average short-term and long-term interest rates on U.S. Treasury are computed with 3-month and 10-year Treasury annual yields, respectively. The average of ICE BofA Emerging markets corporate plus index effective yields is used to compute the average interest rate on EM bonds. The share of foreign holdings of U.S. Treasuries is computed as foreign holdings of U.S. Treasuries over the total U.S. marketable Treasuries, where both data are from the U.S. Treasury Monthly Statement of the Public Debt (MSPD). All other data are from the St. Louis Fed's FRED database. The averages of monthly observations are reported for all variables except U.S. current account/GDP. For the average U.S. current account/GDP, we compute the mean of quarterly observations.

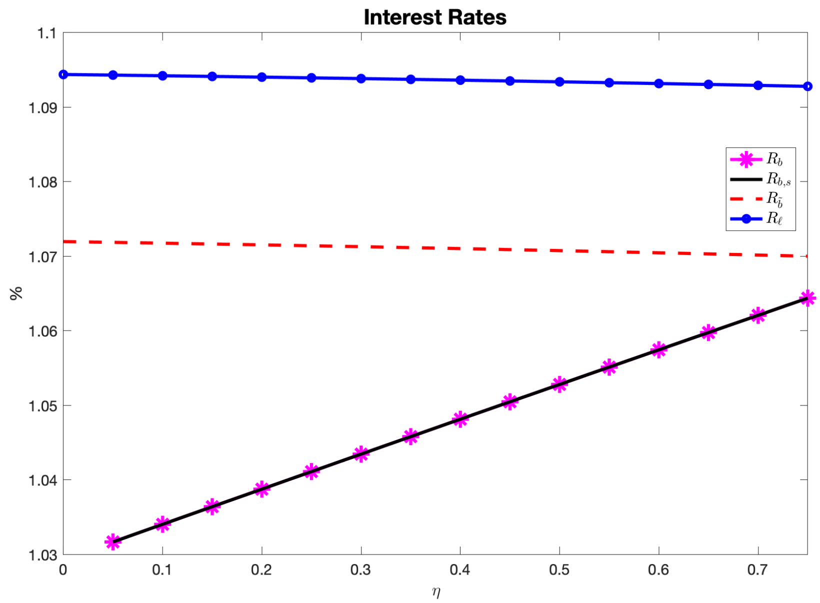
14.

Figure 14 also shows the ex-ante welfare in the U.S. and ROW as η increases. U.S. and ROW households experience a slight fall in their average welfare at a low value of η. They also experience a much more subdued overall increase in their welfare compared to EM households even when η reaches a large value. This welfare result comes from the offsetting effects of an increase in the liquidity share on low income and high income households. Figure 15 shows that as the share of liquid of U.S. Treasuries increases, low income households in the U.S. and ROW benefit from higher liquidity in the market, insuring them from over-saving; however, high income households become worse off. High income households now face lower returns from their savings directly because the composition of Treasuries shifts to more liquid and hence lower interest bearing assets, but also because the interest rates on both less-liquid Treasuries and loans to EMs fall slightly with a higher supply of liquid assets. These changes lead to a reduction in their average welfare initially. Nonetheless, when the share of liquid bonds is high enough, the interest gap between liquid Treasuries and less-liquid Treasuries narrows. And, the positive effect from higher amount of loans to EMs, which yields the highest interests to households, outweighs the former negative effects on the welfare of high income households.

We then explore how the total amount of loans extended to EM changes with the liquidity composition of the U.S. Treasuries, while varying one parameter at a time from its baseline value. Specifically, we experiment with different parameter values of α,p, and Δ, 25% lower or higher than the baseline values in Figures 16, 17, and 18, respectively. In all these figures, we see a positive relationship between the amount of loans extended to EM and the share of liquid bonds in the U.S. Treasuries for the range of parameter values that we have explored. The numerical result is consistent with what we have shown analytically in Proposition 2.

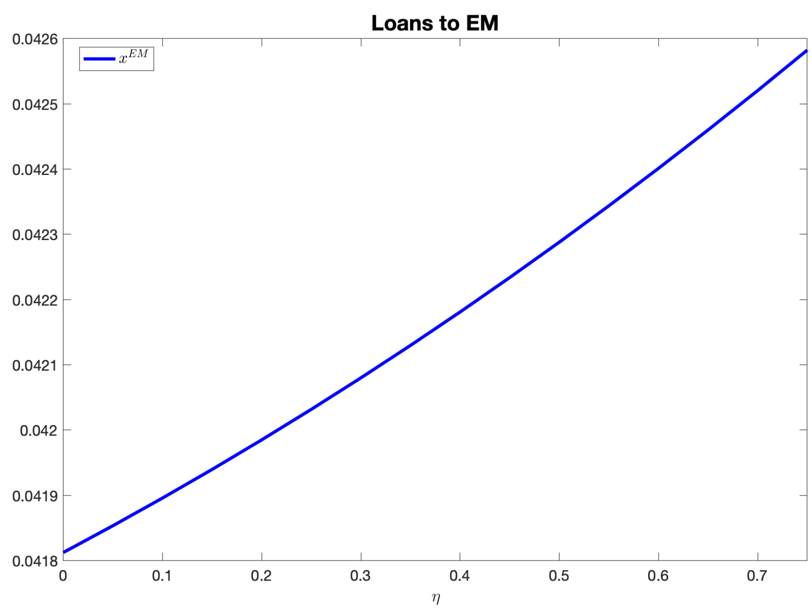
In Figure 16, the amount of illiquid loans to EMs is higher for every η when α is lower. With

Figure 12: Interest Rates Against the Liquidity Composition of Treasuries



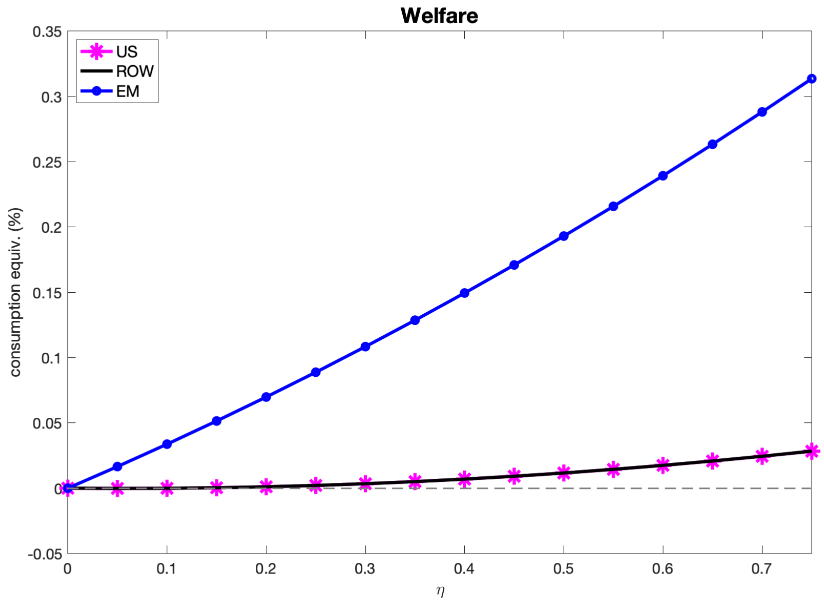
Notes: R_b, $R_{b,s}$, $R_{\tilde{b}}$, and R_ℓ represent the interest rate on liquid U.S. government bonds (pink starred line), their secondary market rate (black solid line), the interest rate on illiquid U.S. government bonds (red dashed line) and the interest rate on EM loans (blue dotted line). η is the share of liquid bonds in the U.S. government bonds.

