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 for decomposing the corporate basis into components measuring the relative demand for risky and safe dollar assets, using credit spread and convenience yield differences across currencies. Using a structural VAR analysis, we document that in response to a shock to credit spreads, investors substitute between risky and safe dollar assets. Our results are robust to using dealer leverage as an instrumental variable, and find support in institutional investor holdings level data. Furthermore, we find significant effects of a shock to USD credit spreads on FX, equity and commodity markets, and real economic activity, highlighting the important role of the US Dollar in global financial markets.

Keywords: 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 is a measure of price differences between corporate bonds issued in US dollars and foreign currencies by the same entity. In a frictionless financial market, the corporate basis should be zero reflecting a no-arbitrage condition in cross-border corporate bond markets after hedging currency risk. However, since the global financial crisis, the corporate basis has shown substantial time variation, as illustrated in Figure 1. This suggests that economic forces such as the demand for dollar-denominated assets and dollar scarcity in cross-border financing may explain the variation in the corporate basis. This study examines the effect of shocks to intermediary leverage and monetary policy on the corporate basis. Our key contribution is to document a substitution effect between risky and safe dollar assets. We also analyze the effects of shocks to the demand for risky and safe dollar assets on exchange rates, equity and commodity markets, and real economic activity.

The prior literature studies 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] CSD measures the difference in credit spread between corporate bonds with USD denominations and otherwise identical ones with non-USD denominations, and captures the relative demand for risky USD assets. CYD measures the yield difference between government bonds and their corresponding risk-free rates, and reflects the relative demand for safe USD assets; CCB is defined as the difference between synthetic and the direct dollar funding cost and thus captures dollar scarcity in FX swap markets.

Using a universe of 32,008 corporate bonds over the period from January 2004 to March 2021, we estimate the corporate basis with respect to six major funding currencies—Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), British Pounds (GBP), Japanese Yen (JPY)—versus the U.S. Dollar (USD). Unlike government bond yields, the corporate yield curve is rather incomplete for individual bond issuers. Therefore, we use cross-sectional regressions to disentangle the currency effect on hedged corporate bond yields. The resultant estimate of corporate basis, together with the CYD and CCB, allows us to derive the CSD from our three-way decomposition. As such, 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,

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

but also between the risky and safe U.S. assets. For example, a decline in the risk-bearing capacity of investors can lead to substitution of demand from risky to safe dollar assets.

To further establish this stylized fact, we conduct a structural VAR (SVAR) analysis to shed light on the joint dynamics of each component of the corporate basis. Our 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. To further identify the causal effect of shocks to the USD credit spread, we use balance sheet constraints of financial intermediaries (He, Kelly, and Manela 2017) as an instrumental variable (IV) to identify a shock to credit spreads. The intuition is that a negative shock to the intermediary's capital ratio tightens primary dealers borrowing constraints and thus reduces their demand for risky assets in the presence of capital requirements such as the Tier 1 capital ratio. The identifying 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.

We also consider monetary policy surprises as an IV for the convenience yield component of the corporate basis. Monetary policy induces a shift in the demand for safe dollar assets 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,

In addition to findings on its pricing impact, we provide quantity-based evidence for this 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. This data allows us to track foreign investors' holdings of US corporate bonds and Treasury securities. We find that foreign investors substitute toward safe dollar assets during the 2008 financial crisis. As intermediary capital was adversely affected during this period, we observe a sharp increase in foreign investors' demand for the safe dollar assets and sell-off of the risky dollar assets during the 2008 GFC. Through the SVAR 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.

To further explore the substitution effect in international currencies, we re-perform the SVAR analysis in which we exclude USD-denominated corporate bonds from our sample to avoid potential confounding effects. The estimation results indicate significant substitution effect between risky and safe assets denominated in EUR and GBP, which are the second and third largest currencies in terms of global bond issuance, after the US dollar. Quantitatively, 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 do not find evidence for the substitution effect in other currencies such as the AUD, CAD, CHF, and JPY, which constitute much less liquid markets in corporate bond issuance. Overall, our results suggest a pecking order of currencies in terms of international bond issuance and investment.

Lastly, we look at the spillover effects of dollar asset demand shocks to other asset classes and economic activity. Turning to FX markets, our results show that a decrease in the corporate basis leads to a significant appreciation in the USD, and is mainly attributed to the primary dealers' balance sheet constraints. On the other hand, the Treasury premium, which is the sum of the demand for safe dollar assets and factors determining scarcity of cross-border liquidity, has a positive effect on the dollar appreciation. We also examine the spillover effects of shocks to the corporate basis on the equity and commodity markets and real economic activity. The findings indicate that shocks to the corporate basis have a significant impact on macroeconomic variables such as CPI, industrial production, unemployment rate, real GDP, real investment, and real consumption. A USD credit spread shock contracts both the U.S. and non-U.S. economy activities due to 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 on the substitution effect between safe and risky dollar assets. Section 5 studies the effect of financial shocks to the corporate basis on FX, equity and commodity markets and measures of real economic activity. Section 6 concludes.

2 Related Literature

There is a large literature studying the international role of the dollar in terms of asset demand. Many studies in this literature examine the liquidity/safety premium on the U.S.

Treasury bonds. Du, Im, and Schreger (2018) measure the U.S. Treasury premium with the difference in the convenience yield of U.S. Treasuries and non-U.S. government bonds. Jiang, Krishnamurthy, and Lustig (2021) propose a safety channel in a model of the global financial cycle, and show that the safety and convenience of USD Treasuries can be used to predict the strength of the USD (Jiang, Krishnamurthy, and Lustig 2020). Recent research focuses on the secular decline of the U.S. Treasury premium, particularly during the Covid-19 episode, due to changes 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).

One component of the corporate basis is the CIP deviation, which is a proxy for scarcity of cross-border dollar liquidity scarcity. 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 2022; Abbassi and Bräuning 2020; Bräuning and Ivashina 2020; Viswanath-Natraj 2020; Cenedese, Della Corte, and Wang 2021; Cerutti, Obstfeld, and Zhou 2021).

Turning to works on the fixed-income market, Du, Im, and Schreger (2018), Liao (2020), and Caramichael and Liao (2021) focus on the factors that affect CIP deviations measured using corporate and government bonds. For example, Caramichael and Liao (2021) quantify the currency premium of USD relative to EUR in corporate bonds, by focusing on bond issuers in third-party countries. Within this literature, our paper is closely associated with Liao (2020), who decomposes the corporate basis into a credit spread and CIP component, and studies the joint dynamics of of credit spread differentials and CIP deviations. Specifically, he measures credit spreads as the difference between corporate bond yields and LIBOR swap rates. Our primary innovation over this methodology is to decompose the corporate basis into three components—the credit spread, convenience yield and CIP deviation across currencies. In contrast to Liao (2020), we measure credit spreads as the difference between corporate and government bond yields.[2] Our decomposition allows us to examine the joint dynamics of the credit spread and convenience yield, and thus to shed light on the substitution between safe and risky dollar assets in response to financial shocks like a tightening of dealer leverage and monetary policy.

We also relate to a literature understanding the role of the U.S. dollar as a reserve currency and international investor demand for risky dollar assets. Maggiori, Neiman, and Schreger (2019, 2020) provide evidence of an increase in U.S. dollar-denominated corporate bonds after 2008, and an increasing role of the U.S. dollar as a reserve currency. We contribute to this literature by documenting the important role of the U.S. dollar

2. As we will outline in our decomposition of the corporate basis in section 3, the sum of our credit spread and convenience yield component is equal to the credit spread defined in Liao (2020)

in international investor balance sheets, and how they substitute between risky and safe dollar assets during a financial crisis when dealer balance sheets are constrained. We substantiate our proposed substitution effect with data on investor holdings, and show how our shocks to the corporate basis can translate to effects on FX, equity and commodity markets and real economic activity in the U.S. and abroad.

Finally, our paper contributes to the literature on intermediary based asset pricing. He and Krishnamurthy (2012, 2013) and Brunnermeier and Sannikov (2014) lay the theoretical foundations for the pricing kernel based on financial intermediaries. Empirically, Adrian, Etula, and Muir (2014) and He, Kelly, and Manela (2017) find that shocks to the leverage/capital ratio of primary dealers possess significant explanatory power for the cross-sectional variation of expected returns for a wide range of asset classes. In addition, He, Khorrami, and Song (2022) show 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 a shock on the demand for risky dollar assets. Our findings provide empirical support to models with financial intermediaries as the marginal investors, and provides suggestive evidence of the propagation of financial shocks to the real economy.

3 Definitions and Data

3.1 Decomposition of Corporate Basis

Consider corporate debts denominated in EUR and USD. In equation (1), we express the difference in yields as the EUR bond yield minus the USD bond yield after controlling for foreign exchange (FX) risk. From an investor's perspective, it reflects the 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 hedging currency risk 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 equation (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).

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

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

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

Equation (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* demand for risky dollar assets, 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* demand for safe dollar assets.

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 obtaining dollar funding via the FX swap 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), in which the credit spread differential is defined as $(y_{e,t} - y^{rf}_{e,t}) - (y_{\$,t} - y^{rf}_{\$,t})$. In other words, his CSD 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 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-puttable, 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;[3] (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 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.[4] 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 number of issues and the

3. Following Liao (2020), we do not exclude bonds issued by supranational and Sovereign agencies.

4. Huang, Nozawa, and Shi (2022) compare BGN with alternative data source, the ICE BofAML database, in studying global corporate bond pricing. They find that the coverage of the two databases largely overlap in the US corporate bond market but show nontrivial differences, e.g., in the sample of JPY denominated bonds. For the bonds appearing in both databases, however, the average credit spreads closely match each other regardless of currency denomination.

outstanding notional. In particular, the average time to maturity over all bond-month observations is around five years, which motivates our focus on CYD and CCB at the five-year maturity in our analysis.

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 2, 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 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 bonds are equally large. Overall, Figure 2 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 equation (3), which are consistent with Du, Tepper, and Verdelhan (2018) and 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 longest maturity is merely 12 months. 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. In our SVAR framework we use the "intermediary capital risk factor"[5] as proposed by He, Kelly, and Manela (2017), in order to identify the financial intermediary constraints shock. In addition, we use high-frequency interest rates on one-month Overnight Indexed swaps (OIS) sourced from Thomson Reuters TickHistory. Finally, to provide quantity-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.[6]

3.3 Estimation of the corporate basis components

Corporate basis

Corporate basis captures currency-hedged corporate yield difference between currency regions. For example, consider BMW, a German multinational manufacturer, which issues both EUR and USD denominated corporate bonds. We compare the promised returns on these two currencies' denomination bonds while controlling for maturity and other characteristics of the bond issues. Following the methodology in Liao (2020), Galvez et al. (2021), and Gopinath, Caramichael, and Liao (2021), we estimate corporate basis

5. 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/.

6. 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

by running the following cross-section regression:[7]

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

where $X_{i,t}$ denotes the corporate yield spread adjusted for the US Treasury premium. To be concrete,

$$X_{i,t} = \begin{cases} CS_{i,t} & \text{for USD,} \\ CS_{i,t} + \text{CYD}_{c,t}^{(\tau)} + \text{CCB}_{c,t}^{(\tau)} & \text{for non-USD,} \end{cases}$$

where $CS_{i,t}$ denotes the corporate bond yield net of government bond yield for the same maturity of bond i at time t, and τ denotes its time to maturity. We calculate the corporate basis as $\Psi_{c,t} = \alpha_{c,t} - \alpha_{USD,t}$.

Convenience yield differential (CYD)

Following Jiang, Krishnamurthy, and Lustig (2021), we measure CYD using the difference between the yield spread of non-US and US government bonds. The yield 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) denominated in the local currency.[8]

Cross-currency basis (CCB)

As shown in Du, Tepper, and Verdelhan (2018), CCB based on Libor are quoted directly as spreads on Libor cross-currency basis swaps. The cross-currency swap involves a currency swap and exchanges of cash flow linked to floating interbank rates, and is equivalent to the long-term CIP deviation.

Credit spread differential (CSD)

CSD measures the difference in corporate bond credit spread across currencies. We consider two approaches to estimating CSD. The first one is directly based on our three-way decomposition,

$$CSD_{c,t}^{Dec} = \Psi_{c,t} - \text{CYD}_{c,t}^{(5)} - \text{CIP}_{c,t}^{(5)}.$$

Our focus on CYD and CCB at the five-year maturity is motivated by the obervation that the average time to maturity over all monthly observations in our corporate bond

7. 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.

