Corporate Basis and Demand for U.S. Dollar Assets

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Abstract

The corporate basis measures the price differences between bonds issued in dollars and foreign currencies by the same corporate entity. In this paper, we propose a novel method to decompose the corporate basis into three components: credit spread differential, convenience yield differential, and deviation from covered interest rate parity. With this decomposition, we document several stylized facts, and in particular, the substitution effect between safe and risky dollar assets. We provide further evidences on the substitution effect using the structural VAR analysis, which shows that a negative shock to financial intermediaries' balance sheets causes a tightening of credit spread differential, a demand shift toward safe assets, and an appreciation of the dollar. We also find consistent holdings-level evidences using foreign investors' aggregated holdings of safe and risky dollar assets. Lastly, we find that the substitution effect also shows great empirical plausibility for bonds denominated in the largest non-USD currencies—Euro and British Pounds—but is not highly relevant to other currencies in our sample. Our results highlight the important role of the top funding currencies, especially the U.S. dollar, in the global financial markets.

Keywords: U.S. Dollar Asset Demand, Credit Spread, Covered Interest Rate Parity, Financial Intermediaries

JEL Classifications: E44, F30, F31, F32, F41, G11, G12, G15, G18, G20

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1 Introduction

The corporate basis defines FX-hedged corporate bond pricing differences. To an institution that invests in both euro- and dollar-denominated corporate bonds, it reflects the differences between the yields of an Euro (EUR) bond and the synthetic EUR yields as constructed from a cash position in a dollar (USD) bond from the same issuer as well as a hedging position in the FX market. Under the no-arbitrage condition, the corporate basis should be zero in a frictionless financial market. However, as shown in Figure 2, the corporate basis is empirically sizable and exhibits substantial variation since the global financial crisis (GFC). The persistent but time-varying deviations from the corporate covered interest rate parity suggest that many economic forces—including demand for dollar-denominated assets as well as dollar scarcity in cross-border financing—potentially interact and jointly shape the corporate basis. In this paper, we study the effects of financial shocks, such as shocks to intermediary leverage and monetary policy, on the corporate basis, exchange rates, as well as spillovers to equity and commodity markets and real economic activity.

Many previous works study the corporate basis from the issuers' perspective and link its variation with firms' currency preference in debt financing (Liao, 2020; Galvez et al., 2021; Liao and Zhang, 2021). Departing from their approach, this study examines the corporate basis from the perspective of investors in the global bond markets. To this end, we introduce a novel decomposition of the corporate basis into components: credit spread differential (CSD), convenience yield differential (CYD), and cross-currency basis (CCB). They reflect in turn the demand for dollar-denominated risky and safe assets, as well as the FX hedging cost capturing cross-border dollar liquidity.[1] Our main focus is on the CSD, which measures the difference in credit spread between corporate bonds with USD denominations and otherwise identical ones with non-USD denominations. As such, it captures the yield difference purely due to the currency difference, and could be used to proxy for the relative demand for risky assets in dollars. Regarding the other two components, CYD measures the yield difference between government bonds and their corresponding risk-free rates, and reflects the relative safe asset demand for dollar assets; CCB is defined as the difference between synthetic and the direct dollar funding cost and thus captures deviations from covered interest rate parity (CIP).

Using a universe of 32,008 corporate bonds denominated in major funding currencies—Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), British Pounds (GBP), Japanese Yen (JPY), and the U.S. Dollar (USD), we estimate the CSD over the period January 2004 and March 2021 as the currency fixed effect after controlling firm,

[1] see e.g. Bahaj and Reis (2021); Ferrara et al. (2022)

maturity, and ratings fixed effects in a cross-sectional regression. With estimates of the CSD and CYD in our decomposition, we uncover a substitution effect between safe and risky assets: foreign investors balance their global bond portfolios not only between the U.S. assets and local assets, but also between the risky and safe U.S. assets. For example, a lower risky dollar asset demand would push up a higher safe dollar asset demand due to the heightened risk-aversion of investors.

To further establish this stylized fact, we perform a structural VAR analysis that involves each component in the corporate basis decomposition as well as the exchange rate. Consistent with the negative correlation between the CSD and CYD, the SVAR estimation results indicate a substitution effect from risky to safe assets. In other words, a positive shock to the USD credit spread leads to an increase in the US Treasury premium and an appreciation of the USD. Since a limitation of the SVAR analysis is about the identification of shocks to each component of the corporate basis, we then proceed to using the balance sheet constraints of financial intermediaries (He, Kelly and Manela, 2017) as an instrument variable (IV) to identify a shock to credit spreads. The intuition is that a negative shock to the intermediary's capital ratio leads to a decline in the wealth share of the intermediary sector, forcing primary dealers to delever risky assets because of tight banking regulations such as the Tier 1 capital ratio. The identification assumption is that a tightening of balance sheet constraints affects the corporate basis through increasing dollar credit spreads relative to other currencies. The findings based on this IV further strengthen our SVAR results. Quantitatively, we find a one-standard-deviation increase (18.6 basis points) in USD credit spreads relative to foreign currency spreads leads to a 2.4 basis point increase in the US Treasury premium, and a short-term appreciation of the USD of 1.8%.

In addition to shocks to the CSD, we consider monetary policy surprises as an IV for the convenience yield component of the corporate basis. Monetary policy induces a shift in safe dollar asset demand through affecting the spread between USD treasuries and corporate bond yields. Following Kearns, Schrimpf and Xia (2022), we identify monetary policy surprises through high-frequency changes in inter-bank rates and the US Treasury yields around scheduled monetary announcements of the Federal Reserve. Coinciding with the results based on intermediary capital shocks, we note a substitution between safe and risky assets in response to a shock to the Treasury premium. Quantitatively, a one-standard-deviation increase in the US Treasury premium (18 basis points) leads to a 27.9 basis point increase in USD credit spreads relative to foreign currencies, and a short-term appreciation of the USD of 2.4 %.

Complementary to our findings on the pricing implications of substituting demand, we also find quantity-based evidence for the substitution effect from foreign investors' net purchases of dollar safe and risky assets. The Treasury International Capital (TIC) System provides monthly transaction data on cross-border purchases and sales of the US assets. By zooming in on the foreign investors' transactions of the US corporate bonds and Treasury securities, we find that the dollar safe assets play a substituting role during the 2008 GFC and 2020 Covid pandemic. In particular, the 2008 GFC represents a typical scenario in which financial intermediaries face a significant negative capital shock. As this shock is transmitted to the US bond market, we observe a sharp increase in foreign investors' demand for the safe dollar assets and selling-off of the risky dollar assets during the 2008 GFC. Through the SAVR model, we further confirm that one standard deviation negative shock to CSD contemporaneously leads to a negative change of around $6.88 billion in the net bond flow by foreign investors. The net bond flow is the foreign private investors' transaction difference between the US corporate bonds and the US Treasury securities.

Extending the analysis to international currencies, we find similar substitution effect between risky and safe assets denominated in Euro (EUR) and British Pounds (GBP), which are the second and third largest currencies in terms of global bond issuance, after the U.S. Dollar. Through a similar SVAR setting, we find that the contemporaneous impact of one standard deviation negative shock to CSD on CYD is 7.72 basis points for EUR and 1.87 basis points for GBP, both are positive and statistically significant at the 5% level. Interestingly, we find no substitution effect for other currencies such as Australia Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), and Japanese Yen (JPY), which are far lessly used as denominations for global corporate bonds. In our estimation of CSD and CYD for non-USD currencies, we exclude USD-denomination corporate bonds in our sample to avoid potential confounding effects from dollar bonds.

We conduct an array of robustness tests that support our main findings. Since we use the LIBOR and coherent interest rate swap (IRS) rates as risk-free rates, one might be concerned about the credit risk given that LIBOR is an unsecured lending rate. We address this concern with alternative risk-free rates with negligible credit risk. For example, in the US market we use the Secured Overnight Financing Rate (SOFR), a broad measure of the borrowing rate in the repo market. Anothe concern on our empirical methodology is that the CSD is estimated from cross-sectional regressions. We assess the robustness of our CSD estimates by focusing on a subsample in which model-free estimates of the CSD are available. We find that our main results are robust with the alternative risk-free rates and alternative measures for the CSD.

Lastly, we look at the spillover effect of dollar asset demand shocks to other asset classes and economic activity. In our IV specification based on shocks to dealers' equity capital, an increase in the USD credit spreads weakens risk-bearing capacity of financial institutions, resulting in negative returns in the equity and commodity markets. Moreover, we document macro-financial effects on a series of economic activity variables, including inflation, GDP and unemployment rate. To be more specific, a shock to the USD credit spreads depresses both the U.S. and non-U.S. economy activities because of a lower capacity of primary dealers in supplying credit to the economy Gilchrist and Zakrajšek (2012).

The remainder of the paper is structured as follows. We review our contribution to literature in section 2. In section 3, we discuss our framework for the determinants of the corporate basis and the data sources. Section 4 presents our main empirical findings. Section 5 extends the substitution effect to the international-level. Section 6 discusses the robustness of our main results as well as impacts on other markets. Section 7 concludes.

2 Related Literature

The corporate basis is closely related to the literature on CIP deviations. The CIP deviation is a proxy for the cross-border dollar liquidity scarcity, and Du, Tepper and Verdelhan (2018) documents a persistent CIP deviation after the GFC. A number of studies provide possible explanations on banking regulation, heterogeneous funding costs, interest rate differentials, unconventional monetary policy (e.g. Borio et al., 2016; Avdjiev et al., 2019; Rime, Schrimpf and Syrstad, 2021; Abbassi and Bräuning, 2020; Bräuning and Ivashina, 2020; Viswanath-Natraj, 2020; Cenedese, Della Corte and Wang, 2021; Cerutti, Obstfeld and Zhou, 2021). In addition, Du, Im and Schreger (2018) apply the CIP deviation into the government bond market to measure the relative convenience yield of non-U.S. government bonds and U.S. government bonds as the U.S. Treasury premium. The U.S. Treasury premium reflects the "specialness" of the U.S. Treasuries as the safe dollar asset demand, and we further decompose the U.S. Treasury premium to convenience yields differentials and CIP deviations. The convenience yield differential indicates safe dollar asset demand. Also, Liao (2020); Galvez et al. (2021); Caramichael and Liao (2021) examine the CIP deviation in the corporate bond market as the corporate basis, and they look at the non-U.S. firm's perspective and identify the corporate basis as the difference between local bond funding costs and hedged dollar bond funding costs. This paper is closely linked with Liao (2020), who decomposes the corporate basis into the credit spread differentials and CIP deviation and studies the interaction between these two pricing anomalies. In particular, he measures credit spreads as the difference between corporate bond yields and LIBOR swap rates. Our primary innovation relative to prior studies is to study the corporate basis from the (non-U.S.) investors' perspective, instead of from issuers' perspective. In terms of empirical methodology, we decompose the basis into three components—the credit spread differentials, convenience yield differentials and CIP deviation—as we measure credit spreads as the difference between corporate bond yields and government bond yields. This decomposition allows us to study the interaction between risky dollar asset demand, safe dollar asset demand and CIP deviations.

This paper contributes to the literature studying the international role of the dollar. Maggiori, Neiman and Schreger (2019, 2020) documents a surged dollar-denominated cross-border holding in corporate bonds after 2008. U.S. treasury bonds are the most liquid and safe assets in the world (Krishnamurthy and Vissing-Jorgensen, 2012). Jiang, Krishnamurthy and Lustig (2021) propose a safe dollar asset demand channel that directly impacts the dollar exchange rate, and they further rationalize the safe dollar asset demand in a model of the global financial cycle (Jiang, Krishnamurthy and Lustig, 2020). Recent research focuses on the diminishing privilege of the U.S. Treasury, particularly during the Covid-19 episode, and several studies point out the Treasury inconvenience yields due to the shifts in Treasury ownership, tight banking regulation and sovereign default risk (Augustin et al., 2021; Klingler and Sundaresan, 2020; Duffie, 2020; Vissing-Jorgensen, 2021; He, Nagel and Song, 2022). Our findings support the dominant position of dollar asset in the international market but also document a diminishing premium on safe dollar assets.

Finally, our paper contributes to the literature on intermediary based asset pricing. He and Krishnamurthy (2013); Brunnermeier and Sannikov (2014) model the pricing power of financial intermediaries as marginal investors, and He, Kelly and Manela (2017) empirically examine the idea based on the balance sheet constraints of primary dealers. In addition, He, Khorrami and Song (2019) finds that two intermediary-based factors can explain about 50% of credit spread changes of the corporate bonds. Based on this evidence, we use the intermediary-based factor to identify the risky dollar asset demand shock and explore a significant causal effect on the FX, equity and commodity market. Our evidence also supports financial intermediaries as the marginal investors.

3 Definitions and Data

3.1 Decomposition of Corporate Basis

Consider corporate debts denominated in EUR relative to USD. In Eq. (1), we express the difference in yields as the EUR bond yield minus the USD bond yield after controlling for

FX risk. From a bond investor's perspective, it reflects the promised return from holding a EUR-denominated corporate bond ($y_{e,t}$) in excess of the synthetic yield as constructed from a cash position in a USD bond from the same issuer ($y_{\$,t}$) and a hedging position in the FX market. The FX-hedging cost is $-(f_t - s_t)$, where s_t and f_t denotes the spot and forward (log) exchange rate quoted in EUR per USD. We can also express the corporate basis in Eq. (2) as the sum of a credit spread differential—which captures variations in risky asset demand across currencies—and the U.S. Treasury premium (Jiang, Krishnamurthy and Lustig, 2021; Du, Im and Schreger, 2018).

$$\Psi_t = \underbrace{y_{e,t}}_{\text{EUR-denomination bond yield}} - \underbrace{(y_{\$,t} + f_t - s_t)}_{\text{FX-hedged USD-denomination bond yield}} \tag{1}$$

$$= \underbrace{\left[(y_{e,t} - y^G_{e,t}) - (y_{\$,t} - y^G_{\$,t})\right]}_{\text{Credit spread differentials}} + \underbrace{\left[(y^G_{e,t} + s_t - f_t) - y^G_{\$,t}\right]}_{\text{U.S. Treasury premiums}} \tag{2}$$

$$= \underbrace{\left[(y_{e,t} - y^G_{e,t}) - (y_{\$,t} - y^G_{\$,t})\right]}_{\text{Credit spread differentials}} + \underbrace{\left[(y^G_{e,t} - y^{rf}_{e,t}) - (y^G_{\$,t} - y^{rf}_{\$,t})\right]}_{\text{Convenience yields differentials}} + \underbrace{\left[(y^{rf}_{e,t} + s_t - f_t) - y^{rf}_{\$,t}\right]}_{\text{Cross-currency basis}} \tag{3}$$

Eq. (3) represents the decomposition that we focus on in this paper. $y^{rf}_{e,t}$ and $y^{rf}_{\$,t}$ denote the euro and dollar risk-free rates, respectively, and $y^G_{e,t}$ and $y^G_{\$,t}$ are the corresponding government bond yields. The main difference is that the Treasury premium can be further decomposed into the relative expensiveness of the US Treasuries, which we denote the convenience yield differential, and deviation from the CIP condition, which we denote the cross-currency basis. Therefore, our decomposition of the corporate basis constitutes three elements: differences in risky asset yields (credit spread differential), differences in sovereign yields (convenience yield differential), and FX market frictions (cross-currency basis). We provide more details on each component below.

Credit spread differentials (CSD): CSD is the difference in credit spread between bonds with denominations in foreign currencies and bonds denominated in the dollar. A decrease in CSD corresponds to an increase in the promised return (in excess of non-defaultable bonds) from holding USD-denomination corporate bonds. From an investor's perspective, it indicates a decrease in the demand for *unhedged* risky dollar asset, which could be driven by greater risk aversion among bond investors or higher FX hedging costs (e.g. in the GFC).

Convenience yields differentials (CYD): CYD is the difference between the non-U.S. government bonds' yield spread and U.S. Treasuries' yield spread relative to riskfree rates. A positive value means a lower excess return on holding the U.S. Treasury. It reflects the *unhedged* safe dollar asset demand, equal to the U.S. treasury premium without the FX risk hedging.

Cross-currency basis (CCB): CCB is the difference between synthetic dollar funding cost ($y^{rf}_{e,t} + s_t - f_t$) and the direct dollar funding cost ($y^{rf}_{\$,t}$). A positive value indicates that foreign investors are willing to pay a premium on getting the dollar funding via the FX market, reflecting a strong dollar demand or the dollar liquidity stress in the cross-border market due to the limit on accessing the direct dollar funding.