Figure 13: Loans to EMs Against the Liquidity Composition of Treasuries



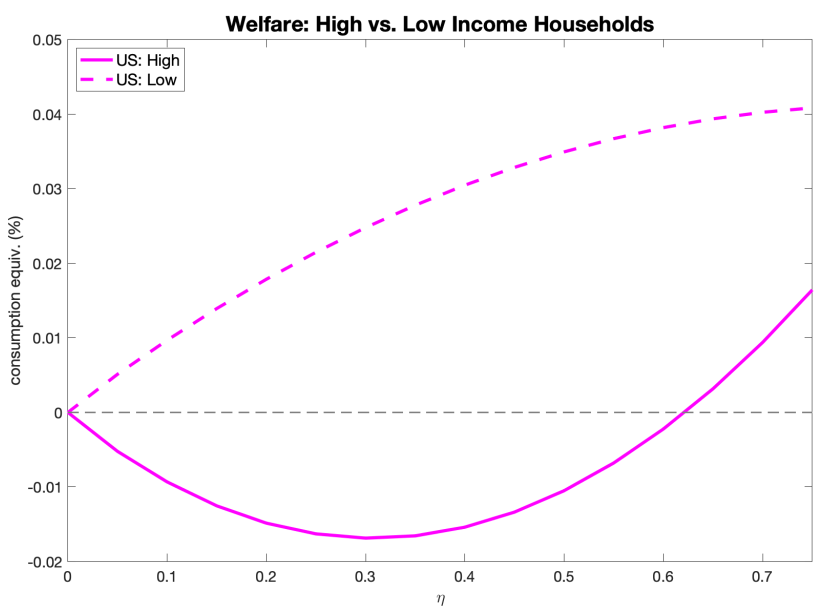
Notes: x^{EM} is the total amount of loans to EM households: $\frac{\ell^{EM}}{R_\ell}$. η is the share of liquid bonds in the U.S. government bonds.

Figure 14: Welfare Across Countries Against the Liquidity Composition of Treasuries



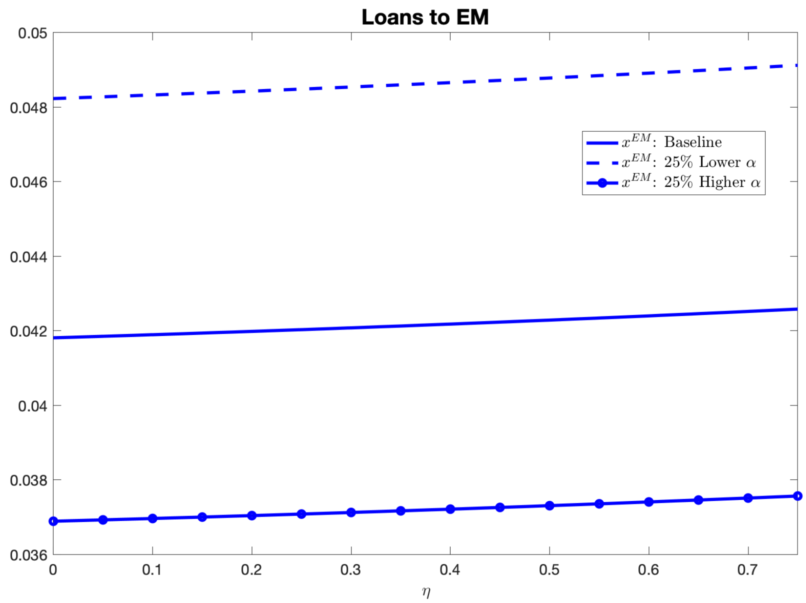
Notes: Welfare gain/loss is computed as a consumption equivalent (%). η is the share of liquid bonds in the U.S. government bonds. The welfare of the U.S. and the ROW households does not include the utility from the government spending.

Figure 15: Welfare of High vs. Low Income Households in the U.S. Against the Liquidity Composition of Treasuries



Notes: Welfare gain/loss is computed as a consumption equivalent (%). η is the share of liquid bonds in the U.S. government bonds. The welfare of the U.S. households does not include the utility from the government spending. The solid line is the U.S. high income households' welfare against η, and the dashed line is the U.S. low income households' welfare against η.

Figure 16: Loans to EMs Against the Liquidity Composition of Treasuries for Different α

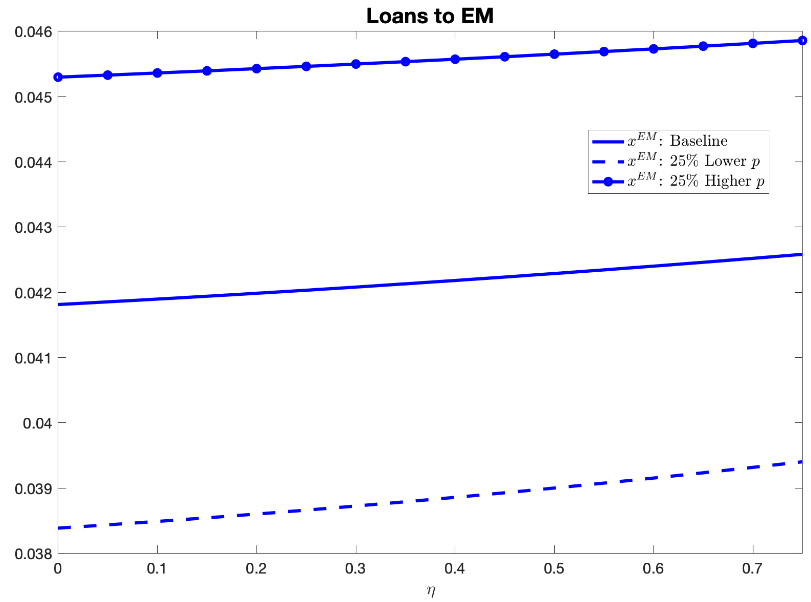


Notes: x^{EM} is the total amount of loans extended to EM households: $\frac{\ell^{EM}}{R_\ell}$. η is the share of liquid bonds in the U.S. government bonds. α governs the size of the transaction costs that households need to pay per one unit of loan lent/borrowed. The total amount of loans extended to EM households is plotted against η (i) with our baseline parameter values in a solid line, (ii) with 25% lower α in a dashed line, and (iii) with 25% higher α in a dotted line.

lower transaction costs that households need to pay when lending/borrowing via illiquid loans, they lend and borrow more from each other. A larger amount of illiquid loans for every η is observed when p is higher, shown in Figure 17, which is a consequence of having a higher average income in period 0 for the U.S. and the ROW households as the probability of having a high income is higher. As lender households have more average endowments in period 0, they lend more to the emerging markets.