8. 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.

sample is around five years. The second approach follows our estimation of the corporate basis. In other words, we replace $Z_{i,t}$ in Eq. (4) with $CS_{i,t}$,

$$CS_{i,t} = \alpha^{cs}_{c,t} + \beta^{cs}_{f,t} + \gamma^{cs}_{m,t} + \delta^{cs}_{r,t} + \epsilon^{cs}_{i,t}. \tag{5}$$

It follows that the CSD between currency c and USD could be calculated as $\text{CSD}^{Reg}_{c,t} = \alpha^{cs}_{c,t} - \alpha^{cs}_{USD,t}$.

Summary statistics

In Figure 1, the monthly time-series of the corporate basis is presented for currency pairs with one leg in USD and the other in non-USD (AUD, CAD, CHF, EUR, GBP or JPY) from January 2004 to March 2021. The corporate basis measures the difference between the non-U.S. corporate yield and hedged U.S. corporate yield. It has exhibited negative spikes during two crisis periods (the GFC and Covid-19), which may indicate either surging hedging costs or lower demand for risky dollar assets. Before the GFC, the basis was close to zero, but it deviated significantly from zero and experienced significant fluctuations after the crisis.

Figure 4 compares alternative estimates of the CSD. We note that different estimators lead to remarkably similar results for all currencies. Indeed, the time-series of decomposition-based estimate (CSD_Dec) and regression-based one (CSD_Reg) overlap with each in many episodes. Their correlation coefficient also indicates an almost one-to-one correspondence. Given the robustness of our estimation results, we focus on CSD_Dec in the following discussion.

The three components of the corporate basis, namely CYD, CSD, and CCB, are examined separately in Figure 3. Table 2 presents corresponding summary statistics for the entire sample, as well as 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). CSD reflects the demand for risky dollar assets. During the crisis period, CSD declined sharply, implying a run on risky dollar assets due to decreased risk appetite and high FX risk and hedging costs. Among the currencies in our sample, JPY and CHF had the most negative CSD, followed by EUR, GBP, CAD, and AUD. The time-series of CYD exhibited a downward trend, suggesting that the U.S. safe asset has become less "special" after the GFC. For most currencies, the mean of CYD turned negative after the GFC. The spike of CYD during the GFC reflected the "flight to safety", while the spike was less pronounced during the Covid-19, consistent with the dash for dollars during the pandemic (Cesa-Bianchi and Eguren-Martin 2021; Ma, Xiao, and Zeng 2022; He, Nagel, and Song 2022). CCB reflects dollar liquidity stress in global financial markets, which was near zero before the GFC but has been persistently high since.

Table 3 displays the results of our variance decomposition of the corporate basis, using the decomposition of CCB, CYD, and CSD. The variance of CSD is the largest contributor to the variation of the corporate basis, with an average ratio of $\frac{var(\text{CSD})}{var(\Psi)}$ of 1.40. This is in contrast to the variances of CCB and CYD, which have a much smaller impact. Of particular interest is the negative co-variance between CSD and CYD, which has a large average magnitude of 0.69 and is the second largest component of the corporate basis variance. While CSD also co-moves negatively with CCB, this effect is smaller in magnitude. The variances of CYD and CCB contribute much less to the variation of the corporate basis. The negative co-variance between CSD and CYD is a significant contributor to the variation of the corporate basis during our sample period, and is explored further in the next section of our paper.

4 Empirical findings: substitution effect between safe and risky assets

4.1 Joint dynamics of the corporate basis elements

We plot the time-series of the cross-currency mean of CYD and CSD together at the top panel of Figure 5 for the sample period from January 2004 to March 2021. 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 a decrease in CSD and an increase in CYD, reflecting a *flight to safety* of global investors. The pattern is similar for the recent Covid-19 pandemic period, where we observe a large decline in CSD but only a moderate increase in CYD. The moderate increase in CYD is consistent with a recent literature that suggests U.S. Treasuries have lost their specialness during the pandemic (Cesa-Bianchi and Eguren-Martin 2021; Ma, Xiao, and Zeng 2022; He, Nagel, and Song 2022).

This substitution effect is robust even if we exclude the GFC and the pandemic periods in our sample. We report a correlation between the monthly changes of CSD and CYD is -0.33 when excluding these periods, which is statistically significant at the 1% level. Our results are robust across all currencies. In other panels of Figure 5, we present the time-series of CSD and CYD for each of the six non-USD currencies in our sample. Across all six currencies we observe negative co-movement between CSD and CYD.

4.1.1 Structural VAR: Baseline Estimation

To understand the joint dynamics of CSD, CYD and CCB we estimate a SVAR in Eq. (6).

$$AY_t = \sum_{j=1}^{N} A_j Y_{t-j} + \epsilon_t, \tag{6}$$

where $Y_t = [CSD_t\ CYD_t\ CCB_t]'$ and ϵ_t is a vector of orthogonal structural innovations with zero mean. [9] N is set to be one based on the BIC criteria of VAR model. ϵ_t consists of a shock to the risky and safe components of asset demand ($\epsilon_t^{\text{CSD shock}}$ and $\epsilon_t^{\text{CYD shock}}$ respectively), 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 Eq. (7):

$$Y_t = CY_{t-1} + B\epsilon_t \tag{7}$$

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 6 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. [10] The IRF is estimated based on 1,000 bootstraps. The results support a substitution between safe and risky 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.

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

A limitation of the unrestricted SVAR estimation 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 external instruments to identify shocks to components of the corporate basis.

Let Z_t be a vector of instrumental variables (IV) for shocks to CSD. In other words,

9. ϵ_t is assumed to be $E(\epsilon_t \epsilon_t') = \sum = \not{\mathbb{K}}$ (mutually uncorrelated and unit variance).

10. 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 space limit.

Z_t is required to be correlated with $\epsilon_t^{\text{CSD shock}}$ but orthogonal to other shocks to be a valid instrument:

$$E[Z_t\epsilon_t^{\text{CSD shock}}] = \phi; \quad E[Z_t\epsilon_t^{\text{CYD shock}}] = 0; \quad \text{and} \quad E[Z_t\epsilon_t^{\text{CCB shock}}] = 0. \tag{8}$$

The reduced-form VAR representation can be expressed in Eq. (9):

$$\begin{bmatrix} CSD_t \\ CYD_t \\ CCB_t \end{bmatrix} = \begin{bmatrix} c11 & c12 & c13 \\ c21 & c22 & c23 \\ c31 & c32 & c33 \end{bmatrix} \begin{bmatrix} CSD_{t-1} \\ CYD_{t-1} \\ CCB_{t-1} \end{bmatrix} + \begin{bmatrix} b11 & b12 & b13 \\ b21 & b22 & b23 \\ b31 & b32 & b33 \end{bmatrix} \begin{bmatrix} \epsilon_t^{\text{CSD shock}} \\ \epsilon_t^{\text{CYD shock}} \\ \epsilon_t^{\text{CCB shock}} \end{bmatrix}. \tag{9}$$

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 equation ((13)):

$$u_t^{CSD} = \alpha + \beta Z_t + w_t. \tag{10}$$

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 and CCB are transmitted through the instrument's effect on CSD:[11]

$$\begin{aligned} u_t^{CYD} &= \alpha + \gamma_1\widehat{u_t^{CSD}} + w_t \\ u_t^{CCB} &= \alpha + \gamma_2\widehat{u_t^{CSD}} + w_t \end{aligned} \tag{11}$$

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

We use the SVAR approach with external instruments and hypothesize that dealers facing balance sheet constraints would need to decrease their risky asset demand to meet

11. Proofs:
$\gamma_1 = cov(u_t^{CYD}\widehat{u_t^{CSD}})/var(\widehat{u_t^{CSD}})$
$cov(u_t^{CYD}, \widehat{u_t^{CSD}}) = cov(b21\epsilon_t^{\text{CSD shock}}, \beta Z_t) = b21\beta cov(\epsilon_t^{\text{CSD shock}}, Z_t)$
$var(\widehat{u_t^{CSD}}) = \beta^2 var(Z_t)$

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

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 $\gamma_2 = b31/b11$.

the minimum requirements such as Tier 1 capital ratio. To identify the risky component of dollar asset demand, we use an external instrument called the "intermediary capital risk factor" proposed by He, Kelly, and Manela (2017), which measures the monthly growth rate of primary dealers' capital ratio. We assess the exclusion restrictions requirements by examining the correlation between the change in the instrument variable (IV) and the change in the components of dollar asset demand, such as CSD, CYD, and CCB. The results suggest that balance sheet constraints directly impact the demand for risky dollar assets, but they do not affect the demand for safe dollar assets. 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 demand for risky dollar assets but do not affect the demand for safe dollar assets.

Figure 7a focuses on the impact of CSD on CYD and uses 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 an R^2 of 0.32, which rules out the weak instrument problem. Our findings indicate that a negative shock to the capital ratio increases the marginal funding cost of USD, and dealers cut back on risky dollar corporate bonds, leading to an increase in U.S. corporate bond spreads relative to non-U.S. spreads (CSD $\downarrow$). This, in turn, increases the convenience yield on USD government bonds (CYD $\uparrow$), as dealers substitute toward safe dollar assets. We observe that this substitution effect is strongest contemporaneously, indicating that primary dealers immediately react to the tightening of balance sheet constraints. We also find that dealers face restrictions in supplying dollars in the FX swap market due to higher funding costs in USD, leading to an increase in the premium to borrow dollars in FX swap markets, widening CCB. Our quantitative analysis suggests that 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. We also test the substitution effect by excluding the 2008 global financial crisis period (December 2007 to May 2009), and the results remain robust.

4.1.3 Instrument Variable For CYD: Monetary Policy Shocks

We now repeat our exercise using an instrument for CYD. Monetary policy could directly affect the U.S. Treasury market and transmit to the foreign demand for safe dollar assets. For example, a (tightening) U.S. monetary policy shock leads to higher yields of the U.S. treasuries, which increases the holding period return on safe dollar assets. This, in turn, results in a higher demand for safe dollar assets. Therefore, we use the monetary policy shock as an external instrument to identify a shock to the demand for safe dollar assets. Following Kearns, Schrimpf, and Xia (2022), we construct the monetary policy shock as the one-month OIS rate changes around U.S. scheduled monetary policy announcements.

In Eq. (12), 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 a potential mismatch of the announcement timestamp with the data.

$$\Delta r_t = \overline{r_{t+5\,\text{min}\to t+20\,\text{min}}} - \overline{r_{t-20\,\text{min}\to t-5\,\text{min}}} \tag{12}$$

We then convert the high-frequency monetary policy shock to a monthly variable by taking the mean of Δr_t within the month. We set values to 0 if the month has no scheduled monetary policy announcements. Using our SVAR-IV methodology, let Z_t be a vector of instrument variables (IV) for CYD. Z_t must be correlated with $\epsilon_t^{\text{CYD shock}}$ but orthogonal to other shocks to be a valid instrument.[12]

$$E[Z_t \epsilon_t^{\text{CYD shock}}] = \phi; \quad E[Z_t \epsilon_t^{\text{CSD shock}}] = 0; \quad \text{and} \quad E[Z_t \epsilon_t^{\text{CCB shock}}] = 0. \tag{13}$$

Figure 7b presents the impulse response function (IRF) of the CYD shock based on our measure of FOMC monetary surprises as an IV. Quantitatively, a one standard deviation (18 basis points) increase in CYD contemporaneously leads to a decrease in CSD of 27.9 basis points. In addition, the safe dollar demand 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-statistic 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. Taken together, our findings offer insights on the effect of US monetary policy on the substitution between safe and risky dollar assets.