We note that our decomposition of the corporate basis differs from Liao (2020), which measures the credit spread differential using the risk-free rate as the benchmark yield. in Liao (2020) the credit spread differential is defined as $(y_{e,t} - y^{rf}_{e,t}) - (y_{\$,t} - y^{rf}_{\$,t})$, which is equivalent to the sum of our CSD and CYD in Eq. (3). By using the government bond as our benchmark for the estimation of CSD, our decomposition enables us to separate the different demand for the safe and risky dollar assets and investigate their own individual and joint dynamics.

3.2 Estimation of the CSD and Corporate Basis

CSD measures the difference in corporate bond credit spread due to the currency difference. For example, BMW, a German multinational manufacturer, issued both EUR- and USD-denominated corporate bonds. We compare the credit spread for these two currencies' denomination bonds while controlling maturity and fixed effects. Specifically, we apply the same methodology to estimate the CSD and corporate basis used by Liao (2020); Galvez et al. (2021); Gopinath, Caramichael and Liao (2021).

To estimate the CSD, we run the following cross-section regression:[2]

$$S_{i,t} = \alpha_{c,t} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t} + \epsilon_{i,t} \tag{4}$$

where $S_{i,t}$ denotes the corporate yield spread (the corporate bond yield net of government bond yield for the same maturity) of bond i at time t. $\alpha_{c,t}, \beta_{f,t}, \gamma_{m,t}$ and $\delta_{r,t}$ are fixed-effect estimates for currency c, firm f, maturity bucket m, and rating bucket r. The maturity of each bond is categorized into four buckets (one to three years, three to seven years, seven to ten years, and beyond ten years). The rating of each bond is also categorized into four buckets (AAA&AA, A, BBB and speculative grades). The firm fixed effect controls for other bond characteristics at the issuer level. The currency fixed effect $\alpha_{c,t}$ measures the residualized credit spread for bonds denominated in currency c. The credit spread differential between currency c and USD is calculated as $\mathrm{CSD}_{c,t} = \alpha_{c,t} - \alpha_{USD,t}$.

[2] We drop the bond-month data if its remaining maturity is less than one year or 10% of full maturity to mitigate the illiquidity issue.

Following Du, Tepper and Verdelhan (2018), we use the spread on the cross-currency swap as the long-term cross currency basis (CCB), because outright forward currency contracts with maturiy longer than 12 months suffer from poor liquidity. The cross-currency swap involves a currency swap and exchanges of cash flow linked to floating interbank rates, and is the same as the long-term CIP deviation. Regarding the convenience yield differentials (CYD), we follow Jiang, Krishnamurthy and Lustig (2018) by computing the difference between the credit spread of non-US and US government bonds. The credit spread of a government bond is the difference between its yield and the fixed rate of the maturity-matched interest rates swap (as the risk-free rate) demoninated in the local currency.[3]

We further measure the corporate basis Ψ_t based on the regression (4) by replacing $S_{i,t}$ with $S_{i,t}^{Adj.}$. For the USD denomination bonds, $S_{\$,t}^{Adj.}$ is the same bond credit spread $S_{\$,t}$ as before. For a non-USD denomination bond i, $S_{i,t}^{Adj.}$ is the adjusted credit spread by adding $S_{i,t}$ with the respective CYD and CCB, i.e., $S_{i,t}^{Adj.} = S_{i,t} + \text{CYD}_{i,t} + \text{CCB}_{i,t}$. We re-estimate the Eq. (4) for $S_{i,t}^{Adj.}$ and calculate the corporate basis $\Psi_{c,t}$ as $\Psi_{c,t} = \alpha_{c,t}^{Adj.} - \alpha_{USD,t}^{Adj.}$.

3.3 Data

Corporate Bond Data

We build our corporate bond data set on the bond issuance information as retrieved from the SDC Platinum Global New Issues database. This database contains various characteristics of each issue, including the notional principal, maturity date, coupon structure, currency of denomination, the issuer's country of origin, and indicators for option-like features. We filter the bond data with the following criteria: (1) the bond is denominated in one of the seven major funding currencies: AUD, CAD, CHF, EUR, GBP, JPY or USD; (2) the ultimate parent of the issuer has outstanding bonds denominated in multiple currencies, and at least one of them is a USD bond; (3) the bond is unsecured, non-putable, non-convertible, non-perpetual, and has fixed-rate coupons; (4) the issuer is not in a government-related industry such as City government or National Government or City agency;[4] (5) the bond has an initial maturity of at least one year and a notional principal of at least $50 million.

The filtered sample of debt issues is then merged with the pricing data from the secondary market. Specifically, we obtain month-end price quotes from Bloomberg (BGN)—a widely

[3]We match the tenor of cross-currency basis with the corporate bond maturity by a linear interpolation method with maturities of 1, 2, 5, 7, 10, 12, 15, 20 and 30 years. We apply the same method to match the maturities between convenience yields differential and corporate bonds, but the maturities of government bonds used in the interpolation depends on the actual data available. For example, the maturities of the Australian government bond are 1, 2, 3, 5, 7, 10, 20 and 30 years.

[4]Following Liao (2020), we include bonds issued by supranational and Sovereign agencies

used data sources for studies on the international corporate bond markets (Valenzuela, 2016; Liao, 2020; Geng, 2021)—and link them to bond characteristics via ISIN. Owing to the relative sparseness of pricing observations before 2004, we focus on the sample period from January 2004 to March 2021. To each bond-month observation, we assign a credit rating by following Dick-Nielsen, Feldhütter and Lando (2012)'s approach: we first look up its credit rating in the Standard & Poor's Global Ratings database; if its rating in that month is missing, we turn to the Moody's Default & Recovery Database; if the rating information is still unavailable, we use the rating from other agencies as displayed in Bloomberg (e.g., Fitch and Dominion). Finally, we calculate yield-to-maturity (yield-to-worst for callable bonds) and winsorize it at 1% at the currency-month level to remove outliers.

The final data set consists of 32,008 bonds issued by 3,464 firms with a total notional of $24.2 trillion. Table 1 displays the monthly average of the number of bonds, the notional value in billion dollars, and the number of corresponding firms by rating and maturity categories. On average, we have around 7,190 bonds with notional values of $5,400 billion issued by 1,438 firms each month. The A rating category and the maturity group of 3-7 years take the largest share in terms of both the issue and the outstanding notional.[5] Regarding the market size of each currency, USD-denominated corporate bonds account for around 40% (2,891) of bonds, 48% ($2,582 billions) of notional values, 58% (829) of issuers in our sample. They are followed in turn by EUR-, JPY-, GBP-, CAD-, CHF- and AUD-denominated bonds. Notably, more than 87% of CHF corporate bonds are issued by foreign companies, and this finding is likely driven many international corporations operating in Switzerland. Among USD bonds, more than 44% are issued by foreign firms and they jointly account for 47.5% of notional values of all dollar-denominated bonds.

In addition, we visualize the cross-border bond issuance in Figure 1, using the cross-sectional observations of outstanding amount at the end of our sample period (March 2021). We focus on bond issuers located in the US, Euro Zone, the UK, Switzerland, Canada, Australia and Japan. The size of purple circle reflects the total notional principal of bonds issued by domestic firms. As expected, the US firms take up the largest portion of bond issuance in the global corporate bond markets, followed by issuers in the EU, Japan, and the UK. The thickness of the arrow line, for example, from the EU to the US shows the total size of USD-denominated bonds issued by European firms. A broad comparison of all arrows in the figure reveals that EU-to-US, UK-to-US, and US-to-EU represents the most important types of cross-border bond issuance. Finally, the darkness of the EU-to-US arrow captures the proportion of foreign currency bonds issued

[5] The average maturity is around five years. This is why we use CYD and CCB at the five-year maturity in our analysis.

by European firms that are denominated in USD. We find that USD-denominated bonds are the dominant category of foreign currency bonds in all countries except for Australia. Among foreign currency bonds issued by Australian firms, the shares of USD- and EUR-denominated ones are equally large. Overall, Figure 1 indicates that USD-denominated bonds show a dominant position when firms issue foreign currency bonds, followed by EUR-denominated bonds.

Default-Free Interest Rates and Exchange Rates

Government bond yields, fixed rates of interest rate swaps, cross-currency swap basis (which is Libor-based, as in our measurement of CIP deviations), and spot exchange rates are obtained from Bloomberg. We extract the data with tenors of 1, 2, 5, 7, 10, 12, 15, 20 and 30 years if available. The calculation of the CIP deviation x_t and convenience yields differential λ_t follows Eq. (3), which are consistent with Du, Tepper and Verdelhan (2018); Du, Im and Schreger (2018).

One potential concern associated with the use of Libor swap rates is the credit risk because Libor is an unsecured lending rate. In addition, Libor was manipulated by submitting banks, as revealed in the Libor scandal in 2012. Its use as a reference rate for new transactions officially ends after December 31, 2021. In the US, Libor is replaced by the Secured Overnight Financing Rate (SOFR), which measures the cost of borrowing cash overnight collateralized by the US Treasury securities and thus barely contains any credit-risk component. Other countries are also replacing the Libor rate with a new benchmark rate, similar to the SOFR. We have AUD Overnight Index Average (AONIA), Canadian Overnight Repo Rate Average (CORRA), Swiss Average Rate Overnight (SARON), Euro short-term rate (ESTR), Sterling Overnight Index Average (SONIA) and Tokyo Overnight Average Rate (TONA) using in Australia, Canada, Switzerland, Euro Area, the U.K. and Japan, respectively. In particular, Bloomberg has traced back SOFR, CORRA, ESTR, SONIA and TONA to before 2004 but, currently, the maximum maturity is only 1 year. Therefore, we use the 5-year Libor rates as the benchmark rate in our baseline analysis but use the new benchmark rates with a 1-year maturity in our robustness tests.

Supplementary Data

We supplement the fixed-income and currency market information with data from several other sources. Our SVAR analysis involves VIX, equity indexes and the commodity index data, which are obtained from Bloomberg. Also, we incorporate into our SVAR system the "intermediary capital risk factor"[6] as proposed by He, Kelly and Manela (2017), in order to identify the financial intermediary constraints shock. In addition, The high-frequency interest rates on one-month Overnight Indexed swaps (OIS) are from Thomson Reuters TickHistory. Finally, to provide -based evidence on USD asset demand, we retrieve monthly holdings of the US long-term securities by foreign residents from Treasury International Capital (TIC) database.[7]

3.4 The Corporate Basis and Its Components

We estimate the corporate basis and CSD from the cross-sectional regression specified in Eq. (4). Overall, the determinants in Eq. (4) exhibit great explanatory power for the variations of global corporate yield spread, with the R^2 in the range from 80% to 90%. Considering that the average time to maturity of corporate bonds in our sample is close to five years, we will focus on the CYD and CCB at the five-year maturity in our decomposition of corporate bases.

Focusing first on the corporate basis, Figure 2 shows the monthly time-series for currency pairs with one leg in USD and one leg in non-USD (AUD, CAD, CHF, EUR, GBP or JPY) from January 2004 to March 2021. The basis indicates the difference between non-U.S. corporate yield and hedged US corporate yield, and it has negatively spiked during two crisis periods (the GFC and the Covid-19), probably reflecting either a surging hedging cost or a lower risky dollar asset demand. The basis was close to zero before the GFC, but it has since deviated from zero with a significant fluctuation.

Next, we zoom the lens into the time-series of the three components of the corporate basis, CYD, CSD, and CCB, separately. Figure 3 shows the monthly time-series of CSD, CYD and CCB from January 2004 to March 2021. Table 2 reports the corresponding summary statistics for the full sample, the Pre-GFC period (Jan 2004 to November 2007), the GFC period (December 2007 to May 2009), and the post-GFC period (June 2009 to March 2021). Our main focus in this paper is CSD, which reflects the demand for risky dollar assets. CSD dropped sharply during the crisis period (the GFC and Covid-19), suggesting a run on the risky dollar asset due to lower risk appetite, high FX risk and hedging costs. Among the currencies, JPY and CHF have the most negative CSD, followed by EUR, GBP, CAD, and AUD. CCB reflects the stress of dollar liquidity in the global financial markets, which was close to zero before the GFC but has been persistently large afterward. We also observe a download trend in the time-series of CYD, suggesting that the U.S. safe asset has became less "special" after the GFC. For most currencies, the mean of CYD turns negative after GFC. The spike of CYD in the GFC reflects

[6]The data is obtained from the website of Zhiguo He: https://voices.uchicago.edu/zhiguohe/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/.

[7]The data is obtained from Treasury's website: https://home.treasury.gov/data/treasury-international-capital-tic-system-home-page/help-files/estimating-holdings-of-treasury-securities

the "flight to safety" (e.g. Krishnamurthy and Vissing-Jorgensen, 2012), but the spike was less prominent in the Covid-19, which is consistent with the "dash for dollar" (e.g. Cesa-Bianchi and Eguren Martin, 2021).

Based on the decomposition of CCB, CYD and CSD, we further decompose the variance of the corporate basis and report the results at Table 3. With an average ratio $\frac{var(\text{CSD})}{var(\Psi)}$ of 1.40, it is clear that the variance of CSD has contributed the majority of the variation of the corporate basis, much higher than the variance of CCB and CYD. Interestingly, the second largest component of the corporate basis variance is the co-variance between the CSD and CYD, $\frac{2cov(\text{CSD,CYD})}{var(\Psi)}$, which is negative and has a large average magnitude of 0.69. The CSD also co-moves negatively with CCB, but with a smaller magnitudes. For CYD and CCB, their variance contribute much less to the variation of the corporate basis and the two components tend to move independently. It is therefore clear that the negative co-variance between CSD and CYD contribute substantially to the variation of the corporate basis in our sample period.

4 Empirical Findings

4.1 The Substitution Effect Between CSD and CYD

To understand the join dynamics of CSD and CYD intuitively, we plot the time-series of the mean value of CYD and CSD together at the top panel of Figure 4 for the sample period from January 2004 to March 2021. An important observation from the dynamics of the two time-series is that CSD and CYD tend to co-move in the opposite directions. The full-sample correlation of CSD and CYD is negative at -0.48 for levels and -0.46 for monthly changes, reflecting a strong substitution effect between the demand for safe and risky dollar assets.

During the global financial crisis period, the negative correlation between CSD and CYD turns more negative to -0.83 for levels and -0.59 for monthly changes. This negative co-movement between CSD and CYD during the GFC period is characterized by an increase in CSD and a decrease in CYD, reflecting a "flight to safety" of global investors. The pattern is similar for the recent Covid-19 pandemic period, though with much smaller magnitudes. Different from the GFC period, the pandemic period is characterized by a large drop in CSD but only a moderate increase in CYD. The dynamics of CYD are consistent with the observations that the U.S. Treasuries have lost their specialness to some extend during the pandemic, as discussed in Cesa-Bianchi and Eguren Martin (2021), Ma, Xiao and Zeng (2020), and He, Nagel and Song (2022). The large drop in CSD, however, suggests that there is still substantial drop in the demand for the risky dollar assets during the pandemic period.

Although the substitution effect is more evident for the crisis period, it's worth emphasizing that the substitution effect between CSD and CYD is not driven entirely by the crises. Excluding the GFC and the covid-19 pandemic period in our sample, the correlation between the monthly changes of CSD and CYD is -0.33, negative and statistically significant at the 1% level. The correlation between the levels of CSD and CYD decreases to -0.11, still negative but no longer statistically significant.

The substitution effect between CSD and CYD is also robust across all currencies. This can be seen in the bottom panels of Figure 4, which shows the respective time-series of CSD and CYD for each of the six non-USD currencies in our sample. Across all six currencies, the respective CSD and CYD co-moves negatively.

In the rest of this section, we will provide more analysis and evidences to better understand the joint dynamics of CSD and CYD as well as the underlying mechanism.