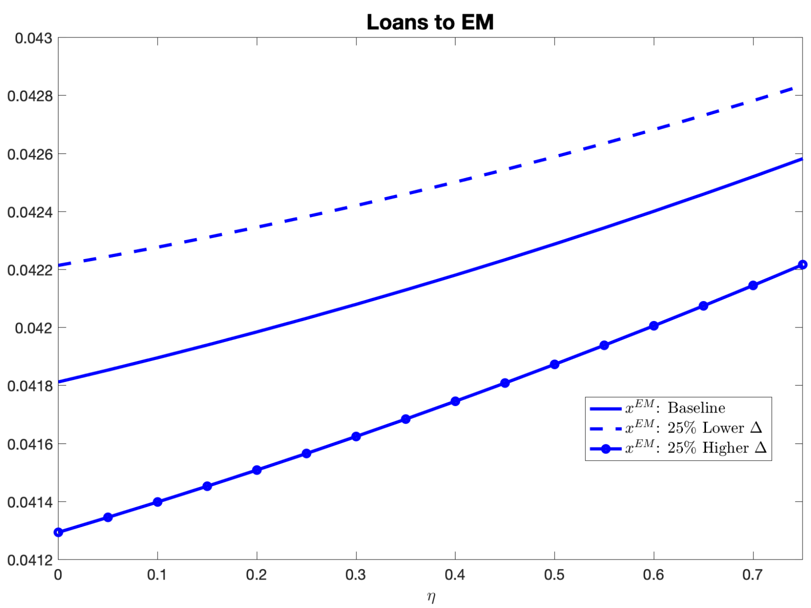
Lastly and most interestingly, in Figure 18, EM households borrow more when Δ is lower for a given level of η; however, an increase in loans extended to EMs, as η increases, is *larger* when the period 0's income dispersion for lender households, Δ, is *higher*. For a given level of liquid Treasuries supplied, lender households are more willing to lend to EMs as lender households know that their incomes in period 0 would be close to the average income, so they do not have to worry about having too much saving when their income levels turn out to be low. On the other hand, a higher supply of liquid Treasuries – higher η – benefits the lender households the most when they obtain their income significantly lower than the average income. Therefore, lender households with higher Δ increase their lending to EMs *by more* when the supply of liquid Treasuries increases.

Figure 17: Loans to EMs Against the Liquidity Composition of Treasuries for Different p



Notes: x^{EM} is the total amount of loans extended to EM households: $\frac{\ell^{EM}}{R_\ell}$. η is the share of liquid bonds in the U.S. government bonds. p is the probability of having a high income in period 0 for the U.S. and the RoW households. The total amount of loans extended to EM households is plotted against η (i) with our baseline parameter values in a solid line, (ii) with 25% lower p in a dashed line, and (iii) with 25% higher p in a dotted line.

Figure 18: Loans to EMs Against the Liquidity Composition of Treasuries for Different Δ



Notes: x^{EM} is the total amount of loans extended to EM households: $\frac{\ell^{EM}}{R_\ell}$. η is the share of liquid bonds in the U.S. government bonds. Δ governs the size of income fluctuations in period 0 for the U.S. and the RoW households. The total amount of loans extended to EM households is plotted against η (i) with our baseline parameter values in a solid line, (ii) with 25% lower Δ in a dashed line, and (iii) with 25% higher Δ in a dotted line.

6 Conclusion

We have seen in the empirical analysis that, holding interest rates constant, a change quantitative easing or tightening in the U.S. appears to influence capital flows to emerging markets. Specifically, the amount of flows increases as the Fed injects liquidity. These flows, then, are not responding to changes in interest rates *per se*, but rather to the composition of assets offered by the U.S. government/Federal Reserve to the public. Quantitative easing replaces longer term Treasury bonds with reserves in the hands of the public. Following Rogoff (2017), we interpret this as a change in the structure of U.S. government liabilities available to the private sector. Reserves held by the banking sector at the Fed are, in essence, very short-term liquid assets. Hence, we examine the effects of quantitative easing or tightening through the lens of the liquidity of government liabilities offered to the public.

We then offer a possible explanation for why changing the composition of these liabilities leads to greater lending to emerging markets. As liquidity increases, investors have more assurance that their funds will not be tied up in illiquid assets in case of an economic downturn (or, in case attractive investment opportunities arise.) In fact, our numerical solutions find that this channel is even stronger during times of greater economic uncertainty. Investors have less fear of being "caught short" when they have the ability to sell liquid assets quickly, and therefore are willing to save and invest more, including in illiquid loans to emerging markets.

Our model of how quantitative easing or tightening influences the supply of liquid assets held by the public, which in turn affects their saving/investment choices, is consistent with how announcements of QE/QT affect the Treasury basis. As the liquid liabilities of the Federal Reserve increase under QE, the convenience yield for liquid U.S. government liabilities falls, and vice-versa for QT.

Emerging market policymakers, in turn, have an interest not only in the restrictiveness of U.S. monetary policy, but also the policy toward liquidity provision. This perspective introduces another dimension to the observation of Rey (2016) concerning the supremacy of U.S. monetary policy decisions in the international transmission mechanism.

References

Sushant Acharya and Keshav Dogra. The side effects of safe asset creation. *Journal of the European Economic Association*, 20(2):581–625, 2022.

Viral V Acharya and Toomas Laarits. When do treasuries earn the convenience yield?: A hedging perspective. 2023. National Bureau of Economic Research, working paper no. 31863.

Viral V Acharya and Raghuram Rajan. Liquidity, liquidity everywhere, not a drop to use–why flooding banks with central bank reserves may not expand liquidity. 2022. National Bureau of Economic Research, working paper no. 29680.

Viral V Acharya, Rahul S Chauhan, Raghuram Rajan, and Sascha Steffen. Liquidity dependence and the waxing and waning of central bank balance sheets. 2023. National Bureau of Economic Research, working paper no. 31050.

Gara Afonso, Marco Cipriani, and Gabriele La Spada. Banks' balance-sheet costs, monetary policy, and the on rrp. 2022. FRB of New York Staff Report, no. 1041.

Shaghil Ahmed and Andrei Zlate. Capital flows to emerging market economies: A brave new world? *Journal of International Money and Finance*, 48:221–248, 2014.