4.1.4 Robustness tests: alternative risk-free rates

We conduct an array of robustness tests that support our main findings, and the results are presented in Appendix A. Since we use the LIBOR and coherent interest rate swap

12. Our methodology for using monetary shocks as an IV for CYD follows the same two stage procedure. The first stage extracts the variation in the u^{CYD} that is due to the IV. We estimate β as $cov(b12\epsilon_t^{\text{CYD shock}}, Z_t)/var(Z_t)$.

$$u_t^{CYD} = \alpha + \beta Z_t + w_t.$$

To identify the effect of the instrument on CSD and CCB, we need to estimate the ratio b22/b12 and b32/b12 from the two stage least squares regression of u_t^{CSD} and u_t^{CCB} on $\widehat{u_t^{CYD}}$, where $\widehat{u_t^{CYD}}$ is fitted value from the first stage regression. We estimate $\gamma_1 = b22/b12$ and $\gamma_2 = b32/b12$ under the identifying assumption that shocks to CSD and CCB are transmitted through the instrument's effect on CYD.

$$u_t^{CSD} = \alpha + \gamma_1 \widehat{u_t^{CYD}} + w_t$$
$$u_t^{CCB} = \alpha + \gamma_2 \widehat{u_t^{CYD}} + w_t$$

Lastly, we normalize b12 to 1. Parameters b22 and b32 are therefore equal to γ_1 and γ_2, respectively.

(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. Another concern on our empirical methodology is that the corporate basis and CSD are estimated from cross-sectional regressions. We assess the robustness of our CSD estimates by focusing on a sub-sample 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.

4.2 Holdings-Level Evidence

In this section, we use holdings-level data to examine the substitution effect between the demand for safe and risky dollar assets by foreign investors. To obtain data on foreign investors' aggregate transactions on the U.S. assets, we use the Treasury International Capital (TIC) S-form data. However, we acknowledge two limitations of the data as outlined in Bertaut and Judson (2014). First, the TIC data records transactions based on the country of the first cross-border counterparty, not the ultimate buyer, actual seller, or security issuer, and certain types of cross-border securities flows that do not pass through standard broker-dealer and other TIC reporter channels are not recorded. Despite these limitations, the TIC data still provides good-quality data for the aggregate transactions of foreign investors in U.S. Treasuries and corporate bonds.

To measure foreign investors' holdings of U.S. assets, we obtain data on historical foreign investors' net purchases of the U.S. assets from *Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities*. We proxy foreign investors' net purchases on USD corporate bonds using the column of *Corporate Bonds: U.S. Corporate Bonds (Long-term), Net Purchases*, and 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*. We also separate the foreign investors into foreign private and sovereign investors and focus on their holdings of the U.S. corporate bonds and Treasuries during two crisis episodes: the 2008 financial crisis and the 2020 Covid-19 pandemic periods.

We present our findings in Figure 8a. The left panel shows foreign private investors' substitution demand between dollar risky and safe assets during the 2008 financial crisis. Foreign private investors reduced their holdings of U.S. corporate bonds and increased 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. This behavior is consistent with our previous findings on the substitution effect between safe and risky dollar assets, as foreign investors purchase U.S. Treasuries and sell U.S. corporate bonds simultaneously.

We then examine the period around the Covid-19 pandemic, which is shown in the right panel of Figure 8a. We find that foreign private investors had a significant outflow from U.S. Treasuries and a negligible inflow to the U.S. Corporate bonds in March 2020, indicating that U.S. Treasuries were no longer considered safe assets by foreign investors. This finding is consistent with several stylized facts documented in the literature. Ma, Xiao, and Zeng (2022) 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. For example, Cesa-Bianchi and Eguren-Martin (2021) document a dash for dollars phenomenon during the 2020 pandemic, in which investors in need of the U.S. dollar sold their bonds denominated in USD first. He, Nagel, and Song (2022) show that the Treasury market experienced severe stress and illiquidity during the Covid-19 crisis, due to concerns about the U.S. Treasuries' safe-haven status. These papers support our evidence that the substitution between safe and risky assets did not occur in response to the March 2020 pandemic.

We further analyze the effect of a negative CSD shock on foreign private investors' net purchases of U.S. assets using the SVAR framework and report the IRF in Figure 8b. We define the net U.S. bond flow as the difference in the net purchase of U.S. corporate bonds and U.S. Treasuries. Consistent with our findings on the substitution effect between risky and safe assets, we find 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.

4.3 Substitution between safe and risky assets: the non-dollar evidence

In this section, we test if the substitution between safe and risky assets is applicable to non-USD currencies. To this end, we re-estimate CSD and CYD by using major non-USD currencies (AUD, CAD, CHF, EUR, GBP and JPY) as the fixed-leg currency, and exclude dollar-denominated corporate bonds from the estimation sample to avoid potential confounding effects. Table 5 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 substantiate these findings using a SVAR analysis. As before, we use financial intermediaries' balance sheet constraints shocks to identify shocks to dealer demand for risky assets denominated in non-USD currencies. While our measure is focused on primary dealers in the US market, their leverage is important in global financial markets. 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 the EUR and GBP in Figure 10. We do not find significant substitution effects for other non-USD currencies in our sample.

To explain why the substitution effect is relevant to the USD, EUR and GBP, but not for other currencies, we examine foreign firms' issuance as well as foreign mutual funds' holdings of corporate bonds. 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 refer to debt securities statistics provided by BIS. Specifically, we retrieve the statistics on the outstanding International Debt Securities (IDS) denominated in our sample of currencies at the end of March 2021.[13] 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 ranked by total asset-under-management with the investment category on global and emerging market economies fixed incomes.[14] 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 holdings at the end of March 2021. There are 4,031 funds in total, with 1,737 US funds and 1,570 European funds.

Consolidating these data-sets in Table 6, we establish a pecking order of currencies in terms of international bond issuance and holdings. USD, EUR and GBP turn out the most commonly used currencies in terms of corporate bond issuance and investment. For other currencies in our sample, the issuance and demands from foreign firms and mutual funds are relatively small. To put it differently, there is a remarkably wide gap between the third largest currency, GBP, and the fourth largest one, CHF, in the cross-border bond issuance and investment. This suggests that substitution effect between risky and safe assets is more prevalent in more liquid currencies.

13. 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.*"

14. 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.

5 Empirical findings: financial markets and real economic activity

5.1 FX Market

The connection between foreign demand for U.S. assets and cross-border liquidity is closely related to the FX market. In this section, we decompose the effect of each component of the corporate basis on the dollar. To do this, we start with a simple OLS regression, where the dependent variable is the monthly change in the log of the spot dollar value against a basket of currencies. [15] The main independent variables include the first difference in the corporate basis, the U.S. Treasury Premium, CSD, CYD, and CCB. We also control for market risk by using the VIX.

The results of the regression are presented in Table 7. We find that the corporate basis has a negative impact on the strength of the USD. Based on our estimates in column (1), a one standard deviation (13.7 basis points) decrease in the corporate basis leads to a 0.98% (98 basis points) appreciation in the USD. 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%. Additionally, the Treasury premium, which is defined as the sum of CYD and CCB, has a positive effect on the dollar appreciation. 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 demand for safe dollar assets (CYD) and factors determining scarcity of cross-border liquidity (CCB). Both factors contribute to the USD appreciation: 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.

To further investigate the effect of CSD and CYD shocks, we extend our SVAR results in section 4 to include the value of the spot value of USD vis-a-vis our basket of currencies. In Figure 11a, a negative shock on primary dealers' balance sheet constraints results in lower demand for risky dollar assets due to tight regulation and an increase in demand for safe dollar assets. The limited dealer leverage reduces the capacity to arbitrage in FX swap markets, resulting in a widening of CIP deviations. Reflecting the scarcity of the USD in funding markets, we find our shock results in an appreciation of the USD. The contemporaneous effect is that a 1 standard deviation negative shock to the CSD leads to a 0.15 standard deviation shock in the strength of the USD against our basket of currencies. In Figure 11b, a positive shock on the demand for safe dollar assets, through

15. The basket of currencies include AUD, CAD, CHF, EUR, GBP and JPY.

our monetary policy shock, leads to an appreciation of the dollar. This leads to a widening of CIP deviations and excess returns on the dollar. Our results broadly support Jiang, Krishnamurthy, and Lustig (2021) that an increase in demand for safe dollar assets, as indicated by an increase in the Treasury premium, leads to a medium-term appreciation of the USD.

5.2 Equity and Commodity Markets

In addition to the FX market, we also examine how our shocks to risky asset demand translates to effects on the equity and commodity market. We hypothesize a negative shock to the primary dealer leverage induces a persistent impact on other asset classes because of the lower risk-bearing capacity of investors. We examine spillover effects of shocks to the corporate basis on the SPX (S&P 500) index, Non-U.S. index and commodity index.[16] In Figure 12, 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 the SPX index, non-U.S. index and commodity index, respectively.[17] 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 capital, and leads to excess asset returns as risk compensation to the U.S investor (He, Kelly, and Manela 2017).

5.3 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. 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, and other variables are observed at a quarterly frequency. Figure 13 documents the IRF of a negative CSD shock on U.S. economic activity. 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 the unemployment rate. Our results broadly support other studies examining the effect of financial shocks on real economic activity (Gertler and Karadi 2015).

16. All indices are in log terms. 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.

17. 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 appendix B, we also find significant spillovers to economic activities of other countries in our sample, including Canada, Japan, Euro Area, UK, Switzerland and Australia.[18] Consistent with the results on the U.S. economic activity, a negative shock to the demand for risky dollar assets 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.

6 Conclusion

In this paper, we study the determinants of the corporate basis and investigate the effects of financial shocks 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 cross-currency basis. These components reflect the demand for dollar-denominated risky and safe assets, as well as the FX hedging cost capturing cross-border dollar liquidity. Using a rich data set comprising 32,008 corporate bonds denominated in major funding currencies reveals that there is a substitution effect between safe and risky assets. In response to periods of tightening capital constraints and an increase in risk aversion, investors lower their demand for risky dollar assets, pushing up demand for safe dollar assets.

To further support our findings on the substitution effect, we use financial intermediaries' balance sheet constraints and monetary policy surprises as instruments to identify the causal effect of shocks to the CSD and CYD components of the corporate basis. The findings show that a positive shock to the USD credit spread leads to an increase in the US Treasury premium, indicating a substitution effect from risky to safe assets. Similarly, a shock to the Treasury premium leads to a substitution between safe and risky assets. We complement our price analysis with quantity-based evidence for the substitution effect from foreign investors' net purchases of dollar safe and risky assets. The Treasury International Capital (TIC) System data reveals that foreign investors substitute toward safe dollar assets during the 2008 financial crisis, coinciding with the adverse impact of intermediary capital during this period.

Finally, using shocks to the capital ratio of financial intermediaries as an instrumental variable, we find spillovers to other financial markets and real economic activity. A deterioration in USD credit spreads leads to an appreciation of the USD, negative returns in the equity and commodity market, and a contraction in both U.S. and non-U.S. economy

18. For some countries in our sample we only have quarterly data on the industrial production, such as Switzerland and Australia. We also only have quarterly CPI data 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.

activities. Taken together, our findings suggest the crucial role the USD plays as a key funding currency in global financial markets.