4.2 Structural VAR: Baseline Estimation

First, we rely on the structural VAR (SVAR) estimation to understand the causal effect of structural shocks on CSD, CYD, and CCB:

$$AY_t = \sum_{j=1}^{N} A_j Y_{t-j} + \epsilon_t, \tag{5}$$

where $Y_t = [CSD_t \; CYD_t \; CCB_t]'$ and ϵ_t is a vector of orthogonal structural innovations with zero mean. [8] N is set to be one based on the BIC criteria of VAR model. ϵ_t consists of a shock to the risky component of dollar asset demand ($\epsilon_t^{\text{CSD shock}}$), a shock to the safe dollar asset demand($\epsilon_t^{\text{CYD shock}}$), and a shock to the cross-border dollar liquidity ($\epsilon_t^{\text{CCB shock}}$). Multiplying each side of the equation by A^{-1} yields the reduced form representation in equation (6):

$$Y_t = CY_{t-1} + B\epsilon_t \tag{6}$$

where $B = A^{-1}$ and $C = A^{-1}A_1$

In our baseline estimations, we assume the causality runs from CSD to CYD and CCB. Therefore shocks to CSD contemporaneously affect CYD and CCB, and shocks to CYD contemporaneously affect CCB. Figure 5 presents the impulse response function (IRF) of one unit corresponding shock to each variable based on the mean value of CSD, CYD and CCB across all currencies in our sample. [9] The IRF is estimated based on 1,000 bootstraps. The results

[8] ϵ_t is assumed to be $E(\epsilon_t \epsilon_t') = \sum = \mathbb{1}$ (mutually uncorrelated and unit variance).

[9] We have also studied the impulse response functions for the CSD, CYD, and CCB based on individual currencies. The results remain robust. The IRF plots of each individual currencies are not reported in the paper due to

support a substitution between risky and safe dollar assets as shocks to CSD induce a negative co-movement between the CSD and CYD components. Quantitatively, a one standard deviation (18.6 basis points) increase in CSD leads to a 4.5 basis point decrease in CYD. A positive shock to CSD and CYD can both result in a contemporaneous decrease in CCB. A one standard deviation increase in CSD (18.6 basis points) and CYD (18 basis points) results in a decrease in CCB with 2.46 and 2.45 basis points, respectively.

4.3 Structural VAR: External Instruments

A limitation of the previous Structural VAR estimation with zero restrictions is that it assumes a direction of causality from CSD to CYD and CCB. To identify the causal effects of each component of the corporate basis, we use an alternative specification by adding an external instruments to identify shocks to components of the corporate basis. In particular, let Z_t be a vector of instrument variable (IV) for risky dollar asset demand (CSD). Z_t must be correlated with $\epsilon_t^{\text{CSD shock}}$ but orthogonal to other shocks to be a valid instrument:

$$E[Z_t\epsilon_t^{\text{CSD shock}}] = \phi; \quad E[Z_t\epsilon_t^{\text{CYD shock}}] = 0; \quad \text{and} \quad E[Z_t\epsilon_t^{\text{CCB shock}}] = 0. \tag{7}$$

The reduced-form VAR representation can be expressed in Eq. (8):

$$\begin{bmatrix} CSD_t \\ CYD_t \\ CCB_t \end{bmatrix} = \begin{bmatrix} c11 & c12 & c13 \\ c21 & c22 & c23 \\ c31 & c32 & c33 \end{bmatrix} \begin{bmatrix} CSD_{t-1} \\ CYD_{t-1} \\ CCB_{t-1} \end{bmatrix} + \begin{bmatrix} b11 & b12 & b13 \\ b21 & b22 & b23 \\ b31 & b32 & b33 \end{bmatrix} \begin{bmatrix} \epsilon_t^{\text{CSD shock}} \\ \epsilon_t^{\text{CYD shock}} \\ \epsilon_t^{\text{CCB shock}} \end{bmatrix}. \tag{8}$$

The first stage regression: Let u^{CSD}, u^{CYD} and u^{CCB} be the reduced form residual for the CSD, CYD and CCB, respectively. The first stage extracts the variation in the u^{CSD} that is due to the IV. We estimate β as $cov(b11\epsilon_t^{\text{CSD shock}}, Z_t)/var(Z_t)$ based on the assumption of external instrumental methodology as specified by E1. (7):

$$u_t^{CSD} = \alpha + \beta Z_t + w_t. \tag{9}$$

The second stage regression: To identify the effect of the instrument on CYD and CCB, we need to estimate the ratio b21/b11 and b31/b11 from the two stage least squares regression of u_t^{CYD} and u_t^{CCB} on $\widehat{u_t^{CSD}}$, where $\widehat{u_t^{CSD}}$ is fitted value from the first stage regression. We estimate $\gamma_1 = b21/b11$ and $\gamma_2 = b31/b11$ under the identifying assumption that shocks to CYD

space limit.

and CCB are transmitted through the instrument's effect on CSD:[10]

$$\begin{aligned} u_t^{CYD} &= \alpha + \gamma_1 \widehat{u_t^{CSD}} + w_t \\ u_t^{CCB} &= \alpha + \gamma_2 \widehat{u_t^{CSD}} + w_t \end{aligned} \tag{10}$$

Lastly, we normalize b11 to 1, b21 and b31 therefore equal to γ_1 and γ_2, respectively.

4.3.1 Instrument Variable For CSD: Financial Intermediaries' Balance Sheet Constraint Shocks

We use the SVAR with external instruments to identify the effect of financial intermediaries' balance sheet constraints. We hypothesize that dealers with balance sheet constraints need to lower their risky asset demand to meet minimum requirements such as the Tier 1 capital ratio. Therefore, we use the "intermediary capital risk factor" proposed by He, Kelly and Manela (2017). This measure the monthly growth rate of primary dealers' capital ratio, and is an external instrument to identify the risky component of dollar asset demand. We examine the exclusion restrictions requirements by looking at the correlation between the change in IV and the change in CSD, CYD and CCB. Table 4 reports the results. Notably, the IV has a consistent and significant positive correlation with CSD but an ambiguous and insignificant correlation with CYD. The results are consistent with our assumption that the dealer's balance sheet constraints directly affect the risky dollar asset demand but do not affect the safe dollar asset demands. In addition, the IV is negative and significantly correlated with CCB, but our analysis mainly takes CCB as an additional control for the cross-border dollar liquidity. Our primary focus is the shock of CSD on CYD.

Figure 6a presents the IRF of a standard deviation shock to the CSD based on the financial intermediaries' balance sheet constraints shock IV. The first stage F-statistic is 98 with 0.32 of R^2, and this is above the threshold of 10 suggested by Stock, Wright and Yogo (2002) and rules out the weak instrument problem. When dealers are financially constrained, a negative shock to capital ratio increases the marginal value of a dollar to capital. Dealers then cut back

[10] Proves:
$\gamma_1 = cov(u_t^{CYD} \widehat{u_t^{CSD}})/var(\widehat{u_t^{CSD}})$
$cov(u_t^{CYD}, \widehat{u_t^{CSD}}) = cov(b21\epsilon_t^{\text{CSD shock}}, \beta Z_t) = b21\beta cov(\epsilon_t^{\text{CSD shock}}, Z_t)$
$var(\widehat{u_t^{CSD}}) = \beta^2 var(Z_t)$

$$\gamma_1 = \frac{b21\beta cov(\epsilon_t^{\text{CSD shock}}, Z_t)}{\beta^2 var(Z_t)} = \frac{b21 cov(\epsilon_t^{\text{CSD shock}}, Z_t)}{\beta var(Z_t)}$$

Replacing $\beta = cov(b11\epsilon_t^{\text{CSD shock}}, Z_t)/var(Z_t)$ We can get $\gamma_1 = b21/b11$. Under the same procedure, we also can get $\gamma_2 = b31/b11$.

on risky dollar corporate bonds due to the tight banking regulation. The reduction in risky dollar asset demand increases U.S. corporate bond spreads relative to non-U.S. spreads (CSD $\downarrow$). A substitution toward safe dollar assets has opposite effects on the convenience yield (CYD $\uparrow$). This substitution effect is only significant contemporaneously, which indicates that primary dealers immediately react to the tightening of balance sheet constraints. Dealers are also limited in exploiting the CIP arbitrage (acts as dollar supplier side in the FX market) because of a higher marginal value of the dollar to capital. This translates to an increase in the premium to borrow dollars in FX swap markets, widening CCB. Quantitatively, we find a one standard deviation (18.6 basis points) decrease in CSD leads to a 2.41 basis points increase in CYD, and a 4.64 basis points increase in CCB. In unreported results, we also test the substitution effect by excluding the 2008 global financial crisis period (December 2007 to May 2009). The results remain robust.

4.3.2 Instrument Variable For CYD: Monetary Policy Shocks

Monetary policy could directly affect the U.S. Treasuries market and transmit to the foreign demand on safe dollar assets. For example, a tight U.S. monetary policy shock leads to a higher yield on U.S. treasuries, lifting up the return on holding safe dollar assets, which in turn leads to a higher safe dollar asset demand. Therefore, we use monetary policy shock as an external instrument to identify the safe dollar asset demand shock. Following Kearns, Schrimpf and Xia (2022), we construct the monetary policy shock as the 1-month OIS rate changes around U.S. scheduled monetary policy announcements. We calculate the change in an event window that is 15 minutes before and after the announcement, with a 5 minute adjustment to account for potential mismatch of the announcement timestamp with the data. $\Delta r_t = \overline{r_{t+5\,\text{min}\to t+20\,\text{min}}} - \overline{r_{t-20\,\text{min}\to t-5\,\text{min}}}$. We then convert the high-frequency monetary policy shock to a monthly level by taking a mean of the Δr_t within the month. We set values to 0 if the month has no scheduled monetary policy announcements.

Figure 6b presents the IRF of CYD shock based on the monetary policy shock IV. Compared to the IRF with standard SVAR, the external instrument methodology helps us to separate the substitution effect channel from the safe dollar asset demand to the risky dollar asset demand. Quantitatively, a one standard deviation (18 basis points) increase in CYD contemporaneous leads to a decrease in CSD of 27.9 basis points. In addition, the safe dollar demands shock results in an insignificant effect on the CCB in both the short- and long run. This result is consistent with the fact that we observe a low correlation between CYD and CCB over the full sample. One limitation of our IV is that the F-statistics is only 3.3, indicating a potential weak IV problem. This is a common problem when using a high-frequency shock at a monthly frequency. However, in terms of the economic intuition on the link between the monetary policy shock and safe dollar asset demand shock, our results offer some insight on the effects of US monetary policy on the substitution between safe and risky dollar assets.

4.4 Impact on the FX Market

The foreign demand on U.S. assets and cross-border liquidity have a close connection with the FX market. For example, Jiang, Krishnamurthy and Lustig (2021) propose a safe asset demand channel, in which a higher safe dollar asset demand would contemporaneously lead to an appreciation in the spot USD exchange rate. Our decomposition allows us to investigate the effect of each component of the corporate basis on the dollar.

We start with a simple OLS regression. The dependent variable is the monthly change in the log of spot dollar value against a basket.[11] The main independent variables include the first difference in the corporate basis, the U.S. Treasury Premium, CSD, CYD and CCB. In addition, we control the market risk by the VIX. Table 5 presents the regression results. Column (1) indicates that the corporate basis has a negative impact with a coefficient of -7.12 on the dollar value with a 5% significance level. One standard deviation (13.7 basis points) decrease in the hedged risky dollar asset demand (the corporate basis) would lead to 0.98% (98 basis points) appreciation in the dollar value. Most importantly, this effect is mainly attributed to CSD as shown in columns (3), (5) and (6). For example, column (3) shows that one standard deviation (18.6 basis points) decrease in CSD results in an appreciation of USD by 1.34%.

The Columns (2) and (3) find the Treasury premium has a positive and significant effect on the dollar appreciation, supporting evidence in Jiang, Krishnamurthy and Lustig (2021). A one standard deviation (14.8 basis points) increase in the Treasury premium leads to a 2.39% appreciation in the dollar value based on column (2) with a coefficient of 16.18. We can decompose the U.S. Treasury premium into the safe dollar asset demand (CYD) and the cross-border dollar liquidity scarcity (CCB). A one standard deviation increase (18 basis points) in CYD leads to a 2.3% appreciation in the USD, and a one standard deviation (10.7 basis points) increase in CCB leads to a 2.55% appreciation.

We extend our SVAR results for the IRF of a CSD and CYD shock in Figures 7a and 7b. Figure 7a presents the IRF of CSD shock using the financial intermediaries' balance sheet constraints shock IV. A negative shock on primary dealers' balance sheet constraints results in lower demand on risky dollar assets (CSD) due to the tight regulation and an increase in the demand for safe dollar assets due to the substitution between safe and risky assets. The limited

[11]The basket of currencies include AUD, CAD, CHF, EUR, GBP and JPY.

dealer leverage reduces the capacity to arbitrage in FX swap markets, resulting in a widening of CIP deviations. The declining risk-bearing capacity of financial intermediaries also results in excess returns on the dollar. Figure 7b presents the IRF of CYD shock based on the monetary policy shock IV. Consistent with the OLS regression, there is a safe asset demand channel where a positive shock on the safe dollar asset demand leads to an appreciation of the dollar.

4.5 Holdings-level Evidence

In this section, we investigate the holdings level evidences for the substitution effect between the demand for the safe and risky dollar assets. We obtain the foreign investors' aggregate transaction on U.S. assets from the Treasury International Capital (TIC) S-form data. TIC forms collect the monthly transaction data on cross-border purchases and sales of U.S. assets from U.S.-resident broker-dealers that are responsible for securities transactions with nonresidents, issuers, investors, and money managers. Bertaut and Judson (2014) discuss the TIC data and point out two limitations of the data. First, the TIC data records the transactions based on the country of the first cross-border counterparty, not of the ultimate buyer, actual seller, or security issuer. Second, the TIC data does not record certain types of cross-border securities flows that do not pass through standard broker-dealer and other TIC reporter channels, such as principal repayment flows of asset-backed securities and cross-border acquisitions of stocks through merger-related stock swaps or re-incorporations. Nevertheless, even though the TIC data has certain limitations for the cross-border transactions at the country level, it still provides good-quality data for the aggregate transactions of foreign investors in U.S. Treasuries and corporate bonds.

To measure the foreign investors' holdings of U.S. assets, we obtain the historical foreign investors' net purchases of U.S. assets from *Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities.*[12] We proxy foreign investors' net purchases on USD corporate bonds using the column of *Corporate Bonds: U.S. Corporate Bonds (Long-term), Net Purchases*. Net purchase is the purchase net of the sales. We assume most U.S. corporate bonds are denominated in USD because of the dominant position of dollar bonds in the international market. We measure foreign investors' net purchases in U.S. Treasuries as the sum of *Treasury Bonds and Notes, Net Purchases* and *U.S. Treasury Bills, Net Purchases*. Moreover, we separate the foreign investors into foreign private investors and foreign sovereign investors. Our focus is on foreign investors' holdings of U.S. corporate bonds and Treasuries during two crisis episodes: the 2008 financial crisis and the 2020 Covid pandemic periods.

[12] Data website: https://home.treasury.gov/data/treasury-international-capital-tic-system-home-page/tic-forms-instructions/securities-a-us-transactions-with-foreign-residents-in-long-term-securities

The left panel of Figure 8a shows foreign private investors' substitution demand between dollar risky and safe assets during the 2008 financial crisis. Foreign private investors reduce their holdings of U.S. corporate bonds and increase their holdings of U.S. Treasury bonds in March 2008, the month when Bear Sterns collapsed due to large mortgage-related losses, and from July 2008 to November 2008, when the financial crisis was at its worst. The subprime mortgage crisis represents a typical episode in which the financial intermediaries suffer a negative shock to their balance sheets and, consistent with our previous findings on the substitution effect between safe and risky dollar assets, foreign investors purchase U.S. Treasuries and sell U.S. corporate bonds simultaneously.

We then look at the period around the Covid-19 pandemic, which is shown at the right panel of Figure 8a. The U.S. and global financial markets took a heavy hit in March 2020, triggered by concerns regarding the pandemic. We find that foreign private investors have a significant outflow from U.S. Treasuries and a negligible inflow to the U.S. Corporate bonds in March 2020. The sharp outflow from the U.S. Treasuries is in sharp contrast with the behavior of foreign investors during the 2008 GFC, suggesting that U.S. Treasuries are no longer considered as as safe assets for foreign investors. This phenomenon is consistent with several stylized facts documented in the literature. Cesa-Bianchi and Eguren Martin (2021) document a "dash for dollar" phenomenon during the 2020 pandemic, in which investors in need of the U.S. dollar sold their bonds denominated in USD first. Ma, Xiao and Zeng (2020) show that during the 2020 Covid pandemic, mutual funds followed a pecking order by first selling their liquid assets (such as U.S. Treasuries) to meet the sharp redemption pressure. He, Nagel and Song (2022) show that the Treasury market experienced severe stress and illiiquidity during the Covid-19 crisis, due to concerns about the U.S. Treasuries' safe-haven status.