Joshua Aizenman, Menzie D Chinn, and Hiro Ito. Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions. *Journal of International Money and Finance*, 68:298–330, 2016.

Elias Albagli, Luis Ceballos, Sebastian Claro, and Damian Romero. Channels of US monetary policy spillovers to international bond markets. *Journal of Financial Economics*, 134(2):447–473, 2019.

Pablo Anaya, Michael Hachula, and Christian J Offermanns. Spillovers of US unconventional monetary policy to emerging markets: The role of capital flows. *Journal of International Money and Finance*, 73:275–295, 2017.

David Andolfatto and Fernando M Martin. Monetary policy and liquid government debt. *Journal of Economic Dynamics and Control*, 89:183–199, 2018.

Stefan Avdjiev, Leonardo Gambacorta, Linda S Goldberg, and Stefano Schiaffi. The shifting drivers of global liquidity. *Journal of International Economics*, 125:103324, 2020.

Marina Azzimonti and Pierre Yared. The optimal public and private provision of safe assets. *Journal of Monetary Economics*, 102:126–144, 2019.

Jordan Barone, Alain Chaboud, Adam M Copeland, Cullen Kavoussi, Frank M Keane, and Seth Searls. The global dash for cash: Why sovereign bond market functioning varied across jurisdictions in March 2020. 2022. FRB of New York Staff Report, no. 1010.

Marco Bassetto and Wei Cui. The fiscal theory of the price level in a world of low interest rates. *Journal of Economic Dynamics and Control*, 89:5–22, 2018.

Christian Bayer, Benjamin Born, and Ralph Luetticke. The liquidity channel of fiscal policy. *Journal of Monetary Economics*, 134:86–117, 2023.

Aleksander Berentsen and Christopher Waller. Liquidity premiums on government debt and the fiscal theory of the price level. *Journal of Economic Dynamics and Control*, 89:173–182, 2018.

Saroj Bhattarai, Arpita Chatterjee, and Woong Yong Park. Effects of US quantitative easing on emerging market economies. *Journal of Economic Dynamics and Control*, 122:104031, 2021.

Saki Bigio, Galo Nuño, and Juan Passadore. A framework for debt-maturity management. 2019.

Falk Bräuning and Victoria Ivashina. US monetary policy and emerging market credit cycles. *Journal of Monetary Economics*, 112:57–76, 2020.

Valentina Bruno and Hyun Song Shin. Capital flows and the risk-taking channel of monetary policy. *Journal of Monetary Economics*, 71:119–132, 2015.

Michele Ca'Zorzi, Luca Dedola, Georgios Georgiadis, Marek Jarocinski, Livio Stracca, and Georg Strasser. Monetary policy and its transmission in a globalised world. 2020.

Eugenio M Cerutti, Maurice Obstfeld, and Haonan Zhou. Covered interest parity deviations: Macrofinancial determinants. *Journal of International Economics*, 130:103447, 2021.

Ambrogio Cesa-Bianchi and Fernando Eguren Martin. Dash for dollars. 2021. CEPR Discussion Paper no. DP16415.

Indraneel Chakraborty, Itay Goldstein, and Andrew MacKinlay. Monetary stimulus and bank lending. *Journal of Financial Economics*, 136(1):189–218, 2020.

Anusha Chari, Karlye Dilts Stedman, and Christian Lundblad. Taper tantrums: Quantitative easing, its aftermath, and emerging market capital flows. *Review of Financial Studies*, 34(3):1445–1508, 2021.

Gabriele Ciminelli, John Rogers, and Wenbin Wu. The effects of US monetary policy on international mutual fund investment. *Journal of International Money and Finance*, 127:102676, 2022.

Adam Copeland, Darrell Duffie, and Yilin Yang. Reserves were not so ample after all. 2021. National Bureau of Economic Research, working paper no. 29090.

Giancarlo Corsetti, Simon Lloyd, Emile Marin, and Daniel Ostry. US risk and treasury convenience. 2023.

Pierre De Leo, Gita Gopinath, and Sebnem Kalemli-Ozcan. Monetary policy and the short-rate disconnect in emerging economies. 2024.

Riccardo Degasperi, Seokki Hong, and Giovanni Ricco. The global transmission of US monetary policy. 2020.

William Diamond and Peter Van Tassel. Risk-free rates and convenience yields around the world. 2021.

William F Diamond, Zhengyang Jiang, and Yiming Ma. The reserve supply channel of unconventional monetary policy. 2023. National Bureau of Economic Research, working paper no. 31693.

Wenxin Du and Jesse Schreger. Local currency sovereign risk. *Journal of Finance*, 71(3):1027–1070, 2016.

Wenxin Du and Jesse Schreger. Cip deviations, the dollar, and frictions in international capital markets. In *Handbook of International Economics*, volume 6, pages 147–197. Elsevier, 2022.

Wenxin Du, Joanne Im, and Jesse Schreger. The US treasury premium. *Journal of International Economics*, 112:167–181, 2018.

Wenxin Du, Benjamin Hébert, and Amy Wang Huber. Are intermediary constraints priced? *Review of Financial Studies*, 36(4):1464–1507, 2023.

Wenxin Du, Kristin Forbes, and Matthew N Luzzetti. Quantitative tightening around the globe: What have we learned? 2024. National Bureau of Economic Research, working paper no. 32321.

Marco Lo Duca, Giulio Nicoletti, and Ariadna Vidal Martinez. Global corporate bond issuance: what role for US quantitative easing? *Journal of International Money and Finance*, 60:114–150, 2016.

Darrell Duffie. Resilience redux in the US treasury market. In *Jackson Hole Symposium, Federal Reserve Bank of Kansas City*, 2023.

Charles Engel and Steve Pak Yeung Wu. Liquidity and exchange rates: An empirical investigation. *Review of Economic Studies*, 90(5):2395–2438, 2023.

Marcel Fratzscher, Marco Lo Duca, and Roland Straub. On the international spillovers of US quantitative easing. *Economic Journal*, 128(608):330–377, 2018.

Georgios Georgiadis. Determinants of global spillovers from US monetary policy. *Journal of International Money and Finance*, 67:41–61, 2016.

Georgios Georgiadis and Marek Jarocinski. Global spillovers from multi-dimensional US monetary policy. 2023.

Gary Gorton and Guillermo Ordonez. The supply and demand for safe assets. *Journal of Monetary Economics*, 125:132–147, 2022.

Gary Gorton, Toomas Laarits, and Tyler Muir. Mobile collateral versus immobile collateral. *Journal of Money, Credit and Banking*, 54(6):1673–1703, 2022.

Robin Greenwood, Samuel G Hanson, and Jeremy C Stein. A comparative-advantage approach to government debt maturity. *Journal of Finance*, 70(4):1683–1722, 2015.