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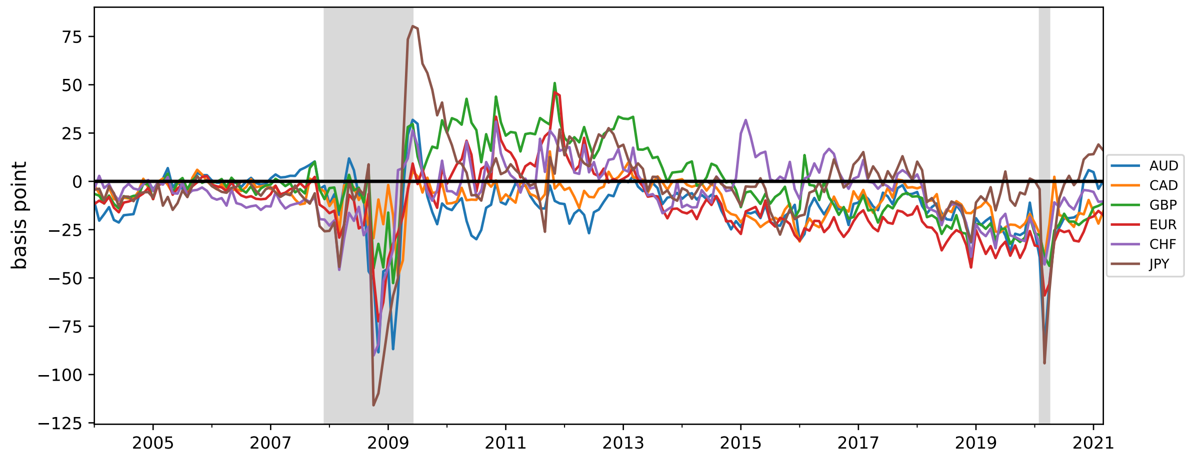
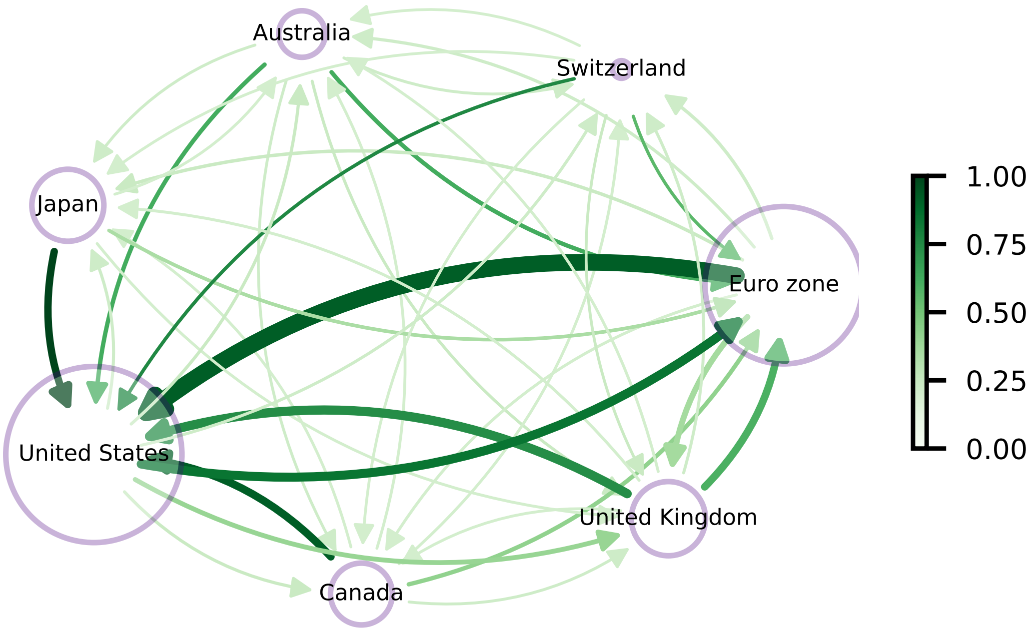
Figure 1: The Corporate Basis



This figure presents the time series of corporate basis by currency. Corporate bases are estimated with cross-sectional regressions in 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.

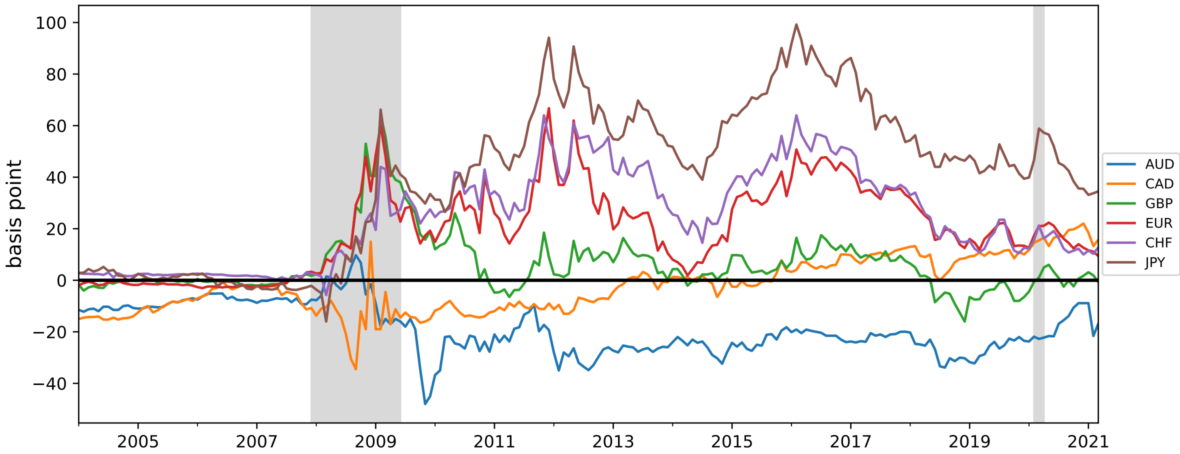
Figure 2: Cross-border Bond Issuance



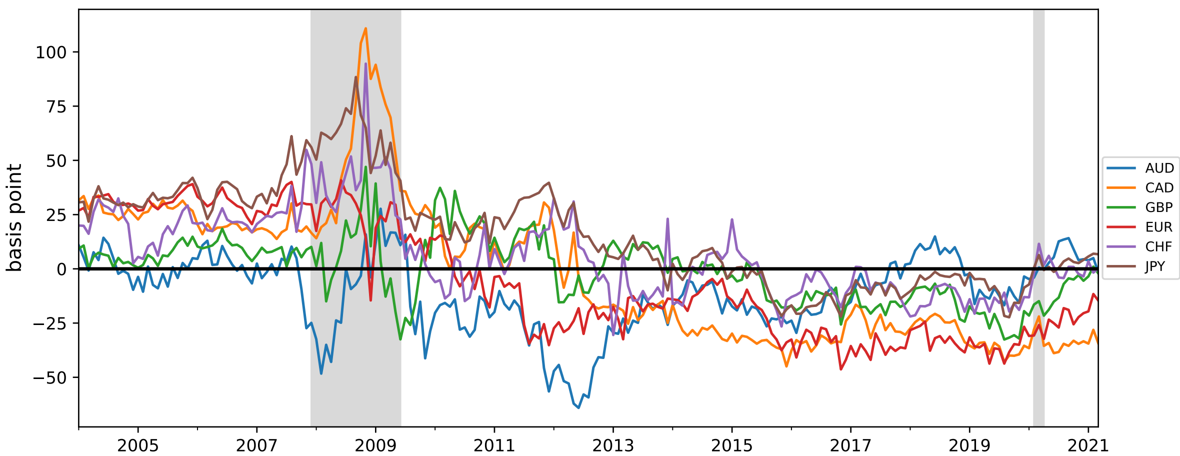
This figure presents the cross-border issuance of corporate bonds with currency denominations in AUD, CAD, CHF, EUR, GBP, JPY, and USD, based on the bond outstanding data in March 2021. Purple circles depicts the total notional principal of outstanding bonds issued by the domestic firms. Green arrows 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 3: The Decomposition of Corporate Basis

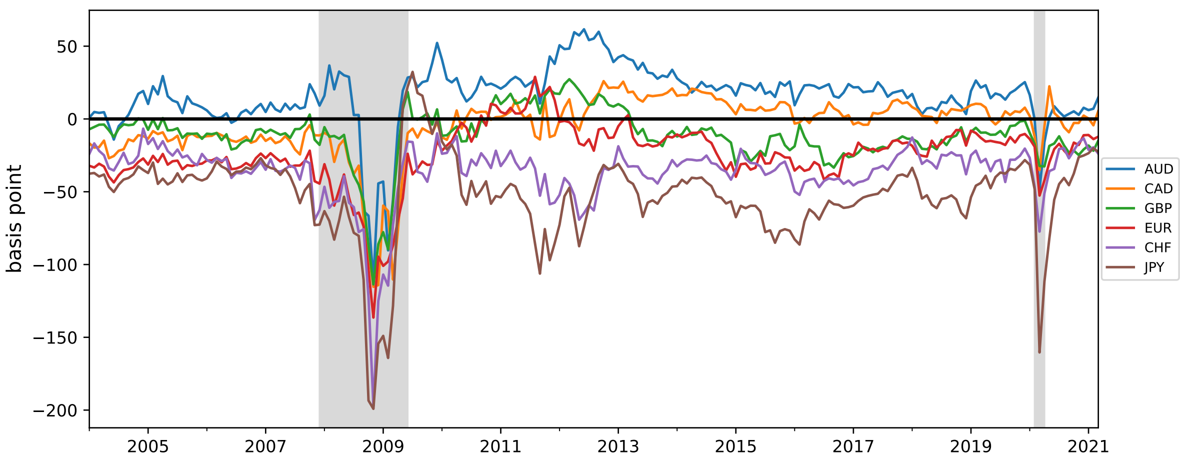
(a) Cross-currency Basis (CCB, 5-year)



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

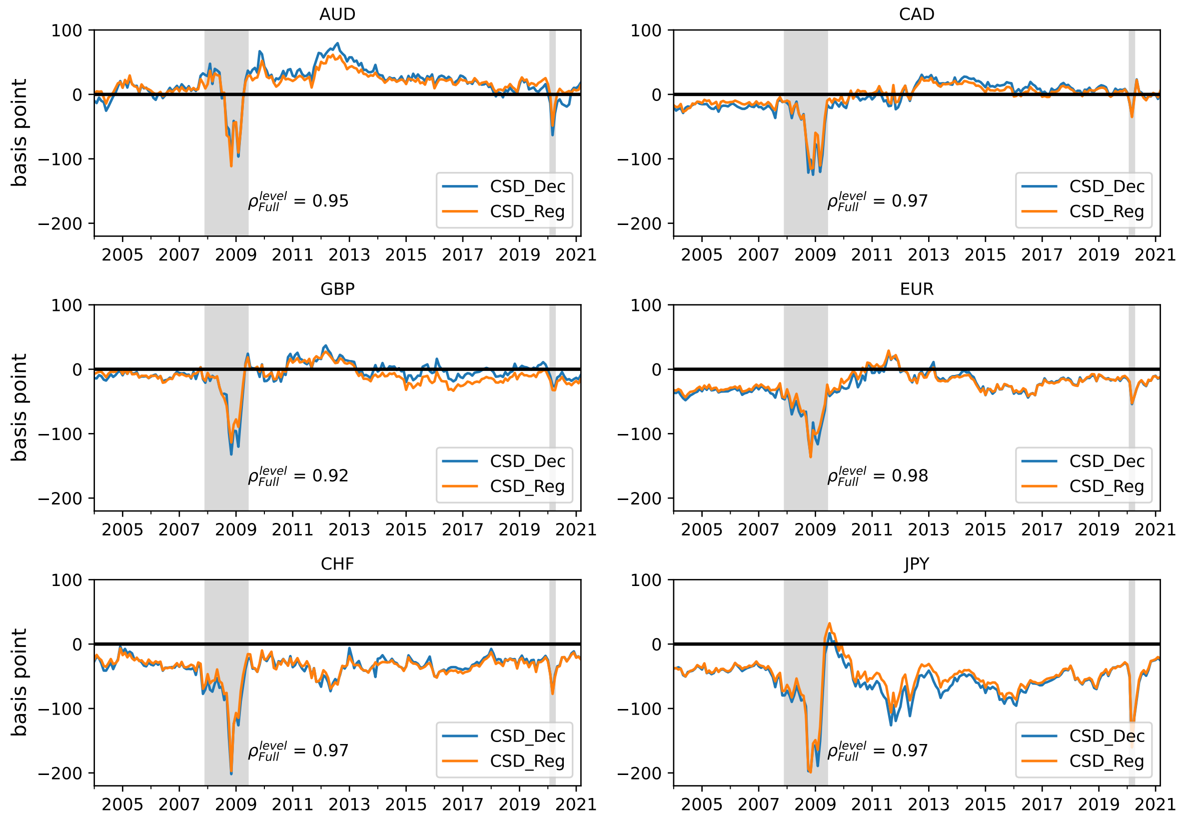


(c) Credit Spread Differentials (CSD)