We further study the effect of a negative CSD shock on foreign private investors' net purchases of U.S. assets using the structural VAR framework, and report the IRF in Figure 8b. Based on the financial intermediaries' balance sheet IV SVAR, one standard deviation negative shock to CSD contemporaneously leads to a negative change of around \$6.88 billion in the net bond flow by foreign investors. The net bond flow is the foreign private investors' transaction difference between the US corporate bonds and the US Treasury securities.

5 Substitution Effect: International Evidences

In our previous discussions, we estimate the CSD and CYD between non-USD currencies and USD (as the fixed-leg), and identify the dollar risky and safe asset demand through the shocks on CSD and CYD. This section extends the analysis to the international level.

We re-estimate CSD and CYD by using major non-USD currencies (AUD, CAD, CHF, EUR, GBP and JPY) as the fixed-leg currency. To avoid potential confounding effect from dollar bonds, we exclude USD-denominated corporate bonds in our estimation of CSD and CYD for non-USD currencies. Table 6 presents the summary statistics of the CYD and CSD for other non-USD currencies. The first column displays the currency of the fixed-leg and indicates that the U.S. is not the only countries with significant (non-zero) CYD and CSD. Indeed, almost all other six countries exhibit a persistent pricing difference between bonds denominated in non-fixed-leg currencies and the fixed-leg currency, for both corporate bonds and government bonds.

Figure 9 complements our analysis of the substitution effect in Section 4.1. We find strong evidence of a negative correlation between CSD and CYD for bonds denominated in EUR, CHF, AUD, and CAD. Therefore, the substitution effect between safe and risky assets shows great empirical relevance to non-USD currencies as well.

We further examine the substitution effect using the SVAR analysis. Again, we rely on the financial intermediaries' balance sheet constraints shocks to identify the shock on the risky asset demand. The intuition is that the primary dealers in the US market also serve as the important financial intermediary in the global market, particularly for the advanced economies. Then, a negative shock on the primary dealers' balance sheet also would lower their demand for other risky assets. Second, we drop the USD-denominated bonds when estimating CSD and CYD for other fixed-leg currencies. In this way, we can eliminate the dominant effect of dollar assets. Our IV therefore could provide a reliable identification for the exogenous shock on risky asset demand. Figure 10 reports the IRF of one (negative) unit of CSD shock on CYD. There are significant substitution effects between risky and safe assets for EUR- and GBP-denomination assets, as shown in the top panel of Figure 10. We do not find significant substitution effects for other CHF-, JPY-, AUD- and CAD-denomination assets.

We then look at the foreign firms' issuance and foreign mutual funds holdings on corporate bonds with AUD, CAD, CHF, and EUR, GBP, JPY, and USD denominations. Specifically, we integrate three databases in Table 7. First, the SDC Platinum Global New Issues database provides global bond issuance-level data and has been used in our main analysis. Here, we only focus on the corporate bonds issued by foreign firms. Second, we use the International Debt Securities (IDS) from BIS. The definition of IDS is "*IDS are issued outside the local market of the country where the borrower resides. They capture issues conventionally known as Eurobonds and foreign bonds and exclude negotiable loans.*". We look at the outstanding IDS denominated in AUD, CAD, CHF, EUR, GBP, JPY and USD in March 2021. Lastly, We obtain foreign mutual funds holding data from Morningstar. Our Morningstar data consists of universe mutual funds with the investment category on US fixed income and mutual funds from the top 20 countries[13] (ranked by the total asset-under-management) with the investment category on global and emerging market economies fixed incomes. Then, we construct foreign mutual funds holdings on corporate bonds at the currency level; foreign funds refer to funds domiciled in countries other than the country corresponding to the currency of a bond. We look at the total holding at the end of March 2021. There are 4,031 funds in total, with 1,737 US funds and 1,570 European funds.

Overall, a significant amount of USD- and EUR-denomination corporate bonds have been issued by foreign firms and held by foreign mutual funds. Non-UK firms (mutual funds) also issued (held) a large amount of GBP-denomination corporate bonds. For CHF-, JPY- AUD- and CAD- denomination corporate bonds, on the other hand, the issuance and demands from foreign firms and mutual funds are relatively small. In other words, there is a pecking order of currencies in terms of international bond issuance and holdings. USD-, EUR- and GBP-denomination corporate bonds are the most popular ones in this pecking order, which are consistent with the strong substitution effect of the risky and safe assets dominated in these currencies.

6 Robustness Tests and Additional Discussions

6.1 Alternative Measures of Risk-free Rates

We use the LIBOR rate as the risk-free rate in our baseline analysis. Since LIBOR rate might contain a credit risk component relating to banks' creditworthiness, we test the robustness of our findings using alternative measures of risk-free rates. We use the Secured Overnight Financing Rate (SOFR), Canadian Overnight Repo Rate Average (CORRA), Euro Short-Term Rate (ESTR), Sterling Overnight Index Average (SONIA), Tokyo Overnight Average Rate (TONA) as the alternative risk-free rates for the U.S., Canada, Euro Area, the U.K and Japan. These rates serve as the new benchmark rates to replace the LIBOR in the bank lending and derivative markets and have negligible credit risk. For example, SOFR is the cost of borrowing cash overnight using U.S. Treasury securities as collateral. Due to the data availability, we only include the currency of CAD, EUR, GBP and JPY in our robustness tests. Due to data availability, the basis components are estimated only for the 1-year maturity.

[13] These are United States, Thailand, Luxembourg, Japan, Ireland, Australia, Canada, France, South Korea, United Kingdom, Switzerland, Austria, Denmark, Germany, Italy, Taiwan, Spain, Cayman Islands, Israel, Liechtenstein.

Figure 11a reports the stylized fact for the basis components estimated using the alternative risk-free rates. Consistent with our baseline results, the correlation between the monthly changes of CSD and CYD is -0.36, negative and statistically significant at the 1% level. The correlation between the levels of CSD and CYD decreases to -0.04, still negative but no longer statistically significant. Figure 11b plots the IRF to a CSD shock. A negative risky dollar asset shock results in a substitution toward safe dollar assets, a widening of CIP deviations, and a USD appreciation. We also find that a higher safe asset demand would result in an appreciation in the USD spot rate. The only divergence from our baseline results is about the effect of the CSD shock on the CCB measure. One possible explanation for the difference is that the risk-free rates are at one-year maturity, but other rates are at five-year maturity. This maturity mismatch would affect our estimation results. In summary, the estimation results based on alternative risk free rates are consistent with our key empirical findings on the dynamics of CSD, CYD and exchange rates, confirming the robustness of our baseline results.

6.2 Alternative Measures of CSD

We examine the robustness of CSD using four alternative measures in the Eq. (4). First, we add several extra controls to mitigate the potential omitting variables biases. The additional controls are the interaction terms between maturity buckets and rating buckets. We denote this CSD as "CSD with M*R". Second, we perform the tests on the sub-sample of non-US firms, which enables us to examine the validity of the USD-denomination effect for bonds issued only by non-US firms. We denote this CSD as "CSD with non-US". Third, we first estimate the firm-level CSD and then take the average value as the aggregate-level CSD. We denote this CSD as "CSD with Firm Level". Lastly, we replace the government bond yield with the AAA corporate bond yield in calculating credit spreads (Chen, Collin-Dufresne and Goldstein, 2009). For example, we use as the benchmark rate for the USD-denominated corporate bonds the effective yield of the ICE BofA AAA US Corporate indices with maturity buckets of 1-3 years, 3-5 years, 5-7 years, 7-10 years and 10+ years.[14] We denote the resultant CSD as "CSD with AAA Yield". This is to address the concern that, given that both CSD and CYD depend on the government yield, the variation of government bond yield may drive the substitution effect between the two.

The CSD estimated with alternative approaches moves closely with the baseline CSD, as shown in Figure 12a. We further examine the substitution effect using the alternative CSD measures and report the IRF of one negative unit of CDS shock to CYD in Figure 12b. All

[14]Due to the data available, we drop the sample with the CHF-denominated bonds.

results are consistent with the baseline results and demonstrate the substitution effect between dollar safe and risky assets.

6.3 CSD Based on Matched Bonds

We provide some anecdotal examples to provide more intuition on our estimation of CSD. For several matched EUR- and USD-denominated bonds issued by the same issuer, we calculate the CSD as the credit spread difference between the EUR-denomination bond and USD-denomination bond with similar remaining maturity and duration. Figure 13 compares the CSD based on the matched bond pairs with the CSD we estimated based on the cross-sectional regressions specified by Eq. (4). Clearly, the baseline CSD we used in the paper is quite close to the CSD estimated based on matched bond pairs.

6.4 Equity and Commodity Markets

In addition to the FX market, we also examine the connection of dollar asset demand and cross-border dollar liquidity with the equity and commodity market. We examine spillover effects of shocks to the corporate basis on the SPX (S&P 500) index, Non-U.S. index and commodity index. The non-U.S. index is the mean of the Austrian Traded Index, S&P/TSX Composite Index, Swiss Market Index, EURONEXT 100, FTSE 100 and Nikkei 225, and the commodity index is the Bloomberg commodity index. All indices are in log terms. Results for the SVAR model with the financial intermediaries' balance sheet constraints shock IV is presented in Figure 14. A one-standard-deviation (18.6 basis points) decrease in CSD contemporaneously leads to a decline of 11.7%, 11.4% and 5.7% in one month of the SPX index, non-U.S. index and commodity index, respectively.[15] This is consistent with the literature on intermediary asset pricing, in which the tightening of dealer leverage constraints increases the marginal value of a dollar of wealth, and leads to excess asset returns as risk compensation to the U.S investor (He, Kelly and Manela, 2017). A negative shock on the primary dealer leverage induces a persistent impact on other asset classes because of a lower risk-bearing capacity.

6.5 Economic Activities

Gilchrist and Zakrajšek (2012) show that shocks to the corporate bond credit spreads have a persistent impact on the economic activity. A decline in the risk-bearing capacity of primary dealers results in significant consequences for the macroeconomy. We can use our framework to study the effects of a dealer leverage shock on credit spreads and macroeconomic activity.

[15] The monthly return standard deviation of the SPX index, non-U.S. index and commodity index is 4.20%, 4.10% and 4.78%, respectively.

In our analysis, we consider macroeconomic variables such as CPI, industrial production, unemployment rate, real GDP, real investment and real consumption. CPI, industrial production and unemployment rate are at the monthly level, and real GDP, others are at the quarterly level. However, we only have quarterly data on the industrial production for Switzerland and Australia and quarterly data on the CPI for Australia. We match the quarterly level by taking a quarterly average of CSD, CYD, and CCB, and there is the intermediary capital risk factor at the quarter level. The unemployment rate is in percentage terms, and all other variables are expressed in log terms.

Figure 15 shows the IRF of a negative CSD shock on U.S. economic activity. In the SVAR with external instruments, using financial intermediaries' balance sheet constraint shock as an IV, we find spillovers to macroeconomic activity, with a decline in the U.S. CPI, industrial production, real investment, real consumption and real GDP with a rise in unemployment rates. In unreported results, we also find significant spillovers to non-U.S. economic activities (Canada, Japan, Euro Area, UK, Switzerland and Australia). Consistent with the results on the U.S. economic activity, a negative shock on risky dollar asset demand leads to a contemporaneous and subsequent deterioration in economic activity, with a decline in CPI, industrial production, real GDP, real investment, real consumption and a higher unemployment rate.

7 Conclusion

In this paper, we study the determinants of the corporate basis and investigate the effects of different financial shocks, especially shocks to financial intermediaries' balance sheets, on the dynamics of corporate basis, exchange rates and economic activities. We decompose the corporate basis into three components, credit spread differential, convenience yield differential, and the CIP deviation, which reflect, respectively, the risky asset demand, the safe asset demand, and the FX hedging risk. Our decomposition reveals a strong substitution effect between safe and risky assets. Using shocks to financial intermediaries' balance sheet constraints as the instrument variable, we find that a negative shock to credit spread differential results in a substitution between safe and risky assets, an appreciation of the USD, negative returns in the equity and commodity market, and deterioration in both U.S. and non-U.S. economy activities. Lastly, we provide holdings-level evidences consistent with the substitution effect between foreign investors' demand on dollar safe and risky assets.

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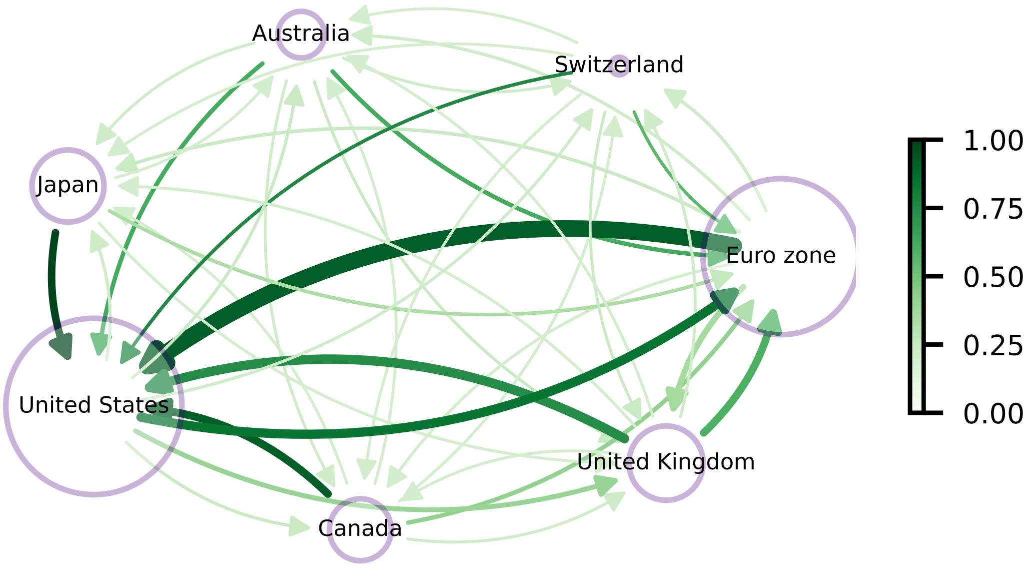
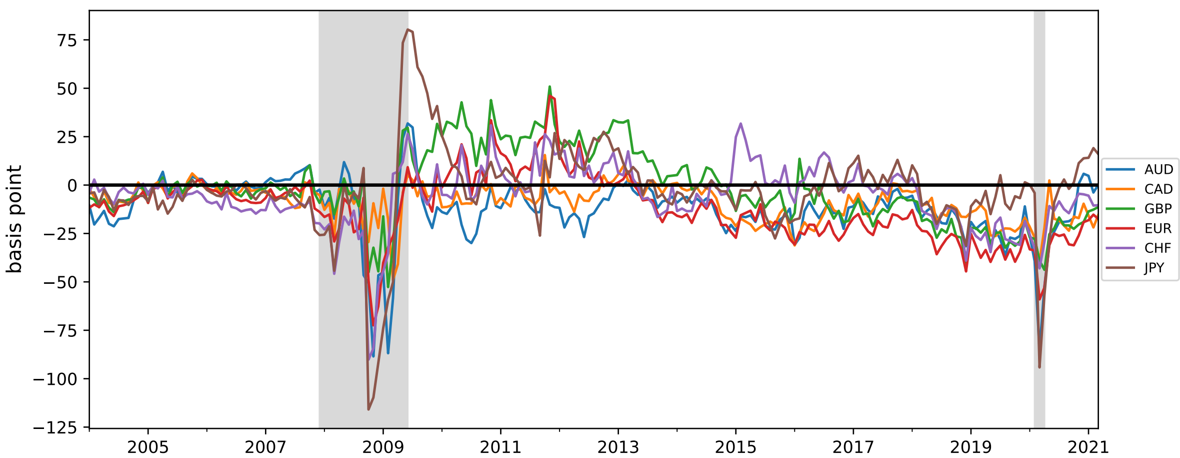
Figure 1: Cross-border Bond Issuance



This figure presents the cross-border issuance of corporate bonds with currency denominations in AUD, CAD, CHF, EUR, GBP, JPY, and USD, based on the bond outstanding data in March 2021. Purple circles depicts the total notional principal of outstanding bonds issued by the domestic firms. Green arrows from country/region A to B represents bonds that are issued by firm in L and denominated in the fiat currency of K: their size reflects the absolute amount of bonds in that category, and their color depth indicates the proportion of A's foreign currency bonds that are denominated in the currency of country/region B.