Frank Hahn. Chapter 2 liquidity. volume 1 of *Handbook of Monetary Economics*, pages 63–80. Elsevier, 1990.

Zhiguo He, Arvind Krishnamurthy, and Konstantin Milbradt. A model of safe asset determination. *American Economic Review*, 109(4):1230–1262, 2019.

Jasper Hoek, Steve Kamin, and Emre Yoldas. Are higher US interest rates always bad news for emerging markets? *Journal of International Economics*, 137:103585, 2022.

Matteo Iacoviello and Gaston Navarro. Foreign effects of higher US interest rates. *Journal of International Money and Finance*, 95:232–250, 2019.

Zhengyang Jiang, Arvind Krishnamurthy, and Hanno Lustig. Foreign safe asset demand and the dollar exchange rate. *Journal of Finance*, 76(3):1049–1089, 2021.

Robert A Jones and Joseph M Ostroy. Flexibility and uncertainty. *Review of Economic Studies*, 51 (1):13–32, 1984.

Òscar Jordà. Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1):161–182, 2005.

Chotibhak Jotikasthira, Christian Lundblad, and Tarun Ramadorai. Asset fire sales and purchases and the international transmission of funding shocks. *Journal of Finance*, 67(6):2015–2050, 2012.

Sebnem Kalemli-Ozcan. US monetary policy and international risk spillovers. 2019. National Bureau of Economic Research, working paper no. 26297.

Sebnem Kalemli-Ozcan and Liliana Varela. Five facts about the uip premium. 2021. National Bureau of Economic Research, working paper no. 28923.

John Kandrac and Bernd Schlusche. Quantitative easing and bank risk taking: evidence from lending. *Journal of Money, Credit and Banking*, 53(4):635–676, 2021.

John Kandrac, Sotirios Kokas, and Alexandros Kontonikas. Unconventional monetary policy and the search for yield. 2021.

Rohan Kekre and Moritz Lenel. The flight to safety and international risk sharing. *American Economic Review*, 114(6):1650–1691, 2024.

Duhyeong Kim. International effects of quantitative easing and foreign exchange intervention. *Journal of International Economics*, 145:103815, 2023.

Marcin Kolasa and Grzegorz Wesołowski. International spillovers of quantitative easing. *Journal of International Economics*, 126:103330, 2020.

Arvind Krishnamurthy and Annette Vissing-Jorgensen. The effects of quantitative easing on interest rates: channels and implications for policy. 2011. National Bureau of Economic Research, working paper no. 17555.

Arvind Krishnamurthy and Annette Vissing-Jorgensen. The aggregate demand for treasury debt. *Journal of Political Economy*, 120(2):233–267, 2012.

Arvind Krishnamurthy, Stefan Nagel, and Annette Vissing-Jorgensen. Ecb policies involving government bond purchases: Impact and channels. *Review of Finance*, 22(1):1–44, 2018.

Wenhao Li, Yiming Ma, and Yang Zhao. The passthrough of treasury supply to bank deposit funding. 2019.

Jamus Jerome Lim, Sanket Mohapatra, and Marc Stocker. Tinker, taper, qe, bye? the effect of quantitative easing on financial flows to developing countries. 2014. World Bank Policy Research Working Paper, no. 6820.

Stephen Miran and Nouriel Roubini. Ati: Activist treasury issuance and the tug-of-war over monetary policy. 2024. Hudson Bay Capital.

Silvia Miranda-Agrippino and Hélene Rey. US monetary policy and the global financial cycle. *Review of Economic Studies*, 87(6):2754–2776, 2020.

Stefan Nagel. The liquidity premium of near-money assets. *Quarterly Journal of Economics*, 131 (4):1927–1971, 2016.

Maurice Obstfeld and Haonan Zhou. The global dollar cycle. *Brookings Papers on Economic Activity*, 2022(2):361–447, 2022.

Maurice Obstfeld, Jonathan D Ostry, and Mahvash S Qureshi. A tie that binds: Revisiting the trilemma in emerging market economies. *Review of Economics and Statistics*, 101(2):279–293, 2019.

Evgenia Passari and Hélène Rey. Financial flows and the international monetary system. *Economic Journal*, 125(584):675–698, 2015.

Hélène Rey. International channels of transmission of monetary policy and the mundellian trilemma. *IMF Economic Review*, 64(1):6–35, 2016.

Alexander Rodnyansky and Olivier M Darmouni. The effects of quantitative easing on bank lending behavior. *Review of Financial Studies*, 30(11):3858–3887, 2017.

Kenneth Rogoff. *The curse of cash: How large-denomination bills aid crime and tax evasion and constrain monetary policy*. Princeton University Press, 2017.

Alexandra M Tabova and Francis E Warnock. Foreign investors and US treasuries. 2021. National Bureau of Economic Research, working paper no. 29313.

Peter Tillmann. Unconventional monetary policy and the spillovers to emerging markets. *Journal of International Money and Finance*, 66:136–156, 2016.

Annette Vissing-Jorgensen. The treasury market in spring 2020 and the response of the federal reserve. *Journal of Monetary Economics*, 124:19–47, 2021.

Appendix

Proof of Proposition 2

Proof. We multiply Equation 13 by p and Equation 14 by $1-p$, and compare to Equation 16 and we get $R_{b,s} = R_b$ From Equation 15 and Equation 17, we get $R_\ell = R_{\tilde{b}}$ because illiquid bonds and loans to EM are equivalent for lenders, given the simplifying assumption that U.S. does not bear the cost of lending to EM households. With these equilibrium conditions and $u'(c) = c^{-\sigma}$, we can write Equations 13–18 as

Then, the first-order conditions give us:

$$\beta^{US} R_b \left(c_1^{US,H}\right)^{-\sigma} = \left(c_0^{US,H}\right)^{-\sigma} \tag{19}$$

$$\beta^{US} R_b \left(c_1^{US,L}\right)^{-\sigma} + \beta^{US} R_b \mu_L = \left(c_0^{US,L}\right)^{-\sigma} \tag{20}$$

$$\beta^{US} p \left(\left(\frac{R_\ell - R_b}{R_\ell}\right)\left(c_1^{US,H}\right)^{-\sigma}\right) + \beta^{US}(1-p)\left(\left(\frac{R_\ell - R_b}{R_\ell}\right)\left(c_1^{US,L}\right)^{-\sigma} - \frac{R_b}{R_\ell}\mu_L\right) = 0 \tag{21}$$

$$\beta^{EM} R_\ell (c_1^{EM})^{-\sigma} + f'\left(\frac{\ell^{EM}}{R_\ell}\right)(c_0^{EM})^{-\sigma} = (c_0^{EM})^{-\sigma} \tag{22}$$