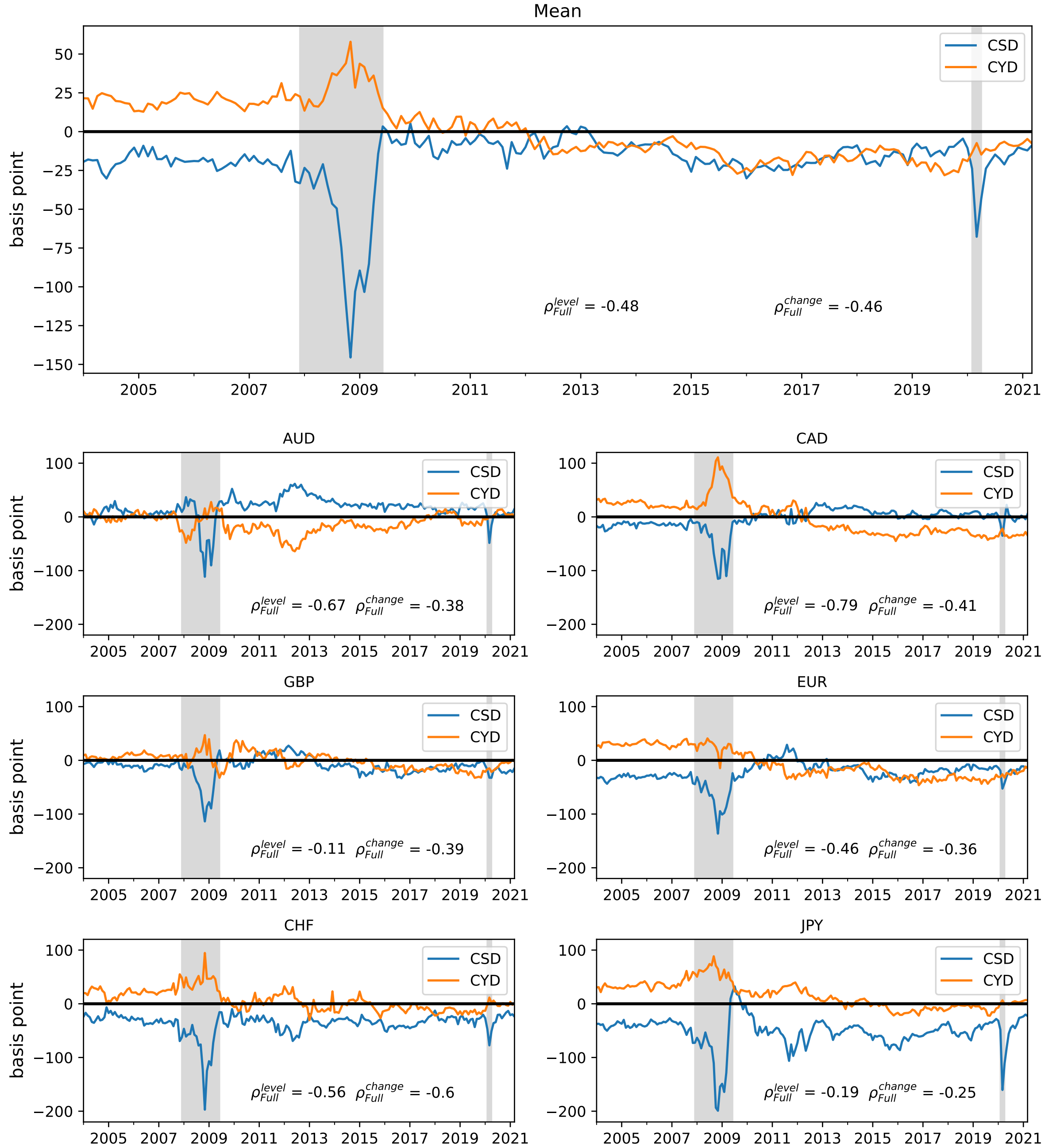
This figure presents the time series of corporate basis components: CSD, CYD (5-year maturity) and CCB (5-year maturity). The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 4: Alternative Estimates of Credit Spread Differentials



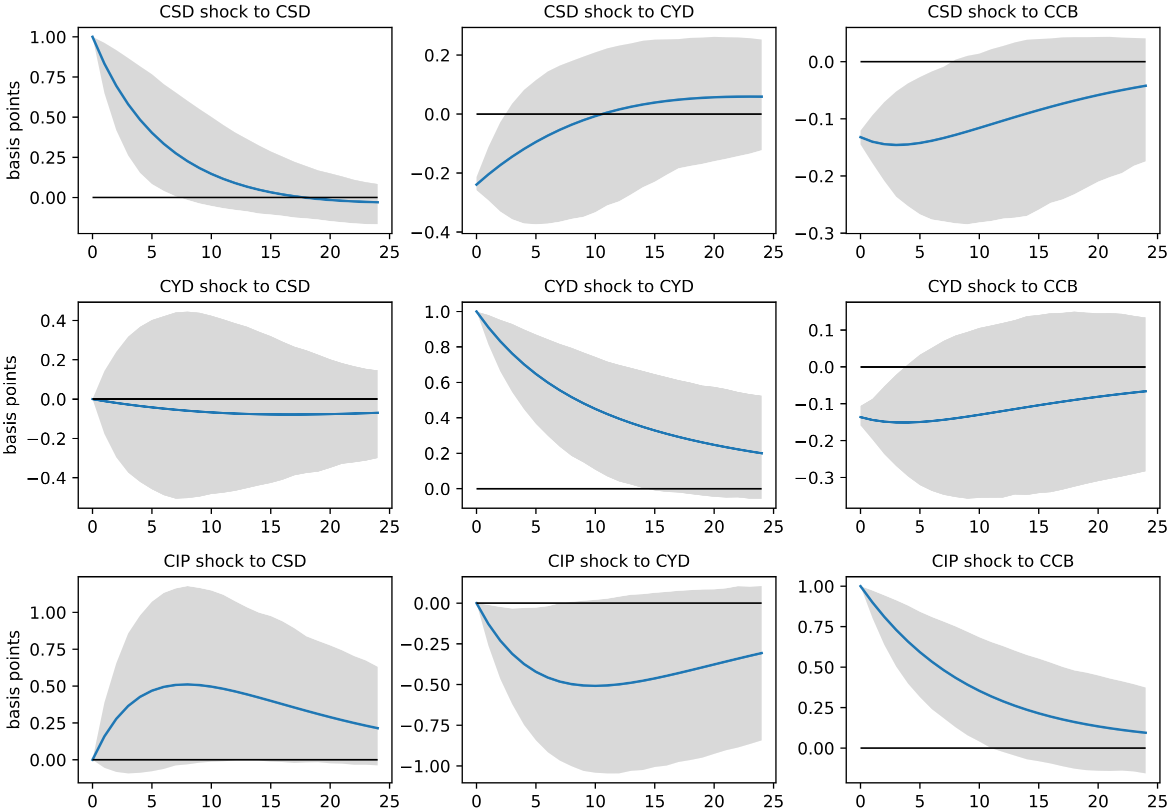
This figure compares the decomposition-based estimate of CDS (CSD_Dec) and regression-based estimate (CSD_Reg). CSD_Dec is derived from the decomposition as presented in Eq. (3) and thus involves the estimate of corporate basis, CYD and CCB. CSD_Reg is directly estimated from the cross-sectional regression of Eq. (5). 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 5: A Substitution Effect Between Safe and Risky Dollar Assets



This figure depicts the co-movement between our estimates of CSD and CYD from January 2004 to March 2021. The top panel plots the average across currencies, and the lower panels display the CSD and CYD for each currency. Correlation coefficients are reported for both the levels and changes of these two variables. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

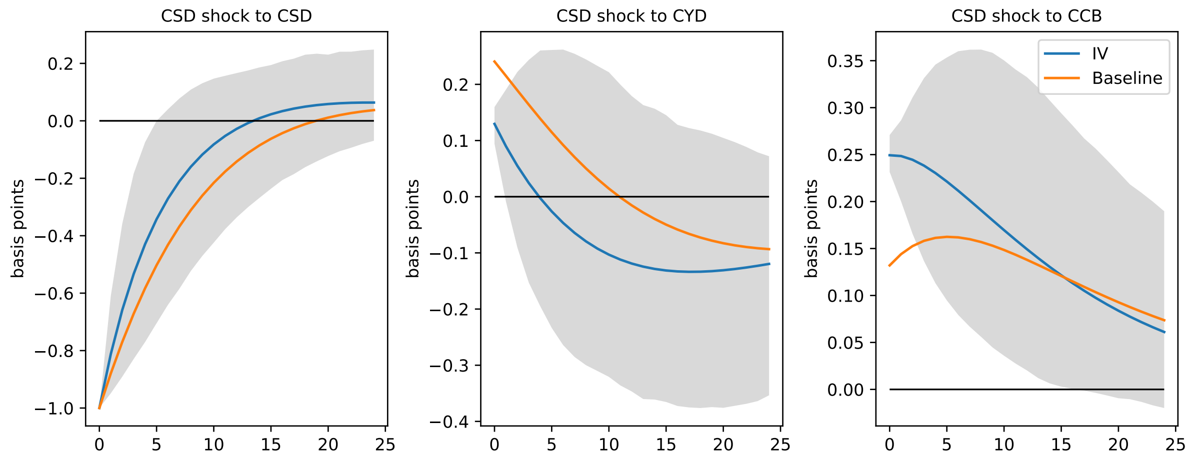
Figure 6: IRF of the Unrestricted SVAR Model (Mean)



This figure presents the impulse response function (IRF) of one unit corresponding shock to each variable in the corporate basis decomposition. 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 cross-currency mean of CSD, CYD and CCB.

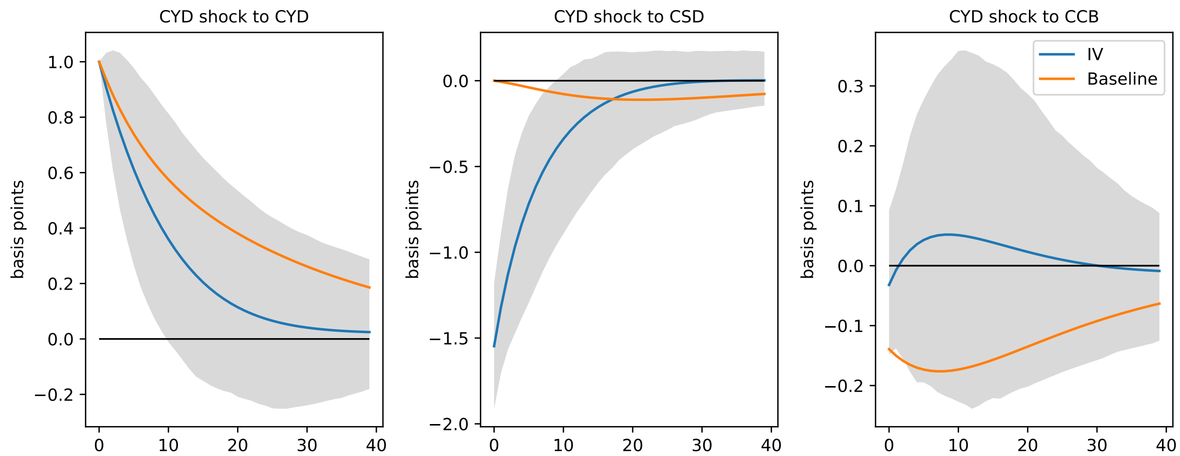
Figure 7: IRF of the SVAR Model with Instrumental Variables

(a) IRF of the CSD Shock (Mean)



First-stage regression: Coefficient: 72; F-statistics: 98; R^2: 0.32.

(b) IRF of the CYD Shock (Mean)

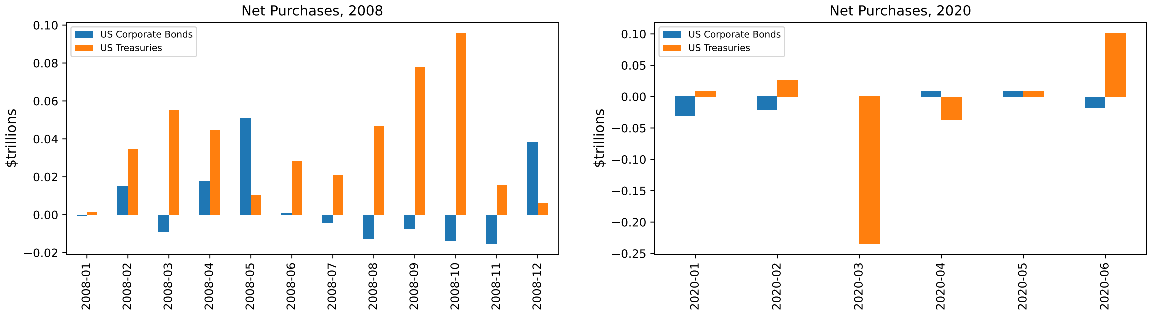


First-stage regression: Coefficient: 28.1; F-statistics: 3.3; R^2: 0.016.