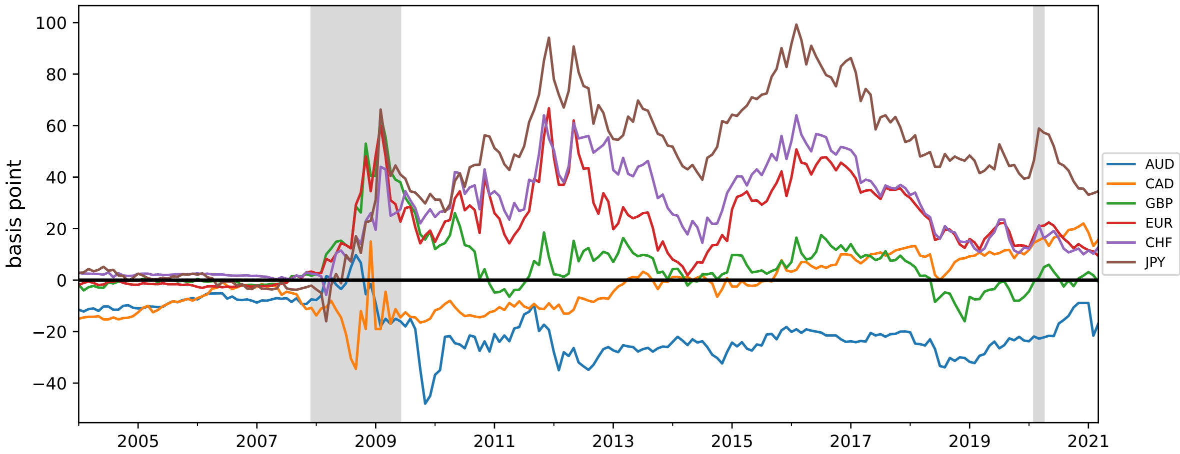
Figure 2: The Corporate Basis



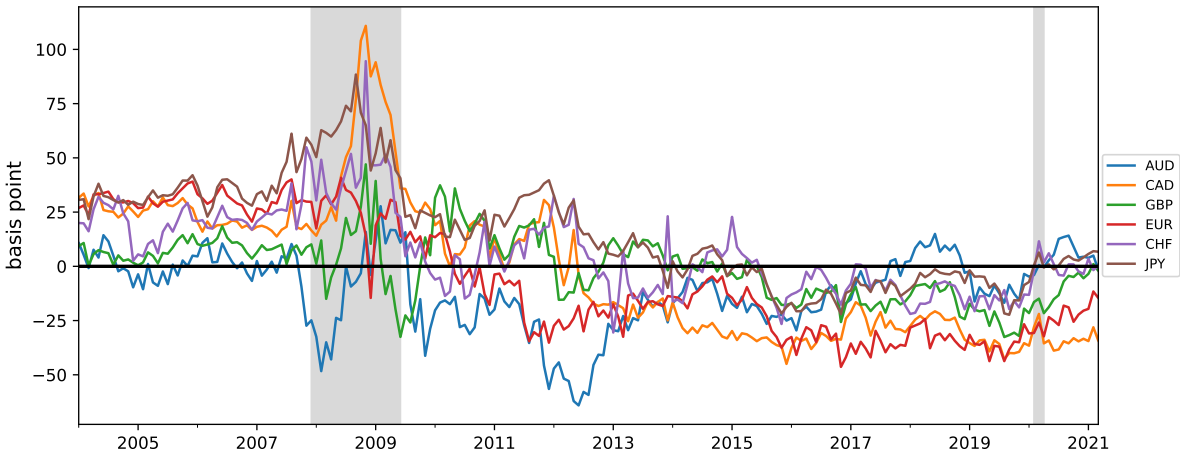
This figure presents the time series of corporate bases, which are estimated based on Eq. (4). The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 3: The Decomposition of Corporate Basis

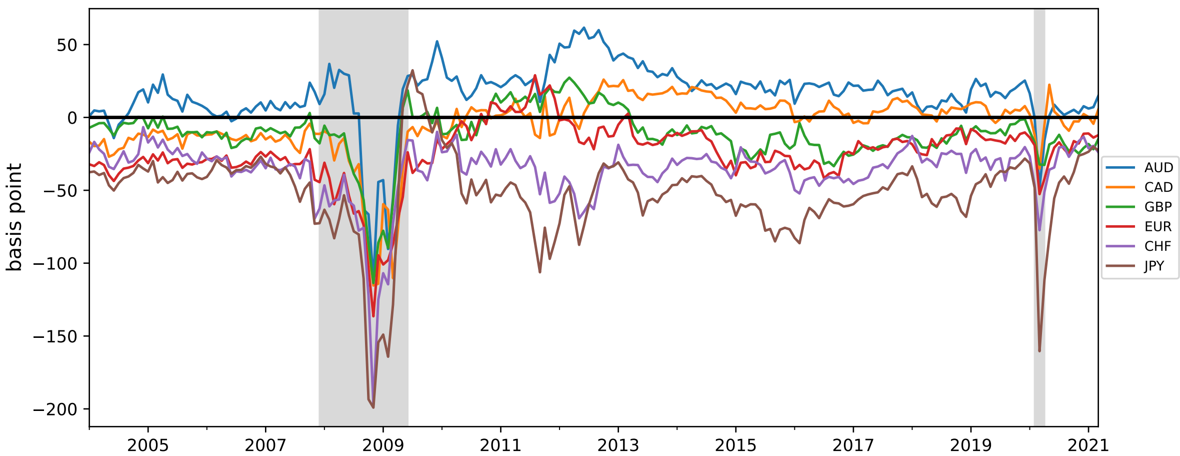
(a) Cross-currency Basis (CCB, 5-year)



(b) Convenience Yields Differentials (CYD, 5-year)

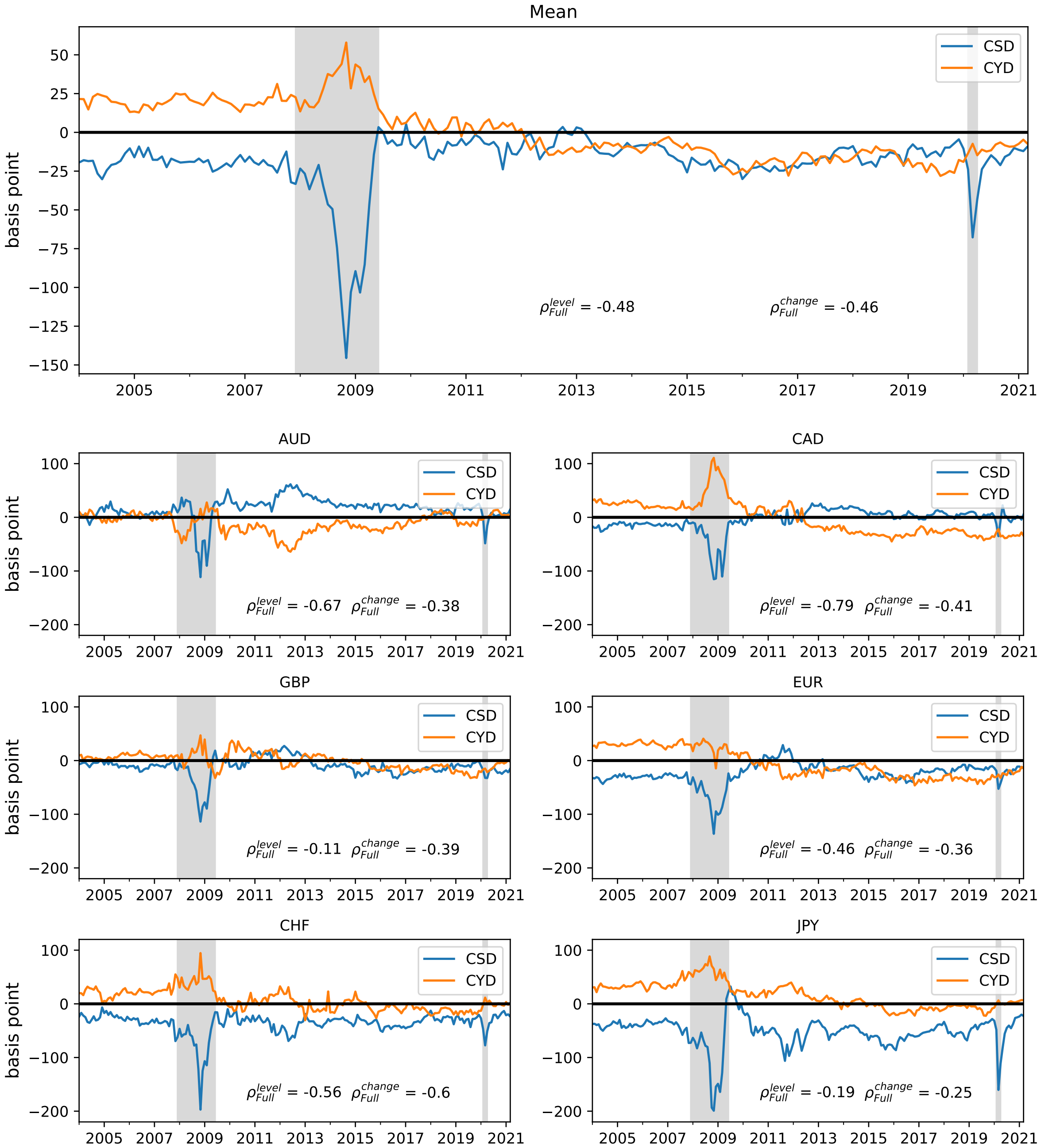


(c) Credit Spread Differentials (CSD)



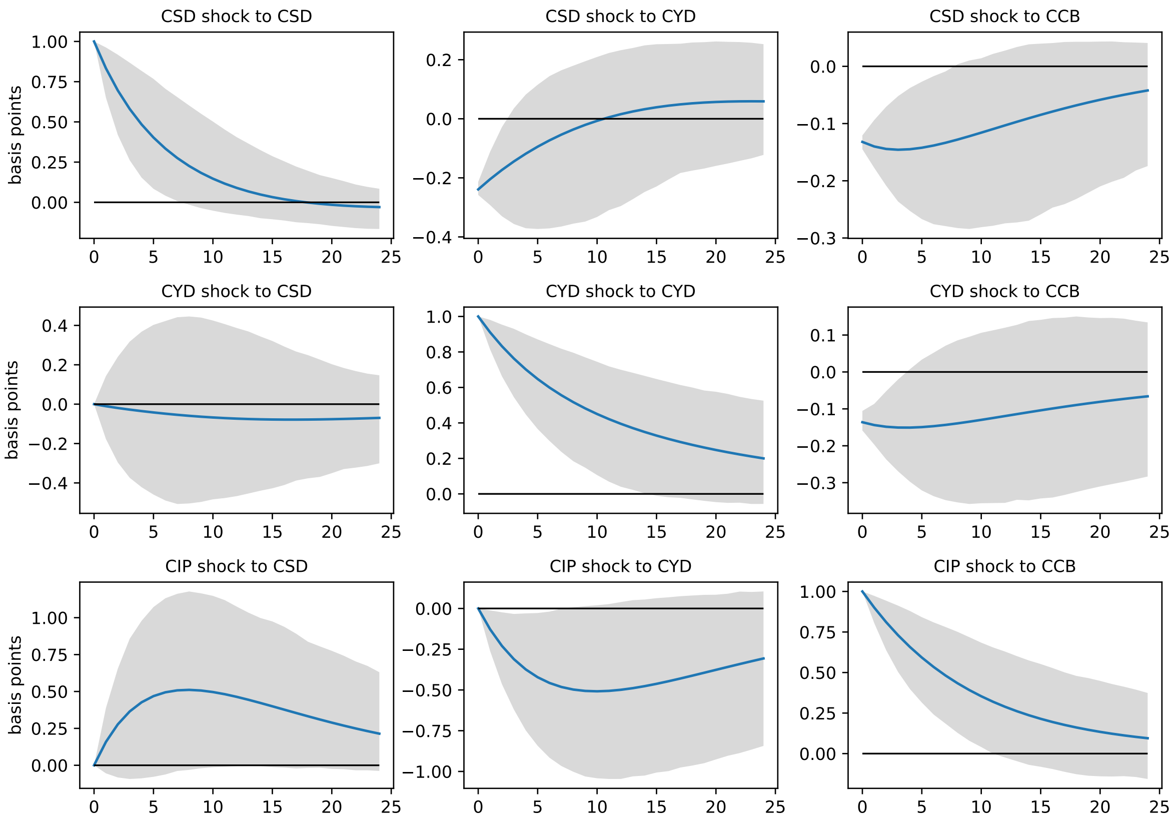
This figure presents the CSD, CYD (5-year maturity) and CCB (5-year maturity) which are estimated based on Eqs. (4) and (3). The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 4: A Substitution Effect Between Safe Dollar and Risky Asset



This figure presents the substitution effect between CSD and CYD in the Mean and currency level from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

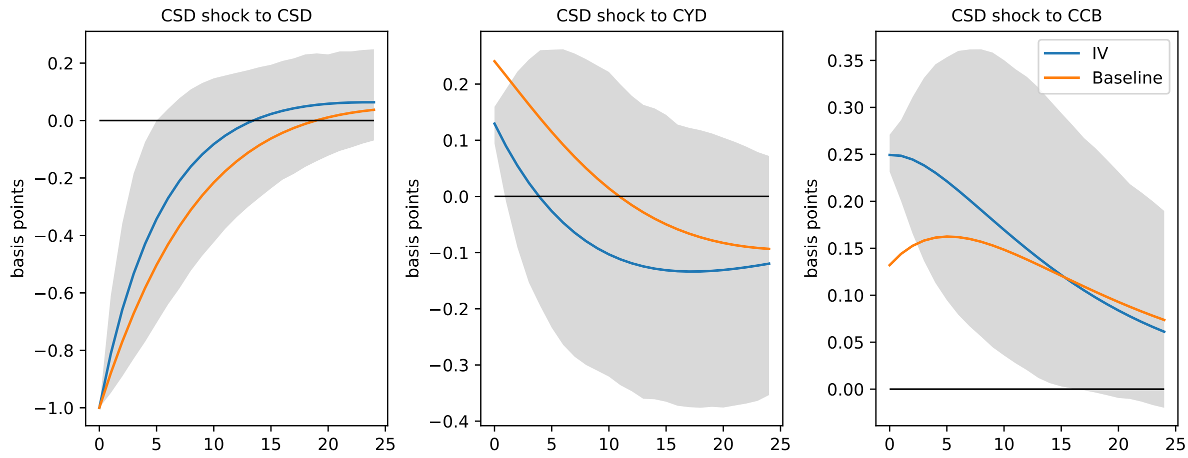
Figure 5: IRF of the Baseline SAVR Model with Zero-restrictions (Mean)



This figure presents the impulse response function (IRF) of one unit corresponding shock to each variable. The plots are based on 1,000 wild bootstraps. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD and CCB.

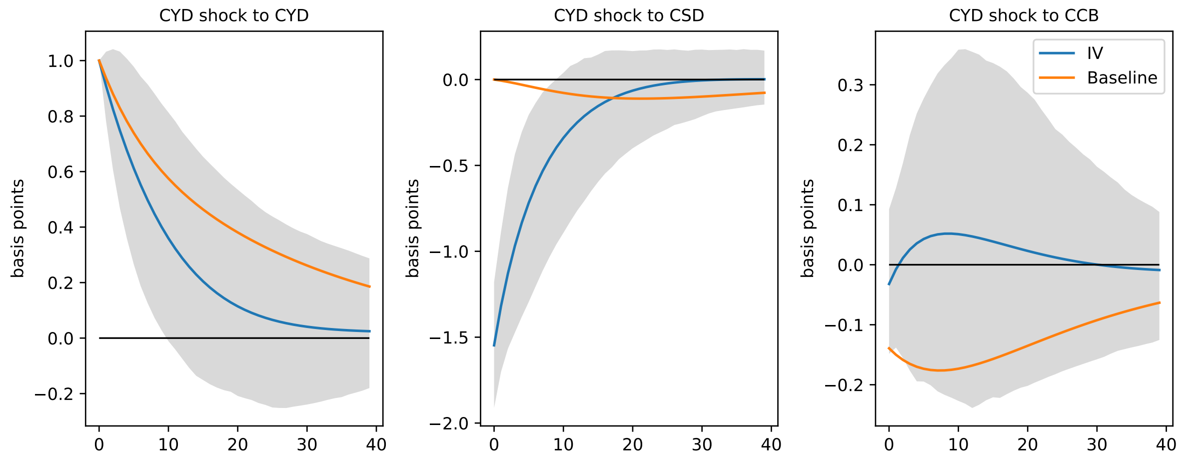
Figure 6: IRF of the SAVR Model with Instrument Variables (IV)

(a) IRF of the CSD Shock (Mean)



This figure presents the impulse response function (IRF) of one unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD and CCB. First stage regression: Coefficient: 72; F-statistics: 98; R^2: 0.32.