Combining Equations 20 and 21 , and we have,

$$\beta^{US} p \left(\left(\frac{R_\ell - R_b}{R_\ell}\right)\left(c_1^{US,H}\right)^{-\sigma}\right) + (1-p)\left(\beta^{US}\left(c_1^{US,L}\right)^{-\sigma} - \frac{1}{R_\ell}\left(c_0^{US,L}\right)^{-\sigma}\right) = 0 \tag{23}$$

Since we are interested in $\frac{dx}{d\eta}$, where $x^{US} = \frac{\ell^{US}}{R_\ell}$, $x^{EM} = \frac{\ell^{EM}}{R_\ell}$, $x^{US} = x^{EM} = x$, we replace ℓ^{US} with $R_\ell x$ and substitute back in the expressions for consumption, we get:

$$\left(y_0^{US,H} - \frac{1}{p}\frac{\eta B}{R_b} - x - \left(\frac{(1-\eta)B}{R_\ell}\right)\right)^{-\sigma} = \beta^{US} R_b \left(y_1^{US} + R_\ell x + B + \frac{1-p}{p}\eta B\right)^{-\sigma} \tag{24}$$

$$\begin{aligned} &\beta^{US} p (R_\ell - R_b)\left(y_1^{US} + R_\ell x + B + \frac{1-p}{p}\eta B\right)^{-\sigma} + \beta^{US}(1-p) R_\ell \left(y_1^{US} + R_\ell x + (1-\eta) B\right)^{-\sigma} \\ &= (1-p)\left(y_0^{US,L} - x - \left(\frac{1-\eta}{R_\ell}\right)\right)^{-\sigma} \end{aligned} \tag{25}$$

$$(y_0^{EM} + x - f(x))^{-\sigma}(1 - f'(x)) = \beta^{EM} R_\ell (y_1^{EM} - R_\ell x)^{-\sigma} \tag{26}$$

Equation 24 becomes:

$$\left(y_0^{US,H} - \frac{1}{p}\frac{\eta B}{R_b} - x - \left(\frac{(1-\eta)B}{R_\ell}\right)\right) = (\beta^{US} R_b)^{-\frac{1}{\sigma}}\left(y_1^{US} + R_\ell x + B + \frac{1-p}{p}\eta B\right) \tag{27}$$

Now, totally differentiate Equation 25:

$$\begin{aligned}
&\beta^{US} p\left(c_1^{US,H}\right)^{-\sigma}(dR_\ell - dR_b) - \beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}(R_\ell - R_b)\left(xdR_\ell + R_\ell dx + \frac{1-p}{p}Bd\eta\right)\\
&+ \beta^{US}(1-p)\left(c_1^{US,L}\right)^{-\sigma} dR_\ell - \beta^{US}\sigma(1-p)\left(c_1^{US,L}\right)^{-\sigma-1} R_\ell\left(xdR_\ell + R_\ell dx - Bd\eta\right)\\
&= -\sigma(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\left(-dx + \frac{B}{R_\ell}d\eta + \frac{(1-\eta)B}{(R_\ell)^2}dR_\ell\right)
\end{aligned} \tag{28}$$

Then, from Equation 26,

$$-\sigma\left(c_0^{EM}\right)^{-\sigma-1}(1-f'(x))^2 dx - \left(c_0^{EM}\right)^{-\sigma} f''(x)dx = \beta^{EM}\left(c_1^{EM}\right)^{-\sigma} dR_\ell + \beta^{EM}\sigma\left(c_1^{EM}\right)^{-\sigma-1} R_\ell\left(xdR_\ell + R_\ell dx\right)$$

Solving for dR_ℓ, we find:

$$\begin{aligned}
dR_\ell &= \frac{-\left(c_0^{EM}\right)^{-\sigma} f'' - \beta^{\text{EM}}\sigma(R_\ell)^2\left(c_1^{EM}\right)^{-\sigma-1} - \sigma\left(c_0^{EM}\right)^{-\sigma-1}(1-f'(x))^2}{\beta^{EM}\left(c_1^{EM}\right)^{-\sigma}\left(1 + \sigma R_\ell x\left(c_1^{EM}\right)^{-1}\right)} dx\\
&\equiv \mathcal{A}dx, \text{where } \mathcal{A} < 0.
\end{aligned}$$

Then, totally differentiating Equation 27:

$$\begin{aligned}
&-\frac{B}{pR_b}d\eta + \frac{\eta B}{p(R_b)^2}dR_b - dx + \frac{B}{R_\ell}d\eta + \frac{(1-\eta)B}{(R_\ell)^2}dR_\ell\\
&= -\frac{1}{\sigma}\beta^{\mathbf{US}\,\frac{-1}{\sigma}}(R_b)^{\frac{-1-\sigma}{\sigma}}\left(c_1^H\right)dR_b + \left(\beta^{US}R_b\right)^{-\frac{1}{\sigma}}\left(R_\ell dx + xdR_\ell + \frac{1-p}{p}Bd\eta\right)
\end{aligned}$$

This can be simplified by noting that $\left(\beta^{US}R_b\right)^{-\frac{1}{\sigma}} = \frac{c_0^{US,H}}{c_1^{US,H}}$. We get:

$$\begin{aligned}
&-\frac{B}{p}d\eta + \frac{\eta B}{pR_b}dR_b - R_b dx + \frac{BR_b}{R_\ell}d\eta + \frac{(1-\eta)BR_b}{(R_\ell)^2}dR_\ell\\
&= -\frac{1}{\sigma}c_0^{US,H}dR_b + \frac{c_0^{US,H}}{c_1^{US,H}}R_b\left(R_\ell dx + xdR_\ell + \frac{1-p}{p}Bd\eta\right)
\end{aligned} \tag{29}$$

Now plug in for dR_ℓ in Equations 28 and 29 and rearrange the terms,

$$\begin{aligned}
&\left[-\frac{1}{p} + \frac{R_b}{R_\ell} - \frac{c_0^{US,H}}{c_1^{US,H}}R_b\frac{1-p}{p}\right]Bd\eta + \left[-R_b + \frac{(1-\eta)BR_b}{(R_\ell)^2}\mathcal{A} - \frac{c_0^{US,H}}{c_1^{US,H}}R_b\left(R_\ell + x\mathcal{A}\right)\right]dx\\
&= -\left[\frac{1}{\sigma}c_0^{US,H} + \frac{\eta B}{pR_b}\right]dR_b
\end{aligned} \tag{30}$$

$$\left[\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\mathcal{A}-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}(R_\ell-R_b)(x\mathcal{A}+R_\ell)+\beta^{US}(1-p)\left(c_1^{US,L}\right)^{-\sigma}\mathcal{A}\right.$$
$$\left.-\beta^{US}\sigma(1-p)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell(x\mathcal{A}+R_\ell)-\sigma(1-p)\left(c_0^{L}\right)^{-\sigma-1}\left(1-\frac{(1-\eta)B}{(R_\ell)^2}\mathcal{A}\right)\right]dx$$
$$+\left[\beta^{US}\sigma(1-p)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell B-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}(R_\ell-R_b)\left(\frac{1-p}{p}\right)B+\sigma(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{B}{R_\ell}\right]d\eta$$
$$=\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}dR_b \tag{31}$$