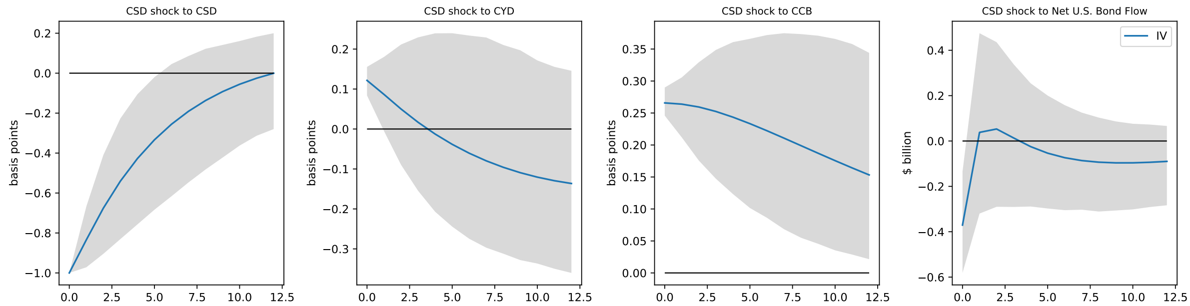
This figure presents the impulse response function (IRF) of one unit CSD shock (Panel A)/CYD shock (Panel B) to each variable in the corporate basis decomposition. Panels A and B are based on 1,000 wild bootstraps with the intermediary capital shock IV and monetary policy shock IV, respectively. The 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 cross-currency mean of CSD, CYD and CCB.

Figure 8: Holding Level Evidence

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



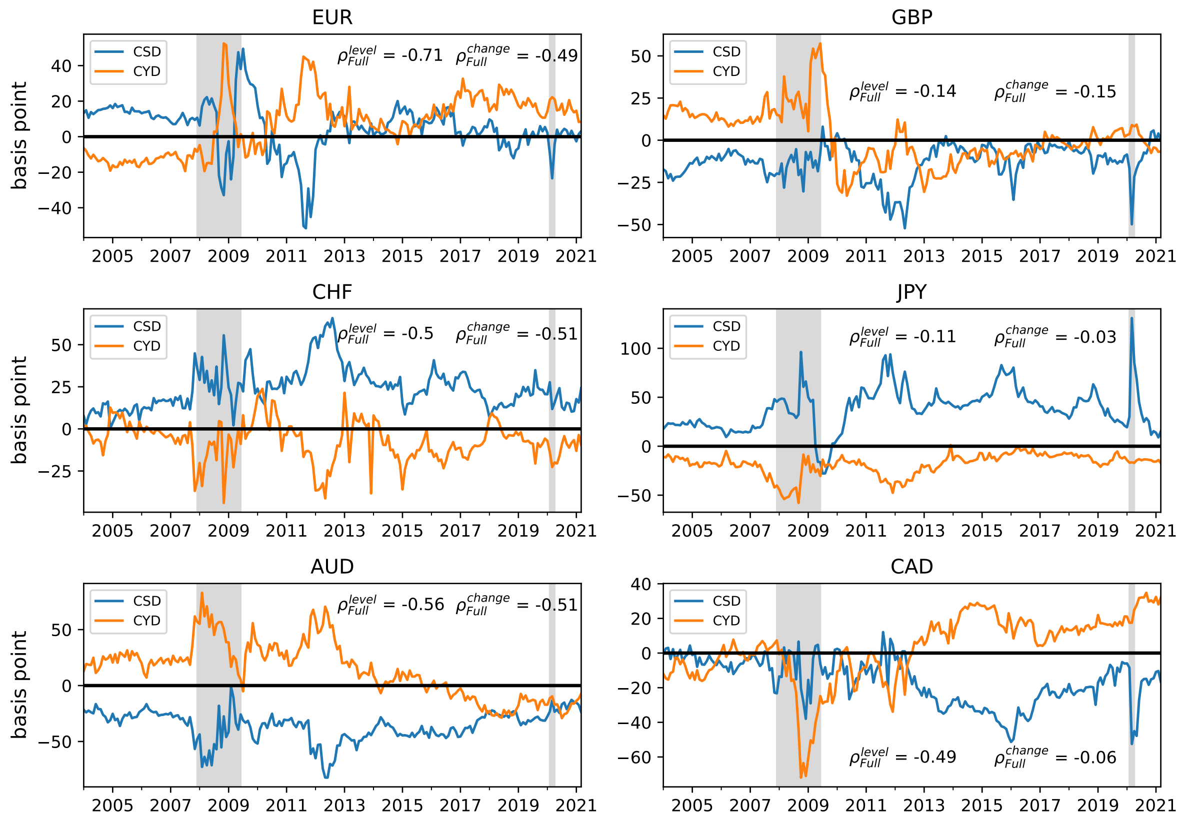
(b) SVAR Model Analysis with the Foreign Investors' Net U.S. Bonds Flow (Mean)



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

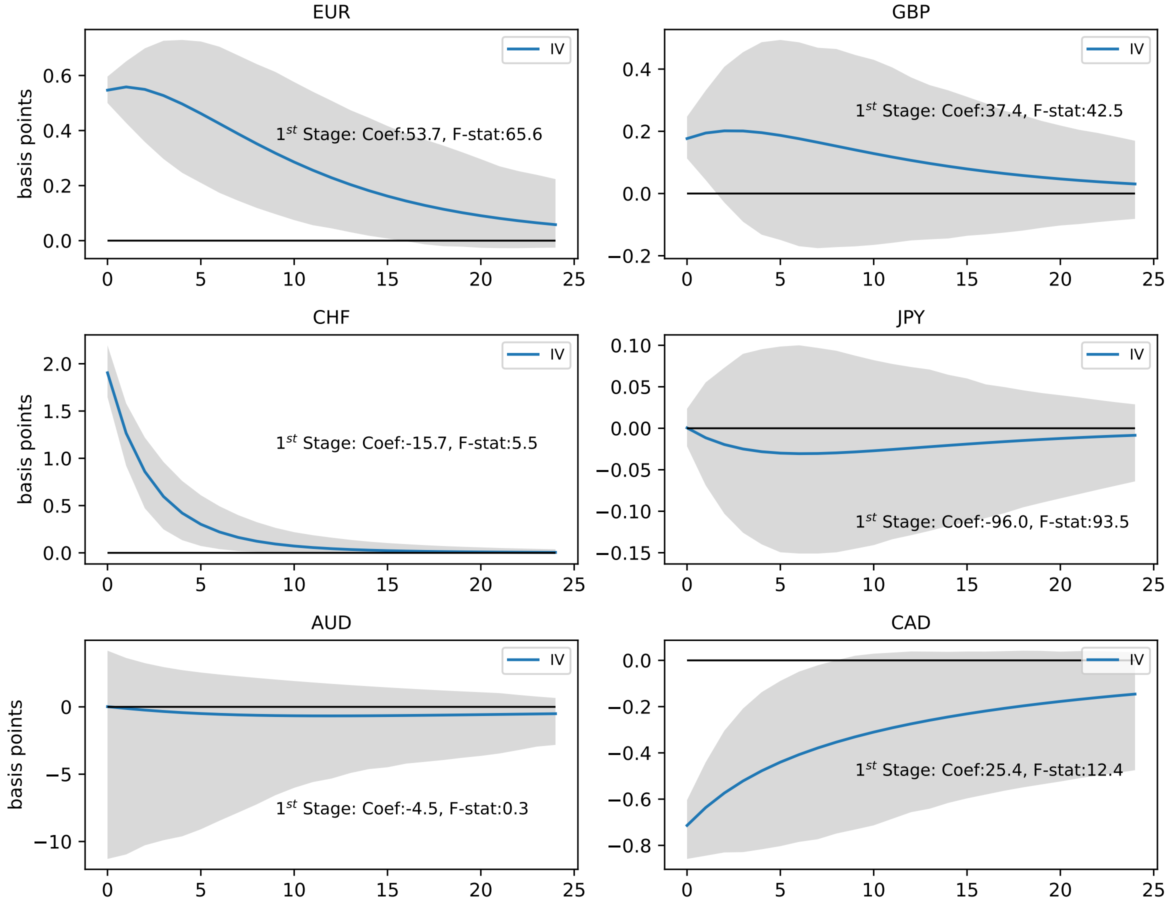
The top figure shows the foreign investors' net purchases of U.S. assets during the 2008 global financial crisis and the 2020 Covid pandemic period. The data is from TIC S form - Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities. The bottom figure presents the impulse response 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 sub-figure 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.

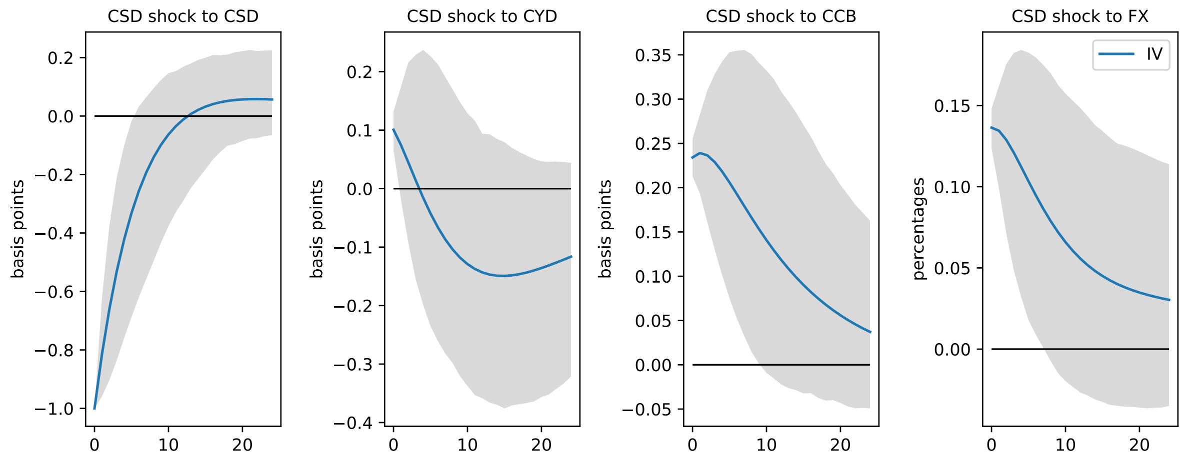
Figure 10: IRF of one negative CSD Shock on CYD (International Evidence)



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.

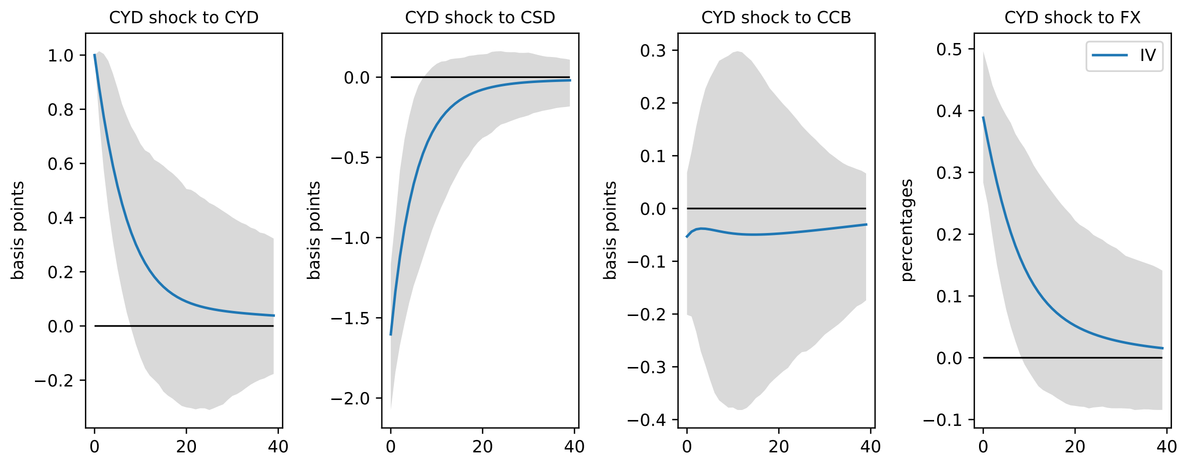
Figure 11: IRF of SVAR Model Incorporating the FX Market

(a) IRF of the CSD Shock



First stage regression: Coefficient: 71; F-statistics: 93; R^2: 0.31.