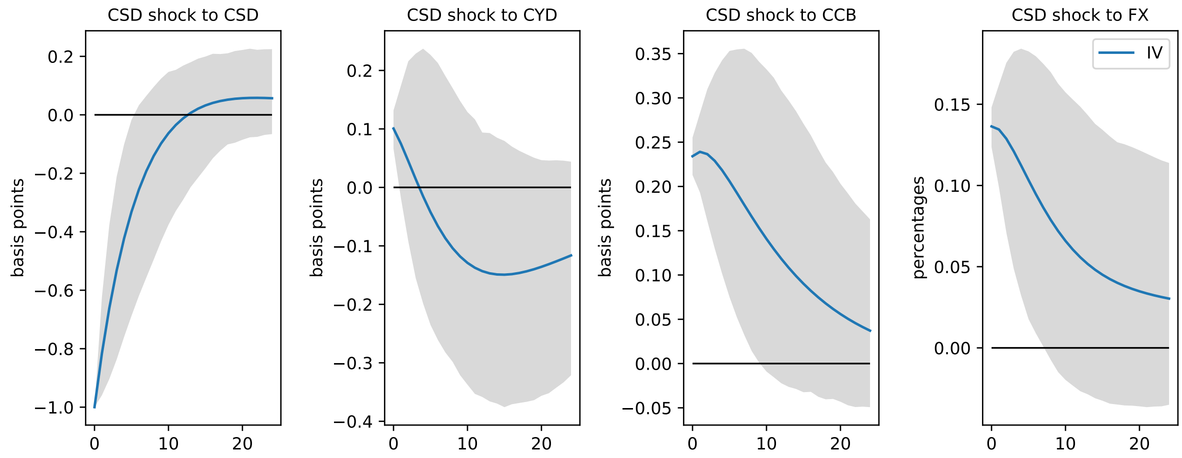
(b) IRF of the CYD Shock (Mean)



This figure presents the impulse response function (IRF) of one unit CYD shock to each variable. The plots are based on 1,000 wild bootstraps with the monetary policy shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD and CCB. First stage regression: Coefficient: 28.1; F-statistics: 3.3; R^2: 0.016.

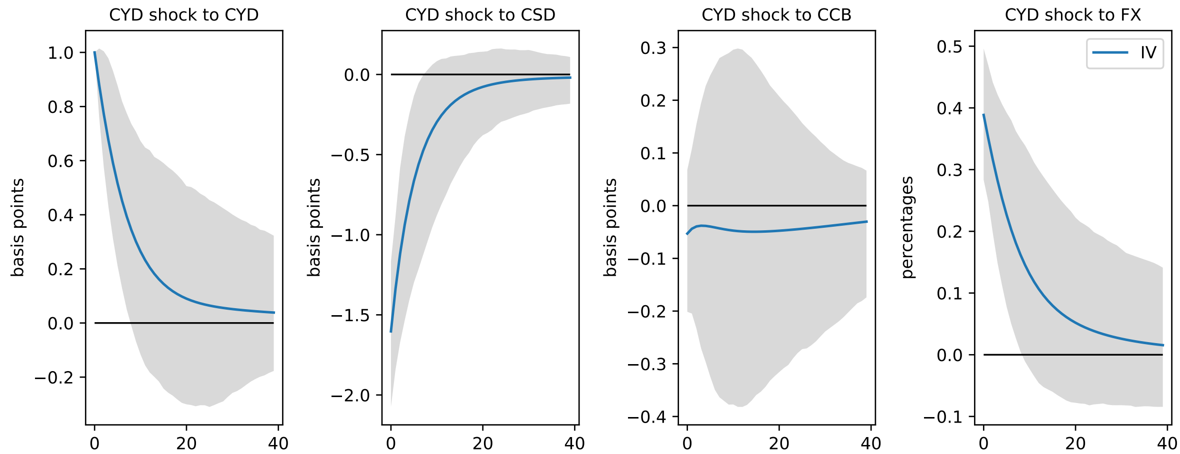
Figure 7: IRF of SVAR Model with the FX Market

(a) IRF of the CSD Shock with the FX Market (Mean)



This figure presents the impulse response function (IRF) of one unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD, CCB and log of the spot USD exchange rate. First stage regression: Coefficient: 71; F-statistics: 93; R^2: 0.31.

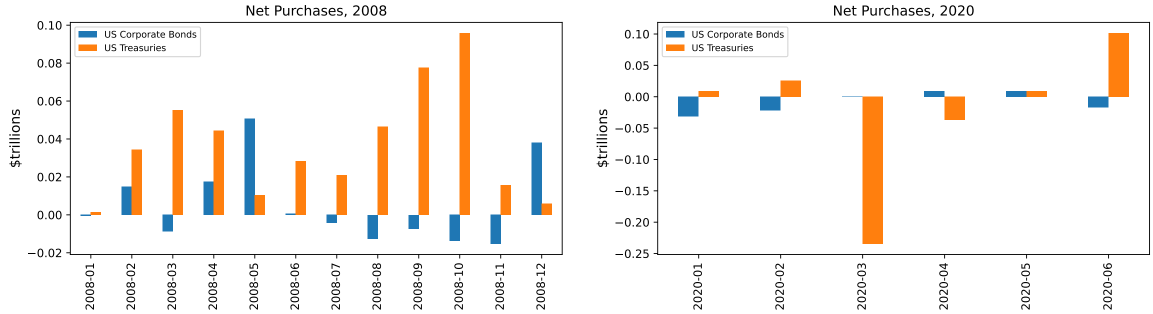
(b) IRF of the CYD Shock with the FX Market (Mean)



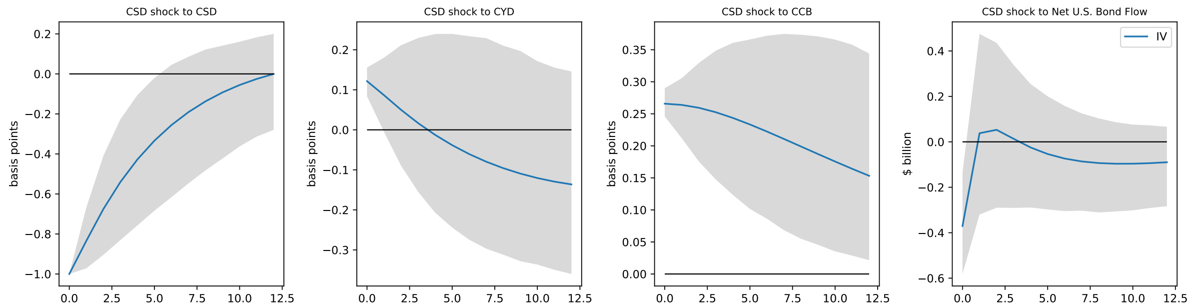
This figure presents the impulse response function (IRF) of one unit CYD shock to each variable. The plots are based on 1,000 wild bootstraps with the monetary policy shock shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD, CCB and log of the spot USD exchange rate. First stage regression: Coefficient: 27.2; F-statistics: 3.18; R^2: 0.020.

Figure 8: Holding Level Evidence

(a) Foreign Investors' Net Purchases of U.S. Assets



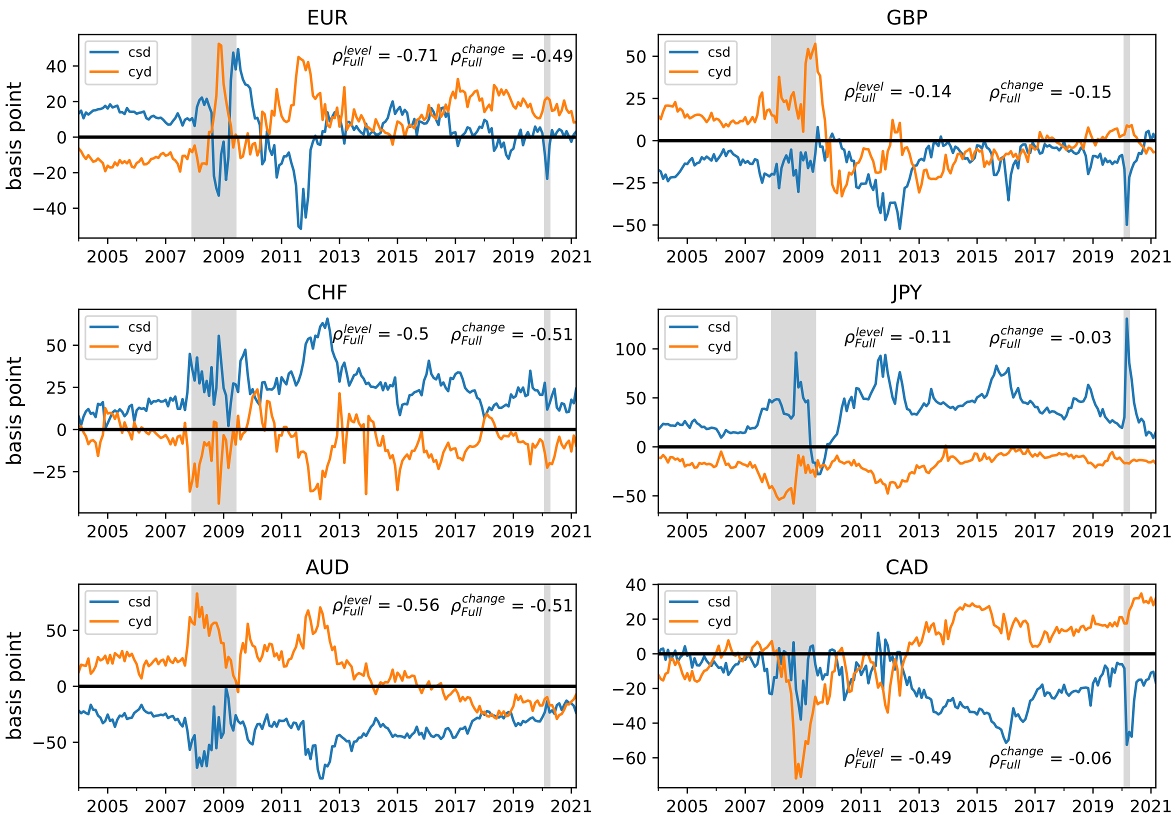
(b) SVAR Model Analysis with the Foreign Investors' Net U.S. Bonds Flow (Mean)



First stage regression: Coefficient: 68.00; F-statistics: 89.05 ; R^2: 0.30.

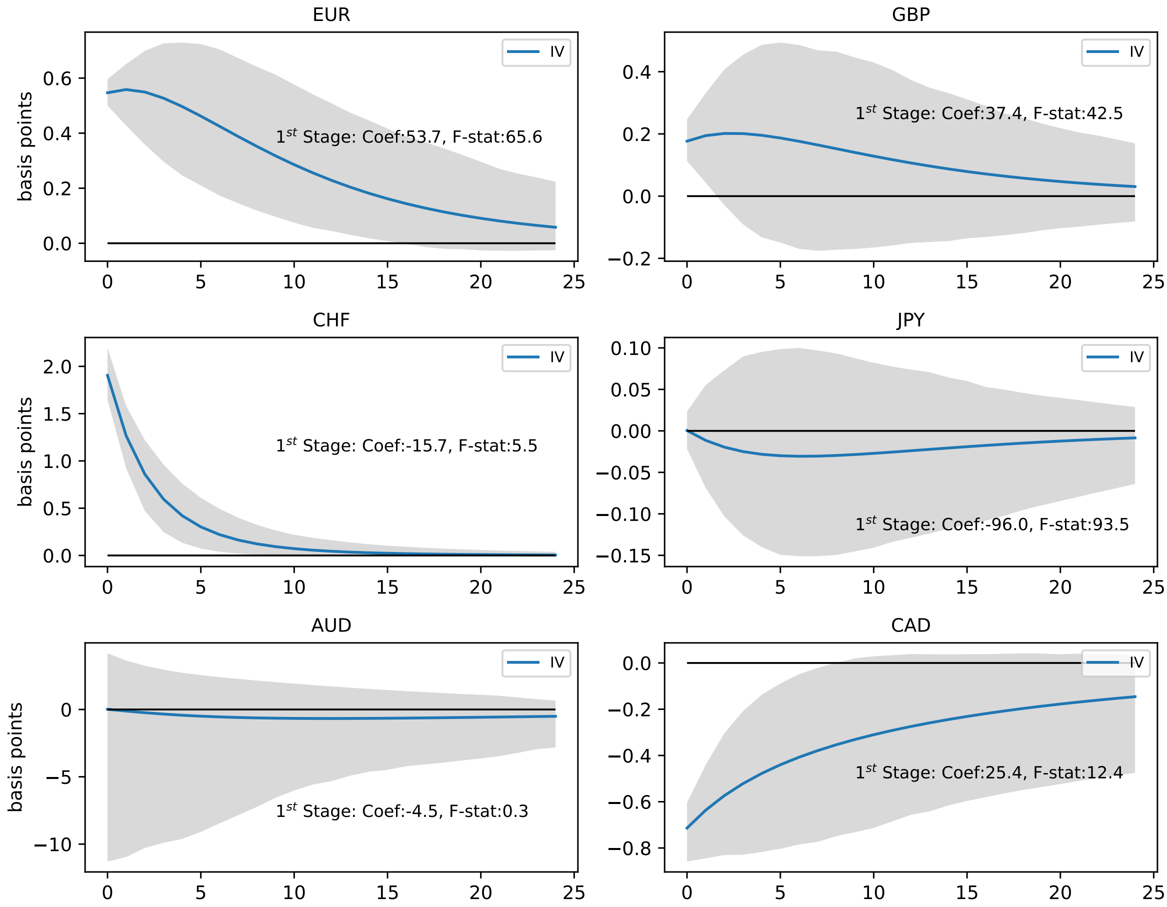
The top figure shows the foreign investors' net purchases of U.S. assets during the 2008 global financial crisis and the 2020 Covid pandemic period. The data is from TIC S form - Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities. The bottom figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The Net U.S. Bonds Flow is the difference in the net purchase of U.S. corporate bonds and U.S. Treasuries. The monthly sample is from January 2004 to March 2021, with the mean value of CSD, CYD, and CCB, as well as foreign private investors' net purchases of U.S. corporate bonds and U.S. Treasuries.