And, we can define Equations 30 and 31 as $A_1d\eta+A_2dx=A_3dR_b$ and $B_1dx+B_2d\eta=B_3dR_b$,where

$$A_1d\eta+A_2dx=A_3dR_b$$
$$A_1=\left(-\frac{1}{p}+\frac{R_b}{R_\ell}-\frac{c_0^{US,H}}{c_1^{US,H}}R_b\frac{1-p}{p}\right)B<0$$
$$A_2=-R_b+\frac{(1-\eta)BR_b}{(R_\ell)^2}\mathcal{A}-\frac{c_0^{US,H}}{c_1^{US,H}}R_b(R_\ell+x\mathcal{A})$$
$$A_3=-\frac{1}{\sigma}c_0^{US,H}-\frac{\eta B}{pR_b}<0$$
$$B_1=\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\mathcal{A}-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}(R_\ell-R_b)(x\mathcal{A}+R_\ell)+\beta^{US}(1-p)\left(c_1^{US,L}\right)^{-\sigma}\mathcal{A}$$
$$-\beta^{US}\sigma(1-p)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell(x\mathcal{A}+R_\ell)-\sigma(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\left(1-\frac{(1-\eta)B}{(R_\ell)^2}\mathcal{A}\right)$$
$$B_2=\left(\beta^{US}\sigma(1-p)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}(R_\ell-R_b)\left(\frac{1-p}{p}\right)+\sigma(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}\right)B$$
$$=\beta^{US}\sigma(1-p)R_\ell\left[\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right]B$$
$$+\beta^{US}\sigma\left(c_1^{US,H}\right)^{-\sigma-1}R_b(1-p)+\sigma(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}B>0$$
$$B_3=\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}>0$$

A_2 and B_1 are negative as long as $(R_\ell+x\mathcal{A})$ is positive.

$$\frac{dx}{d\eta}=\frac{-B_2+B_3\frac{A_1}{A_3}}{B_1-B_3\frac{A_2}{A_3}}$$
$$B_1-B_3\frac{A_2}{A_3}<0$$
$$-B_2<0 \text{ but } B_3\frac{A_1}{A_3}>0$$

We show that $-B_2+B_3\frac{A_1}{A_3}<0$. As B_2 and $B_3\frac{A_1}{A_3}$ are positive, we just need to show:

$$B_2>B_3\frac{A_1}{A_3}$$

$$\left(\beta^{US}\sigma\left(1-p\right)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}\left(R_\ell-R_b\right)\left(\frac{1-p}{p}\right)+\sigma\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}\right)B$$
$$>\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{\left(-\frac{1}{p}+\frac{R_b}{R_\ell}-\frac{c_0^{US,H}}{c_1^{US,H}}R_b\frac{1-p}{p}\right)B}{-\frac{1}{\sigma}c_0^{US,H}-\frac{\eta B}{pR_b}}$$
$$\iff\left(\frac{1}{\sigma}c_0^{US,H}+\frac{\eta B}{pR_b}\right)\left(\beta^{US}\sigma\left(1-p\right)\left(c_1^{US,L}\right)^{-\sigma-1}R_\ell-\beta^{US}\sigma p\left(c_1^{US,H}\right)^{-\sigma-1}\left(R_\ell-R_b\right)\left(\frac{1-p}{p}\right)+\right.$$
$$\left.\sigma\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}\right)>\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\left(\frac{1}{p}-\frac{R_b}{R_\ell}+\frac{c_0^{US,H}}{c_1^{US,H}}R_b\frac{1-p}{p}\right)$$
$$\iff\beta^{US}c_0^{US,H}\left(1-p\right)R_\ell\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+\beta^{US}c_0^{US,H}\left(c_1^{US,H}\right)^{-\sigma-1}R_b\left(1-p\right)$$
$$+c_0^{US,H}\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}+\frac{\beta^{US}\eta B\sigma\left(1-p\right)R_\ell}{pR_b}\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)$$
$$+\frac{\beta^{US}\eta B\sigma\left(1-p\right)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma\left(1-p\right)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}$$
$$>\beta^{US}\left(c_1^{US,H}\right)^{-\sigma}-\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{R_b}{R_\ell}+\beta^{US}\left(c_1^{US,H}\right)^{-\sigma-1}c_0^{US,H}R_b(1-p)$$
$$\iff\beta^{US}c_0^{US,H}\left(1-p\right)R_\ell\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+c_0^{US,H}\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}$$
$$+\frac{\beta^{US}\eta B\sigma\left(1-p\right)R_\ell}{pR_b}\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+\frac{\beta^{US}\eta B\sigma\left(1-p\right)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma\left(1-p\right)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}$$
$$>\beta^{US}\left(c_1^{US,H}\right)^{-\sigma}-\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{R_b}{R_\ell}$$

$$\iff\beta^{US}\left(c_0^{US,H}\left(1-p\right)R_\ell+\frac{\eta B\sigma\left(1-p\right)R_\ell}{pR_b}\right)\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+c_0^{US,H}\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}$$
$$+\frac{\beta^{US}\eta B\sigma\left(1-p\right)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma\left(1-p\right)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}-\beta^{US}\left(c_1^{US,H}\right)^{-\sigma}+\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{R_b}{R_\ell}>0$$
$$\iff\beta^{US}\left(c_0^{US,H}\left(1-p\right)R_\ell+\frac{\eta B\sigma\left(1-p\right)R_\ell}{pR_b}\right)\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+c_0^{US,H}\left(1-p\right)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}$$
$$+\beta^{US}\frac{\eta B\sigma\left(1-p\right)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma\left(1-p\right)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}-\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}-\beta^{US}(1-p)\left(c_1^{US,H}\right)^{-\sigma}$$
$$+\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{R_b}{R_\ell}>0$$