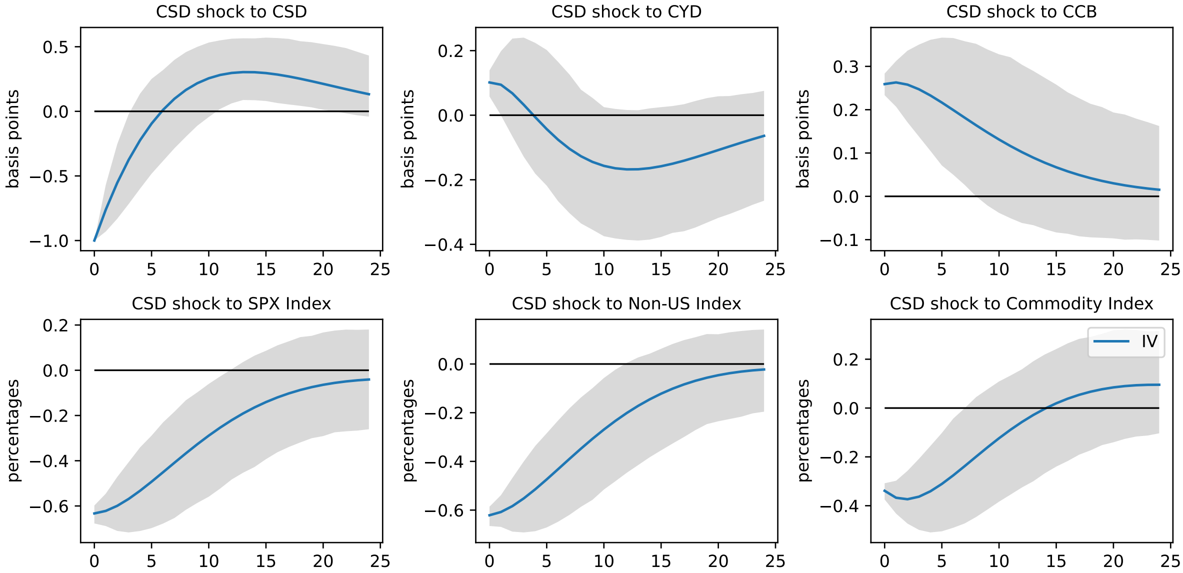
(b) IRF of the CYD Shock



First stage regression: Coefficient: 27.2; F-statistics: 3.18; R^2: 0.020.

This figure presents the impulse response function (IRF) of one unit CSD shock (Panel A)/CYD shock (Panel B) to the USD exchange rate as well as the corporate basis components. Panels A and B are based on 1,000 wild bootstraps with the intermediary capital shock IV and monetary policy shock IV, respectively. 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 cross-currency mean of CSD, CYD, CCB, and logarithm of the spot USD exchange rate.

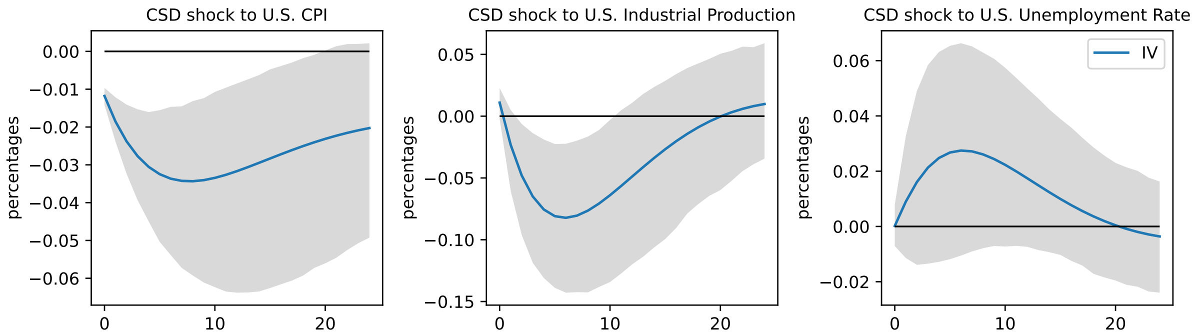
Figure 12: IRF of the CSD Shock with the Other Assets Classes (Mean)



This figure presents the impulse response function (IRF) of one unit CSD shock to indices of the equity and commodity sectors. 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 spans from January 2004 to March 2021 with the cross-currency mean of CSD, CYD, CCB, the logarithm of SPX (S&P 500) index, the logarithm of of international market indices (Austrian Traded Index, S&P/TSX Composite Index, Swiss Market Index, EURONEXT 100, FTSE 100 and Nikkei 225) and the logarithm of of the Bloomberg commodity index.

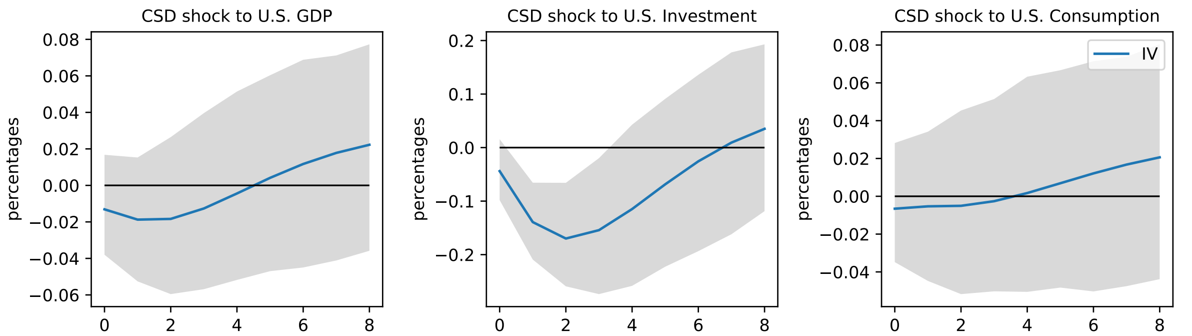
Figure 13: IRF of the CSD Shock with the U.S. Macroeconomic Activity (Mean)

(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 measures of real economic activities. 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 spans from January 2004 to March 2021 with the cross-currency mean of CSD, CYD, CCB, as well as the U.S. CPI, the 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 summarizes the corporate bond sample in the corporate basis analysis. Bonds are classified by their issuance currency and credit rating/years to maturity. Columns 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), respectively. The sample period spans 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 summarize the estimate of CSD, CYD (5-year maturity) and CCB (5-year maturity). The reported statistics include the mean (Mean), White heteroscedasticity-robust standard errors (SEs) and number of observations (N). The sample period spans 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 composed of 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: 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 summarize the estimate of CSD, CYD (5-year maturity) and CCB (5-year maturity). The reported statistics include the mean (Mean), White heteroscedasticity-robust standard errors (SEs) and number of observations (N). 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 sample period spands 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 6: 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-denominated corporate bonds. Three data sources are integrated: the SDC Platinum Global New Issues database, the International Debt Securities (IDS) from BIS and Morningstar Mutual Fund holding data. All entries are expressed in $billions. The monthly sample spans from January 2004 to March 2021.

Table 7: 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 logarithm 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 sample period spans from January 2004 to March 2021. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Appendix

A Robustness Tests

A.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.

Figure A1a 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 A1b 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.

A.2 Alternative Measures of CSD

We examine the robustness of CSD using four alternative measures in the equation (5). 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.[19] 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 A2a. 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 A2b. All results are consistent with the baseline results and support the substitution effect between dollar safe and risky assets.

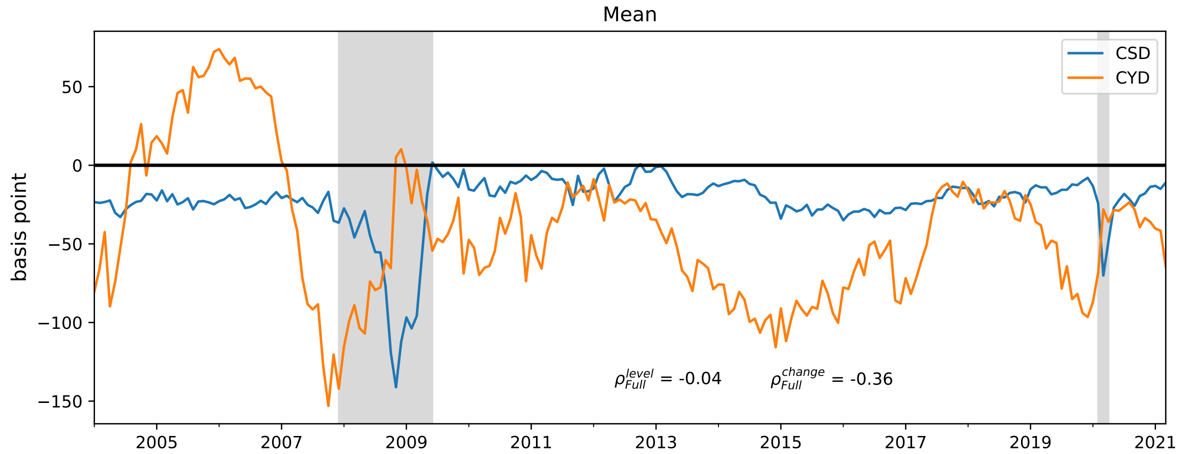
A.3 CSD Based on Matched Bonds

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 and USD denominated bonds with similar remaining maturity and duration. Figure A3 compares the CSD based on the matched bond pairs with the CSD we estimated based on the cross-sectional regressions specified by Eq. (5). The baseline CSD we used in the paper is quite close to the CSD estimated based on matched bond pairs.

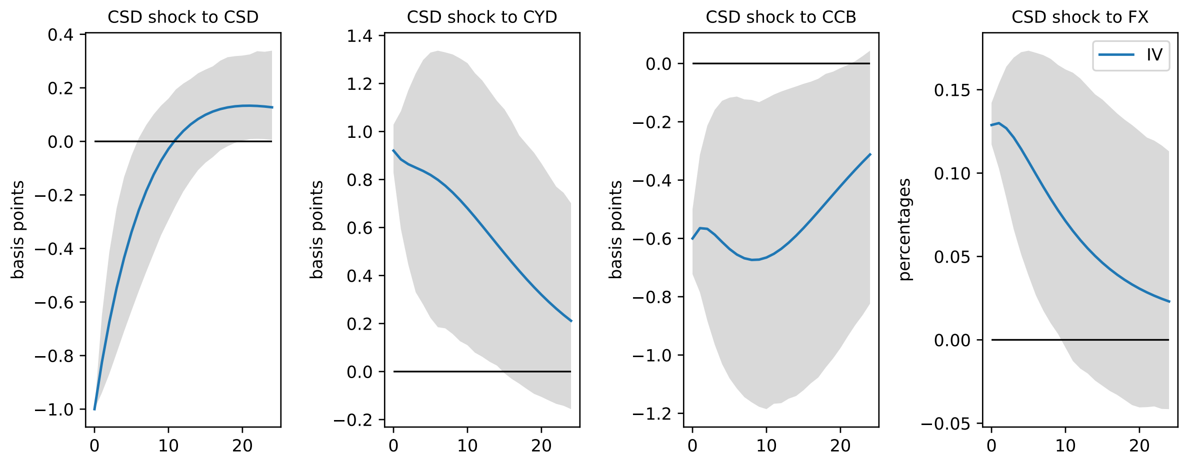
19. Due to the data available, we drop the sample with the CHF-denominated bonds.

Figure A1: Robustness check using Alternative Risk-Free Rates (ARR)

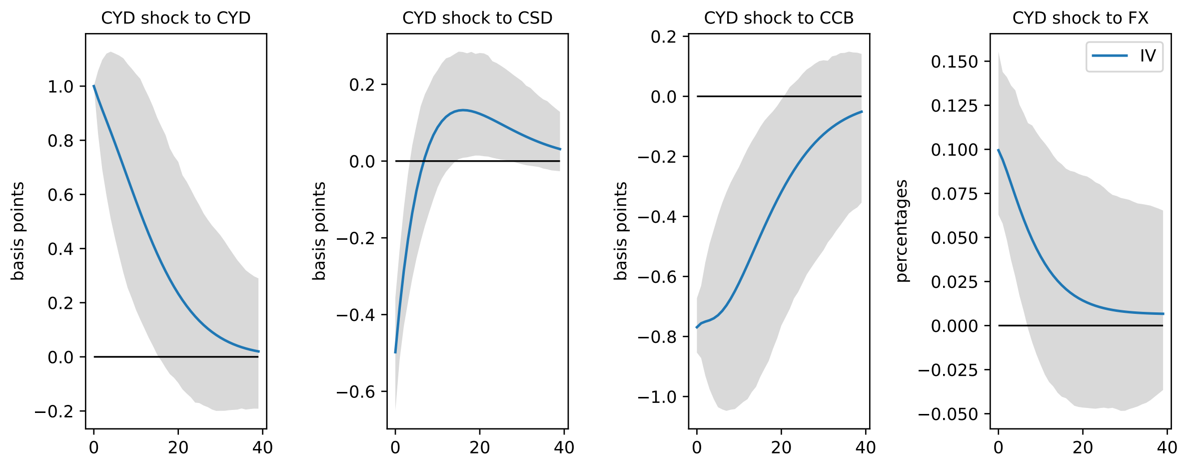
(a) Substitution Effect using Alternative Risk-Free Rates (ARR)



(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.