Figure 9: Substitution Effect for Non-USD Currencies



This figure presents the mean value of CSD and CYD using different fixed-leg currencies (indicated by the subfigure title) from January 2004 to March 2021. For example, the title with "EUR" shows the average of CSD and CYD between the currency pair with non-EUR currencies to EUR. The non-EUR Currencies are major funding currencies (AUD, CAD, CHF, GBP, and JPY). Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

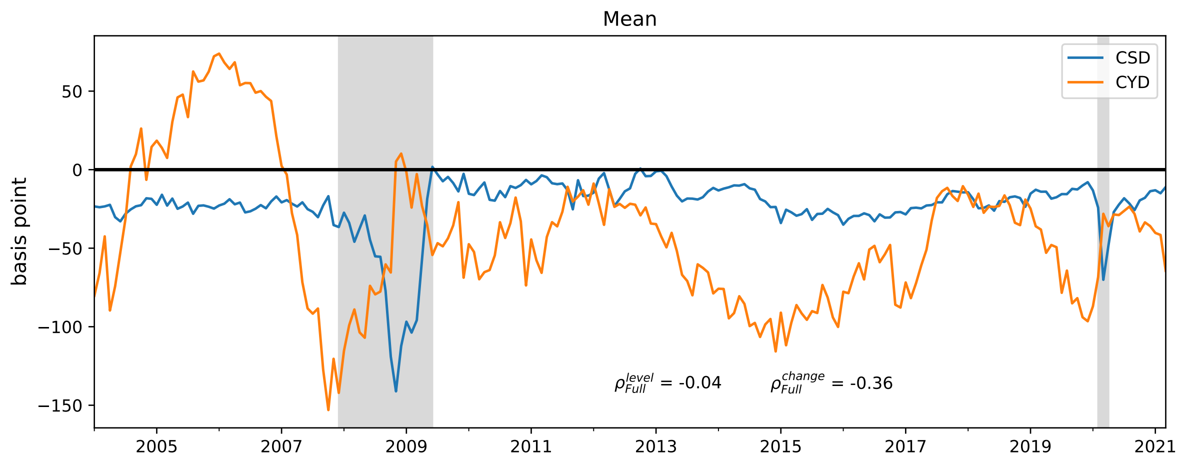
Figure 10: IRF of one negative CSD Shock on CYD (International Evidence)



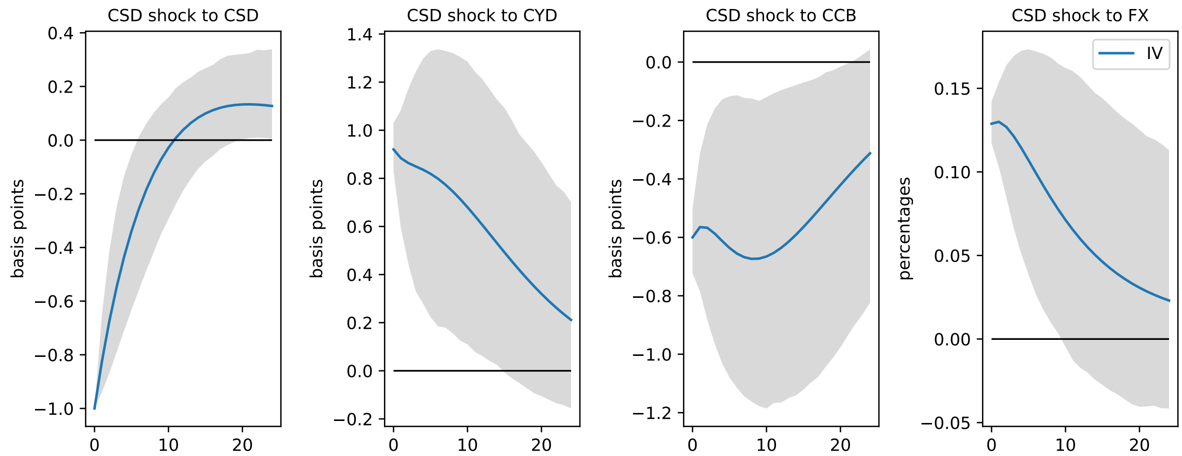
This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to CYD. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. CSD and CYD are estimated using the non-USD fixed-leg currency (indicated by the sub-figures title). For example, the title with "EUR" shows the average of CSD and CYD between the currency pair with non-EUR currencies to EUR. The non-EUR Currencies are major funding currencies (AUD, CAD, CHF, GBP, and JPY). The monthly sample is from January 2004 to March 2021. The first-stage regression result reports in the figure.

Figure 11: Robustness check using Alternative Risk-Free Rates (ARR)

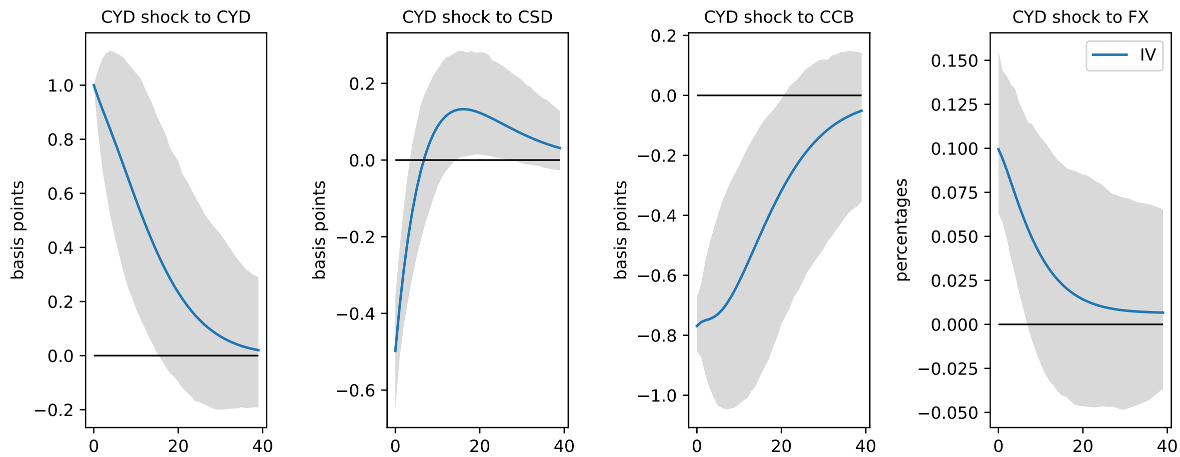
(a) Substitution Effect using Alternative Risk-Free Rates (ARR)



(b) SVAR Model Analysis using Alternative Risk-Free Rates (ARR) (Mean)



First stage regression: Coefficient: 67.53; F-statistics: 92.50 ; R^2: 0.32.

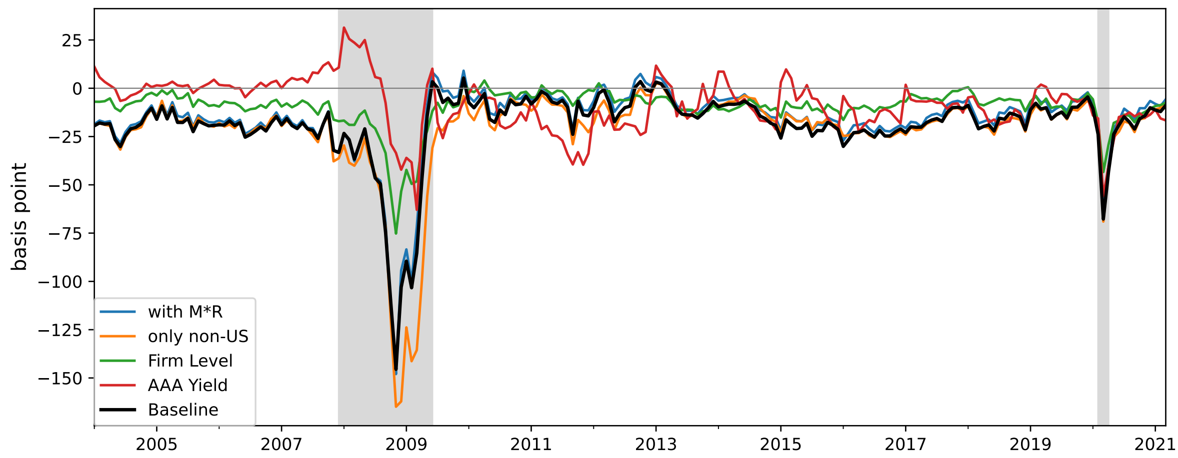


First stage regression: Coefficient: 90.80; F-statistics: 3.11; R^2: 0.015.

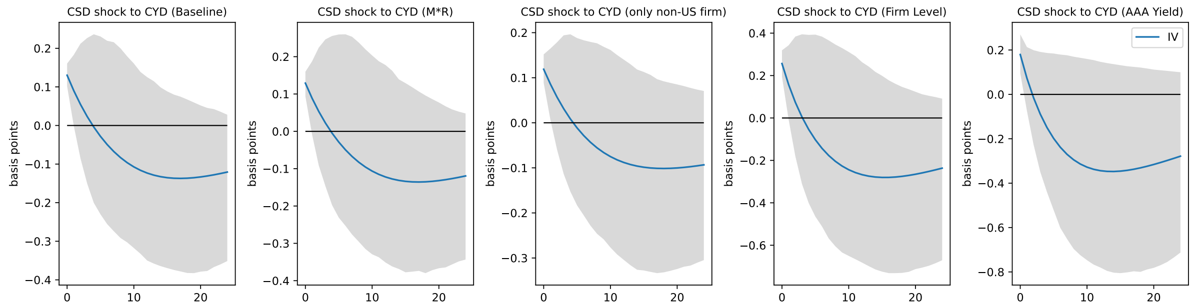
The top figure redraws the substitution effect with the CYD_{ARR} and CCB_{ARR}. The bottom figure redraws the SVAR model analysis with the ARR. The IVs are the financial intermediaries' balance sheet constraints shock and monetary policy shock for CSD shock and CYD shock, respectively. The sample is from January 2004 to March 2021 with the currency of CAD, EUR, GBP and JPY. The shadow areas indicate the recession period of the GFC and Covid-19 based on NBER business cycle dates, respectively.

Figure 12: Alternative Measures of CSD

(a) Alternative Measurement

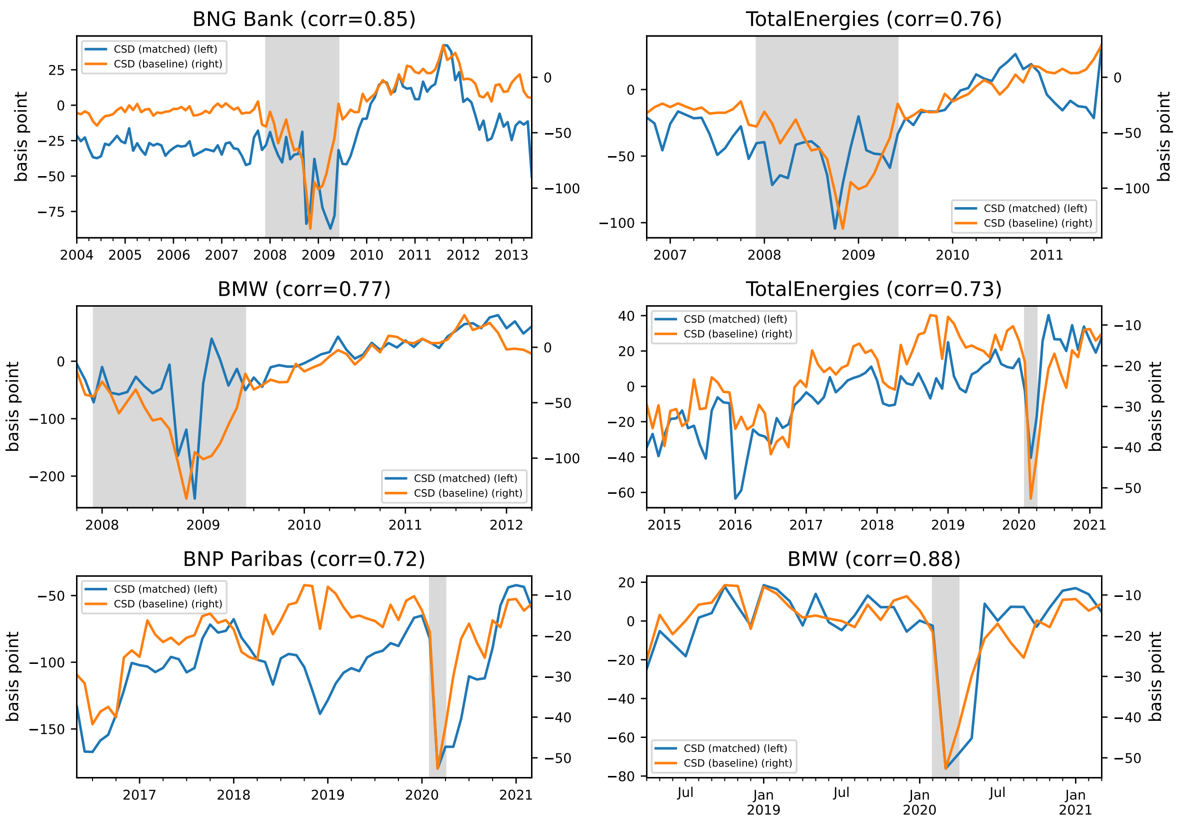


(b) SVAR Model Analysis (Mean)



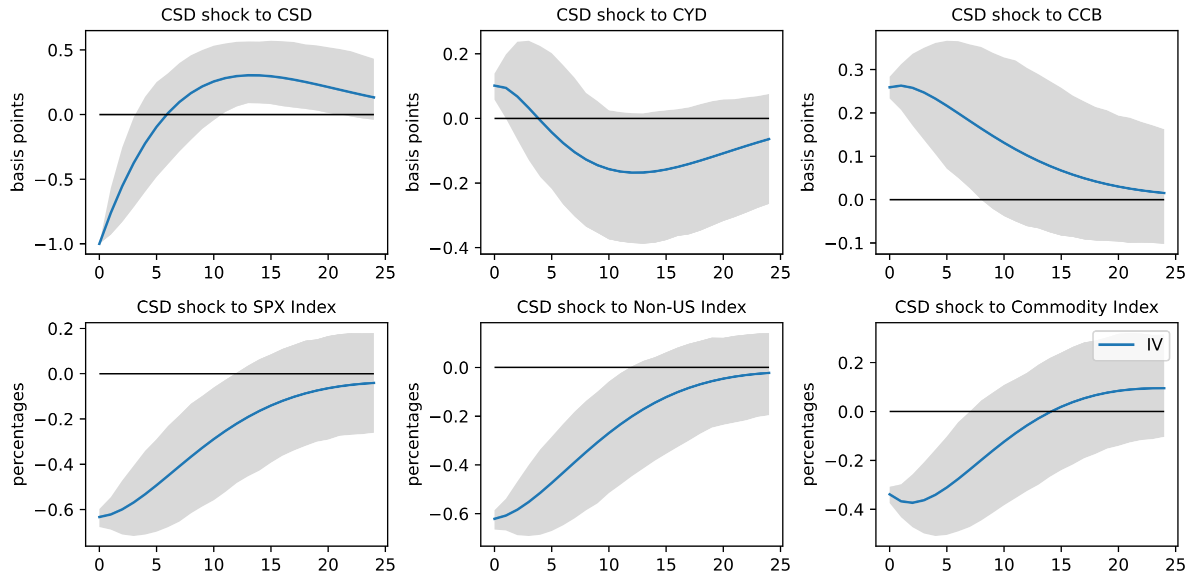
The top figure compares the baseline CSD with four alternative measures. The baseline CSD is the black line. The label "with M*R" line shows the alternative CSD, which adds the interaction terms between maturity buckets and rating buckets into cross-section regression. The label "only non-US" line shows the alternative CSD, which only uses the non-US firms' sample. The label "Firm Level" line shows the CSD, which takes the mean value of firm-level CSD. The label "AAA yield" line shows the CSD, which calculates the corporate bond credit spread as the bond yield net of the AAA bond yield. The bottom figure compares the substitution effect between CSD and CYD when using the baseline and alternative CSD. Each sub-figure shows the impulse response functions (IRF) of one (negative) unit CSD shock to CYD. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The monthly sample is from January 2004 to March 2021. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 13: Credit Spread Differentials Based on Matched Pairs of Bond



This figure presents the CSD at the bond pair-level. The bond pair-level (matched) CSD is the credit spread difference between a EUR-denomination bond and a USD-denomination bond issued by the same firm with similar remaining maturity and duration. The sub-figure title shows the parent firm's name and the correlation between CSD (matched) and the EUR-USD pair' CSD (baseline). Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

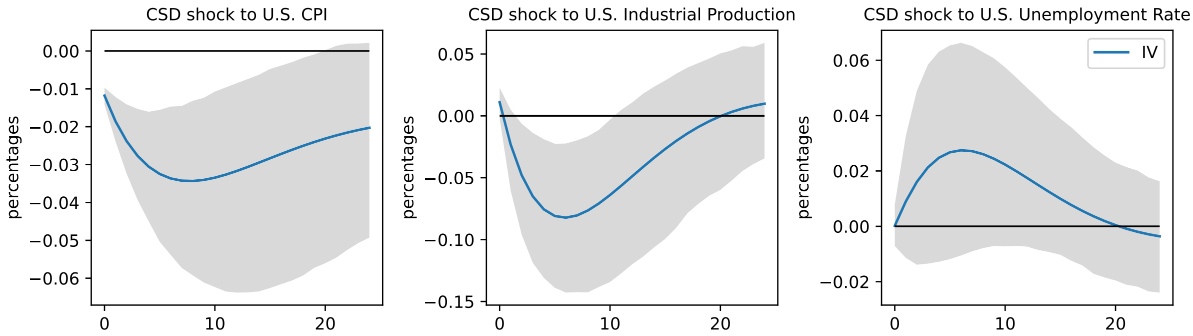
Figure 14: IRF of the CSD Shock with the Other Assets Classes (Mean)



This figure presents the impulse response function (IRF) of one unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD, CCB, log of SPX (S&P 500) index, log of Non-U.S. market index (Austrian Traded Index, S&P/TSX Composite Index, Swiss Market Index, EURONEXT 100, FTSE 100 and Nikkei 225) and log of the Bloomberg commodity index. First stage regression: Coefficient: 69; F-statistics: 91; R^2: 0.31.