Using Equation 23,

$$p\left(\beta^{US}\left(\frac{R_\ell-R_b}{R_\ell}\right)\left(c_1^{US,H}\right)^{-\sigma}\right)+(1-p)\left(\beta^{US}\left(c_1^{US,L}\right)^{-\sigma}-\frac{1}{R_\ell}\left(c_0^{US,L}\right)^{-\sigma}\right)=0,$$

$$\beta^{US}\left(c_0^{US,H}(1-p)R_\ell+\frac{\eta B\sigma(1-p)R_\ell}{pR_b}\right)\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+c_0^{US,H}(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}$$
$$+\frac{\beta^{US}\eta B\sigma(1-p)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma(1-p)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}-\beta^{US}(1-p)\left(c_1^{US,H}\right)^{-\sigma}+\beta^{US}p\left(c_1^{US,H}\right)^{-\sigma}\frac{R_b-R_\ell}{R_\ell}>0$$
$$\iff \beta^{US}\left(c_0^{US,H}(1-p)R_\ell+\frac{\eta B\sigma(1-p)R_\ell}{pR_b}\right)\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)+c_0^{US,H}(1-p)\left(c_0^{US,L}\right)^{-\sigma-1}\frac{1}{R_\ell}$$
$$+\frac{\beta^{US}\eta B\sigma(1-p)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma(1-p)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}-\beta^{US}(1-p)\left(c_1^{US,H}\right)^{-\sigma}$$
$$+(1-p)\left(\beta^{US}\left(c_1^{US,L}\right)^{-\sigma}-\frac{1}{R_\ell}\left(c_0^{US,L}\right)^{-\sigma}\right)>0$$
$$\iff \beta^{US}\left(c_0^{US,H}(1-p)R_\ell+\frac{\eta B\sigma(1-p)R_\ell}{pR_b}\right)\left(\left(c_1^{US,L}\right)^{-\sigma-1}-\left(c_1^{US,H}\right)^{-\sigma-1}\right)$$
$$+(1-p)\frac{1}{R_\ell}\left(c_0^{US,L}\right)^{-\sigma}\left(c_0^{US,H}\left(c_0^{US,L}\right)^{-1}-1\right)$$
$$+\frac{\beta^{US}\eta B\sigma(1-p)}{p}\left(c_1^{US,H}\right)^{-\sigma-1}+\frac{\eta B\sigma(1-p)}{pR_bR_\ell}\left(c_0^{US,L}\right)^{-\sigma-1}+\beta^{US}(1-p)\left(\left(c_1^{US,L}\right)^{-\sigma}-\left(c_1^{US,H}\right)^{-\sigma}\right)>0$$

Since lower income consumption in each period is no greater than high income consumption, all the elements are positive. We show that $\frac{dx}{d\eta}>0$. □

A Model with Investment

In this section, we show that the endowment shock in period 0 can map to a shock to investment needed for the production of outputs in period 1. The U.S. and the ROW households are endowed with K_0^a amount of capital and y_0^a amount of goods. These resources can be consumed or invested to produce capital K, which is used as production in period 1. At the beginning of period 0, households are not yet informed of the production technology of period 1, but they are aware that with probability p, production technology will be high-type and with probability $1-p$, it will be low-type. The production technology $F^{a,k}(K)$ in period 1 is:

$$F^{a,H}(K) = \begin{cases} y_1^a & \text{if } K \geq \mathrm{K}_0^a - \frac{1}{p} I_0^a \\ 0 & if \;\; K < K_0^a - \frac{1}{p} I_0^a \end{cases}$$

$$F^{a,L}(K) = \begin{cases} y_1^a & \text{if } K \geq K_0^a + \frac{1}{1-p} I_0^a \\ 0 & if \;\; K < K_0^a + \frac{1}{1-p} I_0^a \end{cases}$$

Once households learn their production technology, the high-type households will sell capital to the low-type households and lower type will give goods in return. With this technology, the high type households have higher "endowments" of goods, $y_0^a + \frac{1}{p} I_0^a$, while the low type households have lower "endowments", $y_0^a - \frac{1}{1-p} I_0^a$. The value of liquidity then arises from the flexibility to adjust saving in U.S. liquid government bonds as needed for investment.

Online Appendix

Additional Tables and Figures

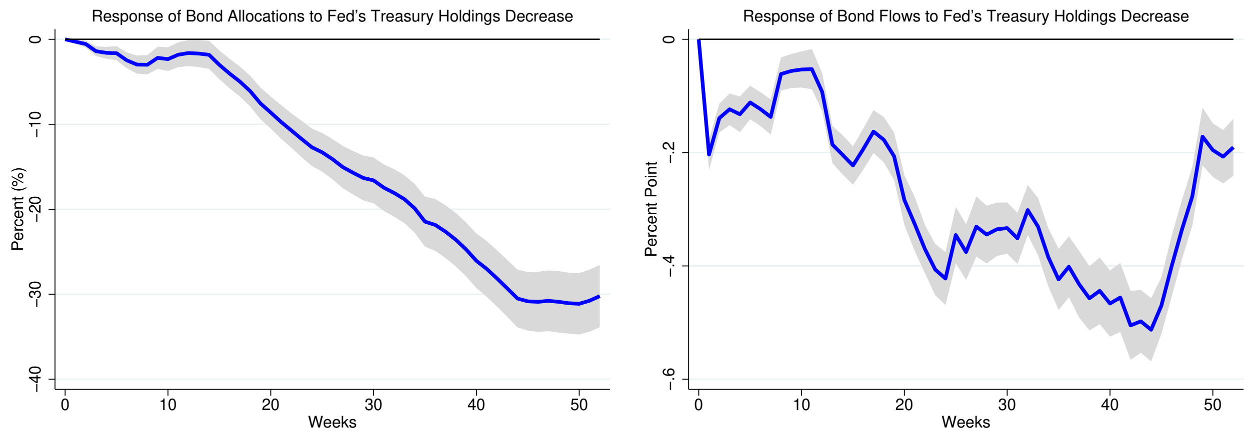
Table 4 summarizes the QE and QT announcement dates that we employ.

Table 4: QE and QT Announcement Dates

Date	Program	Source
25/11/2008	QE1	Fratzscher et al. (2018)
16/12/2008	QE1	
28/01/2009	QE1	
18/03/2009	QE1	
11/3/10	QE2	
21/09/2011	MEP	
20/06/2012	MEP	
13/09/2012	QE3	
12/12/12	QE3	
5/4/17	QT1	Du et al. (2024)
14/06/2017	QT1	
20/09/2017	QT1	

Notes: For QE dates, we take announcement dates of FOMC statements from Table 1A in Fratzscher et al. (2018). The dates of QE announcements about a slowdown, contraction, and end of asset purchases are dropped. Only the dates of announcements conveying a strong signal of asset purchases and their expansion are included. For QT, we employ the announcement dates from Du et al. (2024). The dates of main announcements and news are collected. The dates are in the form of DD/MM/YYYY.

Figure 19: Dynamics of Capital Inflows: Large Decrease in Fed's Holding of U.S. Treasuries



Notes: The figures show the estimation results from weekly panel local linear projections with the dependent variables being $ln(BondFundAllocation_{i,t+k}) - ln(BondFundAllocation_{i,t-1})$ on the left and $\frac{BondFundFlow_{i,t+k}}{BondFundAllocation_{i,t-1}}$ on the right. The response shows how the bond funds allocations (on the left) and weekly bond fund flows (on the right) have changed over 52 weeks after the Fed's large *sale* of the U.S. Treasuries. The shaded area represents the 90% confidence interval, computed using heteroskedasticity-robust standard errors.