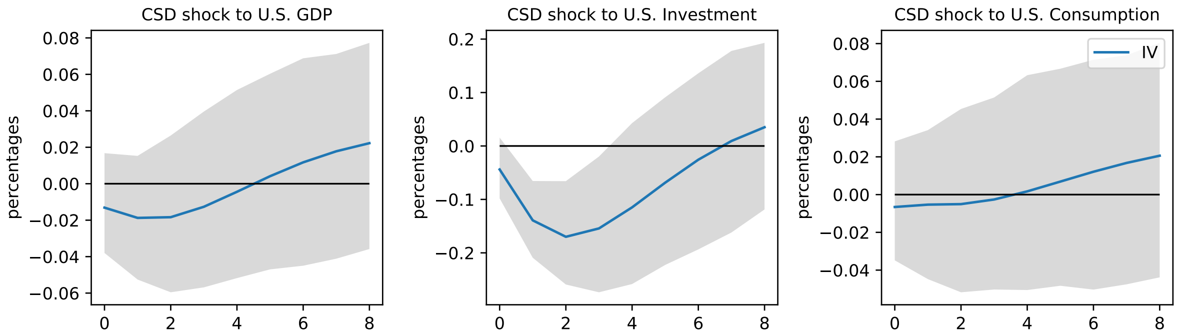
Figure 15: IRF of the CSD Shock with the U.S. Macroeconomic Activity (Mean)

(a) Monthly Variables



First stage regression: Coefficient: 71; F-statistics: 100; R^2: 0.33.

(b) Quarterly Variables



First stage regression: Coefficient: 49.89; F-statistics: 36.79; R^2: 0.36.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the Mean data of CSD, CYD, CCB, U.S. CPI, U.S. Industrial Production, U.S. Unemployment Rate, U.S. Real GDP, U.S. Real Investment and U.S. Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

Table 1: Corporate Bond Information - Currency Level

	No.	**Notl. $bil**	**No. Firms**		**No.**	**Notl. $bil**	**No. Firms**
All				**USD**			
Total	7189.6	5399.8	1438.0	Total	2,890.9	2,581.9	828.5
Rating				**Rating**			
AAA&AA	2174.6	1849.9	278.4	AAA&AA	662.0	771.4	148.6
A	2843.7	1967.1	514.5	A	1,058.6	906.2	273.8
BBB	1743.8	1279.4	488.6	BBB	884.9	701.8	278.2
HY (BB and below)	427.6	303.5	187.7	HY (BB and below)	285.4	202.5	140.4
Maturity				**Maturity**			
1-3 yrs	1809.5	1457.2	730.5	1-3 yrs	754.6	713.5	391.1
3-7 yrs	2819.3	2234.9	975.1	3-7 yrs	1096.8	998.3	538.0
7-10 yrs	1229.4	909.4	584.4	7-10 yrs	513.6	455.0	325.2
10+ yrs	1331.4	798.4	448.3	10+ yrs	526.0	415.1	229.2
% by Foreign Firms				**% by Foreign Firms**	44.1%	47.5%	56.0%
AUD				**CAD**			
Total	251.6	78.4	93.8	Total	280.6	115.1	94.8
Rating				**Rating**			
AAA&AA	166.6	58.5	45.8	AAA&AA	81.3	36.7	30.8
A	59.6	14.1	32.3	A	98.2	41.8	33.0
BBB	24.3	5.6	15.3	BBB	96.8	35.3	28.6
HY (BB and below)	1.2	0.2	0.9	HY (BB and below)	4.4	1.3	2.9
Maturity				**Maturity**			
1-3 yrs	90.1	25.5	53.7	1-3 yrs	74.0	33.8	45.7
3-7 yrs	110.9	36.6	60.2	3-7 yrs	102.1	50.4	58.3
7-10 yrs	39.5	11.7	26.7	7-10 yrs	34.3	13.0	25.2
10+ yrs	11.0	4.6	7.7	10+ yrs	70.3	17.8	29.1
% by Foreign Firms	70.2%	55.9%	72.7%	**% by Foreign Firms**	32.7%	28.0%	44.0%
CHF				**EUR**			515.4
Total	294.4	69.3	131.1	Total	1,702.7	1,915.0	118.3
Rating				**Rating**			
AAA&AA	156.7	35.0	54.8	AAA&AA	507.1	732.4	193.6
A	96.4	23.5	49.0	A	657.4	687.6	159.5
BBB	37.2	9.6	24.9	BBB	445.9	416.1	51.7
HY (BB and below)	4.2	1.2	3.0	HY (BB and below)	92.3	78.9	12.2
Maturity				**Maturity**			
1-3 yrs	85.9	21.5	66.8	1-3 yrs	438.5	526.3	259.3
3-7 yrs	139.3	33.3	85.5	3-7 yrs	784.6	908.2	361.8
7-10 yrs	42.2	9.6	31.7	7-10 yrs	290.8	320.2	175.2
10+ yrs	27.1	4.9	17.7	10+ yrs	188.9	160.3	103.9
% by Foreign Firms	86.8%	79.7%	86.6%	**% by Foreign Firms**	33.1%	30.9%	46.5%
GBP				**JPY**			
Total	479.0	295.9	246.2	Total	1,290.3	344.2	135.2
Rating				**Rating**			
AAA&AA	174.4	92.0	71.6	AAA&AA	426.5	123.9	41.1
A	162.0	114.1	85.4	A	711.5	179.8	67.2
BBB	128.5	82.0	82.4	BBB	126.3	29.0	23.9
HY (BB and below)	14.1	7.8	10.1	HY (BB and below)	26.1	11.5	4.8
Maturity				**Maturity**			
1-3 yrs	91.6	50.4	71.0	1-3 yrs	275.0	86.0	85.5
3-7 yrs	136.2	78.4	103.3	3-7 yrs	449.4	129.5	99.7
7-10 yrs	62.2	40.5	55.7	7-10 yrs	246.9	59.4	64.6
10+ yrs	189.0	126.5	115.5	10+ yrs	319.1	69.3	35.4
% by Foreign Firms	65.4%	64.6%	63.3%	**% by Foreign Firms**	9.1%	11.0%	37.9%

This table reports summary statistics for corporate bond data in the full sample. We classify in the currency level and report the monthly average of the number of bonds (No.), the notional value in $ billions (Notl. $ bil) and the number of corresponding firms (No. Firms) at the total level, rating level and maturity level. The sample is monthly from January 2004 to March 2021.

Table 2: Summary Statistics of CCB, CYD and CSD

		Full Sample Jan 04 to Mar 21	**Pre-GFC Jan 04 to Nov 07**	**GFC Dec 07 to May 09**	**Post-GFC Jun 09 to Mar 21**
			CCB		
AUD	Mean	-18.91***	-8.72***	-4.71**	-24.09***
	SEs	[0.66]	[0.29]	[1.91]	[0.51]
CAD	Mean	-2.29***	-8.22***	-14.04***	1.15
	SEs	[0.73]	[0.71]	[2.45]	[0.83]
GBP	Mean	5.89***	-0.75***	26.40***	5.49***
	SEs	[0.79]	[0.18]	[4.65]	[0.72]
EUR	Mean	19.82***	-1.49***	24.30***	26.31***
	SEs	[1.14]	[0.17]	[4.34]	[1.05]
CHF	Mean	24.51***	1.95***	15.50***	33.12***
	SEs	[1.26]	[0.09]	[3.26]	[1.2]
JPY	Mean	40.60***	0.22	16.51***	57.02***
	SEs	[2.02]	[0.38]	[5.34]	[1.42]
Average	Mean	11.60***	-2.84***	10.66***	16.50***
	SEs	[0.74]	[0.12]	[2.71]	[0.64]
			CYD		
AUD	Mean	-11.11***	0.66	-8.7	-15.31***
	SEs	[1.19]	[1.1]	[5.39]	[1.41]
CAD	Mean	-1.69	23.48***	56.78***	-17.43***
	SEs	[2.21]	[0.81]	[7.61]	[1.77]
GBP	Mean	-0.74	7.58***	8.65**	-4.69***
	SEs	[1.03]	[0.61]	[4.2]	[1.27]
EUR	Mean	-5.55***	30.67***	25.60***	-21.49***
	SEs	[1.87]	[0.61]	[2.84]	[1.22]
CHF	Mean	6.56***	21.83***	43.47***	-3.17***
	SEs	[1.35]	[1.28]	[3.65]	[1.02]
JPY	Mean	15.81***	35.08***	61.13***	3.69***
	SEs	[1.63]	[1.14]	[2.65]	[1.28]
Average	Mean	0.55	19.88***	31.16***	-9.73***
	SEs	[1.25]	[0.55]	[2.83]	[0.83]
			CSD		
AUD	Mean	16.03***	7.64***	-15.61	22.82***
	SEs	[1.51]	[1.16]	[10.97]	[1.23]
CAD	Mean	-4.42***	-14.51***	-51.59***	4.90***
	SEs	[1.49]	[0.68]	[8.75]	[0.81]
GBP	Mean	-11.43***	-8.47***	-42.63***	-8.45***
	SEs	[1.28]	[0.75]	[8.39]	[1.19]
EUR	Mean	-24.20***	-30.81***	-70.35***	-16.16***
	SEs	[1.46]	[0.67]	[6.59]	[1.15]
CHF	Mean	-36.45***	-29.18***	-78.40***	-33.55***
	SEs	[1.42]	[1.38]	[9.63]	[0.96]
JPY	Mean	-52.20***	-39.53***	-99.23***	-50.42***
	SEs	[2.07]	[1.13]	[12.9]	[2.01]
Average	Mean	-18.78***	-19.14***	-59.64***	-13.48***
	SEs	[1.29]	[0.67]	[8.99]	[0.75]
N		207	47	18	142

The table reports the mean (Mean), White heteroscedasticity-robust standard errors (SEs) and number of observations (N) of CSD, CYD (5-year maturity) and CCB (5-year maturity), which are estimated based on the equation 4 and equation 3. The full sample is monthly from January 2004 to March 2021. The sub-periods are Pre-GFC (Jan 2004 to November 2007), GFC (December 2007 to May 2009) and post-GFC (June 2009 to March 2021). *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 3: Variance Decomposition of Corporate Basis Movement

	$\frac{var(\text{CSD})}{var(\Psi)}$	$\frac{var(\text{CYD})}{var(\Psi)}$	$\frac{var(\text{CCB})}{var(\Psi)}$	$\frac{2cov(\text{CSD,CYD})}{var(\Psi)}$	$\frac{2cov(\text{CSD,CCB})}{var(\Psi)}$	$\frac{2cov(\text{CCB,CYD})}{var(\Psi)}$
AUD	1.32	0.56	0.10	-0.66	0.02	-0.05
CAD	1.82	0.73	0.36	-0.94	-0.55	-0.16
GBP	0.73	0.71	0.23	-0.55	-0.24	0.00
EUR	1.02	0.61	0.43	-0.58	-0.33	-0.05
CHF	1.48	0.97	0.25	-1.44	-0.30	0.18
JPY	1.09	0.15	0.14	-0.20	-0.24	0.06
Average	1.40	0.39	0.17	-0.69	-0.35	0.01

This table reports the simple variance decomposition of the corporate basis Ψ. The full sample is monthly observations from January 2004 to March 2021.

Table 4: Exclusion Restrictions Check for the financial intermediaries' balance sheet constraints shock IV

	CSD	CYD	CCB
AUD	0.29***	-0.02	-0.11
CAD	0.16***	-0.16**	0.04
GBP	0.23***	-0.03	-0.19***
EUR	0.15***	0.07	-0.18***
CHF	0.45***	-0.18***	-0.20***
JPY	0.45***	-0.11	-0.22***
Average	0.39***	-0.12*	-0.23***

The table reports the correlation between the change in the financial intermediaries' balance sheet constraints shock IV and the change in CSD, CYD and CCB. The sample is monthly from January 2004 to March 2021. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 5: Effects on the FX Market: Evidence of OLS models

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\Psi$	-7.12**					
	(2.84)					
ΔTreasury Premium		16.18***	9.61***			
		(2.33)	(3.2)			
ΔCSD			-7.18***		-6.99***	-6.05**
			(2.43)		(2.57)	(2.61)
ΔCYD				12.93***	6.89*	6.79*
				(3.3)	(3.99)	(3.88)
ΔCCB				23.79***	16.61***	15.80***
				(3.44)	(4.18)	(4.04)
ΔVIX						0.01*
						(0.01)
N				206		
R^2	0.06	0.19	0.25	0.2	0.26	0.27

The table reports the regression results in which the dependent variable is the monthly change in the log of the spot USD exchange rate against a basket. The independent variables include the corporate basis (Ψ), U.S. Treasury premium, CSD, CYD and CCB in Mean, and we use the simple change as the innovation. The input data is in simple value format (e.g. 10 basis points as 0.001). Only the VIX is the using the percentage change in percentage units. Parentheses include the White heteroscedasticity-robust standard errors. We do not report the constant term. The monthly sample is from January 2004 to March 2021. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 6: Summary Statistics of CYD and CSD of Non-USD Currencies

		Full Sample **Jan 04 to Mar 21**	**Pre-GFC** **Jan 04 to Nov 07**	**GFC** **Dec 07 to May 09**	**Post-GFC** **Jun 09 to Mar 21**
		CYD			
EUR	Mean	7.32***	-12.95***	6.67	14.11***
	SEs	(1.09)	(0.43)	(5.16)	(0.9)
GBP	Mean	1.55	14.76***	27.00***	-6.06***
	SEs	(1.14)	(0.64)	(3.52)	(1.05)
CHF	Mean	-7.22***	-2.34**	-14.77***	-7.88***
	SEs	(0.82)	(1.15)	(3.12)	(1.02)
JPY	Mean	-18.32***	-18.24***	-35.97***	-16.11***
	SEs	(0.77)	(1.03)	(3.7)	(0.78)
AUD	Mean	13.99***	23.07***	47.83***	6.69***
	SEs	(1.72)	(1.17)	(4.52)	(2.06)
CAD	Mean	2.68*	-4.31***	-30.76***	9.24***
	SEs	(1.37)	(1.04)	(6.29)	(1.36)
		CSD			
EUR	Mean	5.02***	12.85***	5.34	2.39**
	SEs	(0.98)	(0.44)	(5.3)	(1.19)
GBP	Mean	-12.74***	-14.12***	-15.42***	-11.95***
	SEs	(0.73)	(0.76)	(1.62)	(1.02)
CHF	Mean	24.03***	13.09***	27.95***	27.15***
	SEs	(0.86)	(0.97)	(2.86)	(1.0)
JPY	Mean	38.05***	21.45***	41.27***	43.13***
	SEs	(1.54)	(1.08)	(5.65)	(1.9)
AUD	Mean	-35.77***	-27.06***	-45.03***	-37.48***
	SEs	(0.94)	(0.93)	(4.89)	(1.08)
CAD	Mean	-16.30***	-4.40***	-10.35***	-21.00***
	SEs	(0.95)	(0.69)	(3.19)	(1.09)
N		207	47	18	142

The table reports the mean (Mean), White heteroscedasticity-robust standard errors (SEs) and number of observations (N) of CSD and CYD (5-year maturity) which are estimated based on the equation 4 and equation 3. The first column indicates the fixed-leg currency while estimating CSD and CYD. For example, the row with "EUR" shows the average of CSD and CYD between the currency pair with non-EUR currencies to EUR. The non-EUR Currencies are major funding currencies (AUD, CAD, CHF, GBP, and JPY). The full sample is monthly from January 2004 to March 2021. The sub-periods are Pre-GFC (Jan 2004 to November 2007), GFC (December 2007 to May 2009) and post-GFC (June 2009 to March 2021). *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 7: Pecking Order Evidence

	SDC: Bond Issuance by Foreigm Firms			BIS: International Debt Securities	Moringstar: Foreign Holdings
$billions	Total Issuance	Outstanding in March 2021	Monthly Average	Outstanding in March 2021	Holdings in March 2021
USD	6359.81	2079.49	1731.95	12462.37	601.98
EUR	2389.73	800.71	726.69	10466.78	86.84
GBP	613.24	268.34	228.14	2201.46	47.04
CHF	267.44	62.69	84.92	189.76	2.21
JPY	222.31	49.10	57.21	406.79	1.69
AUD	214.83	55.84	57.53	274.64	4.89
CAD	170.92	43.28	46.98	140.52	8.33

The table reports foreign firms' issuance and foreign mutual funds holdings on AUD-, CAD-, CHF-, EUR-, GBP-, JPY- and USD- denomination corporate bonds. The table integrates three databases: the SDC Platinum Global New Issues database, the International Debt Securities (IDS) from BIS and Morningstar Mutual Fund holding data. All values are in $billions. The monthly sample is from January 2004 to March 2021.