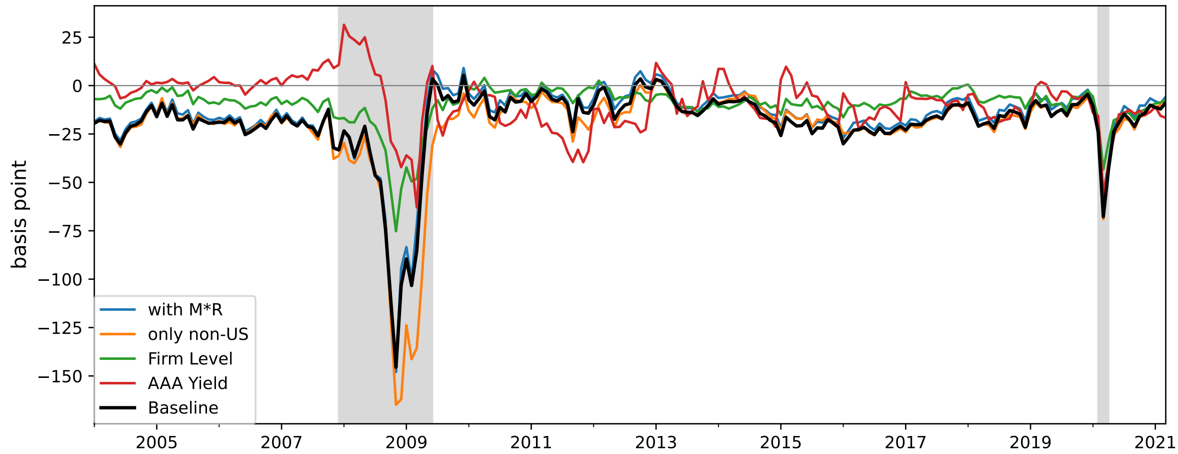


First stage regression: Coefficient: 90.80; F-statistics: 3.11; R^2: 0.015.

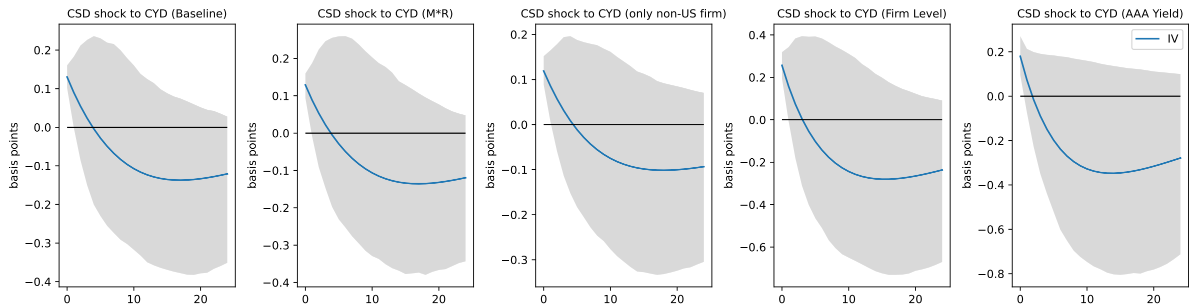
The top figure redraws the substitution effect with the CYD_{ARR} and CCB_{ARR}. The bottom figure redraws the SVAR model analysis with the ARR. The IVs are the financial intermediaries' balance sheet constraints shock and monetary policy shock for CSD shock and CYD shock, respectively. The sample is 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 A2: Alternative Measures of CSD

(a) Alternative Measurement

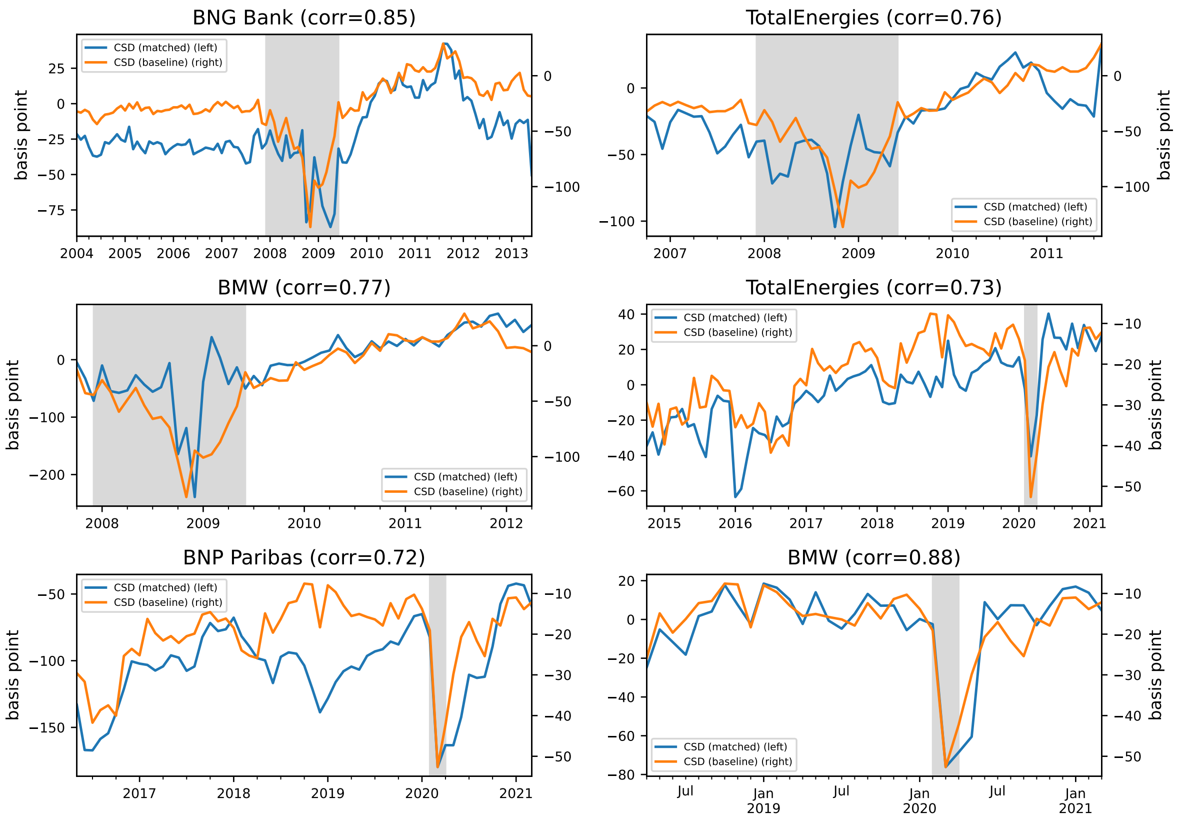


(b) SVAR Model Analysis (Mean)



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 A3: Credit Spread Differentials Based on Matched Pairs of Bond

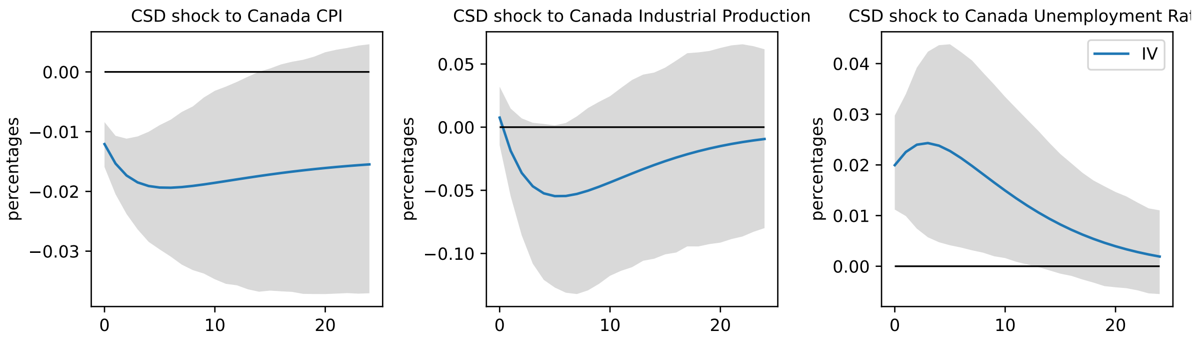


This figure presents the CSD at the bond pair-level. The bond pair-level (matched) CSD is the credit spread difference between a EUR-denomination bond and a USD-denomination bond issued by the same firm with similar remaining maturity and duration. The sub-figure title shows the parent firm's name and 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.

B Macroeconomic effects on other countries

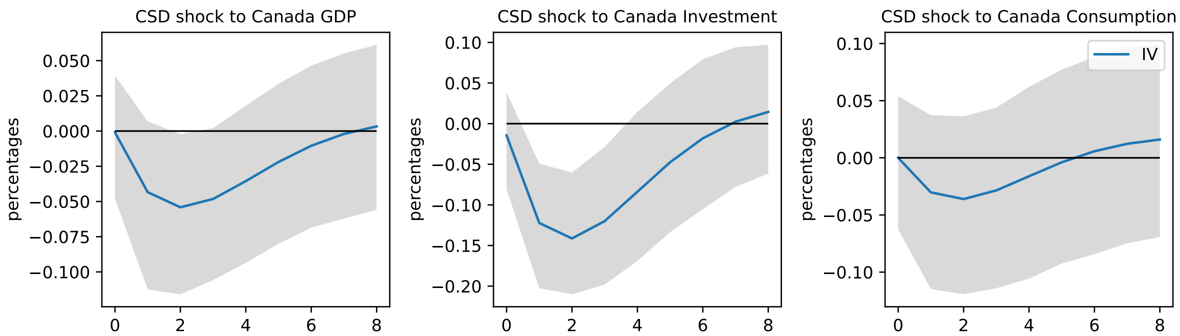
Figure A4: IRF of the CSD Shock with the Canada Macroeconomic Activity (CAD)

(a) Monthly Variables



First stage regression: Coefficient: 38; F-statistics: 20; R^2: 0.09.

(b) Quarterly Variables

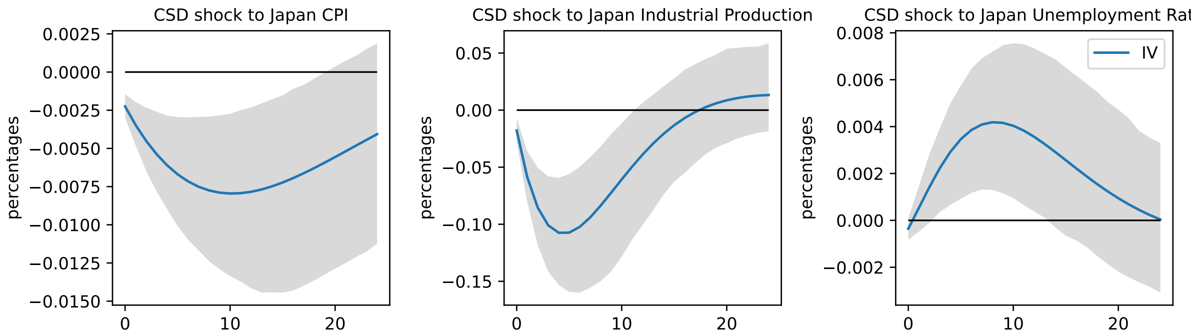


First stage regression: Coefficient: 43.29; F-statistics: 26; R^2: 0.28.

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 CAD data of CSD, CYD, CCB, Canada CPI, Canada Industrial Production, Canada Unemployment Rate, Canada Real GDP, Canada Real Investment and Canada Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

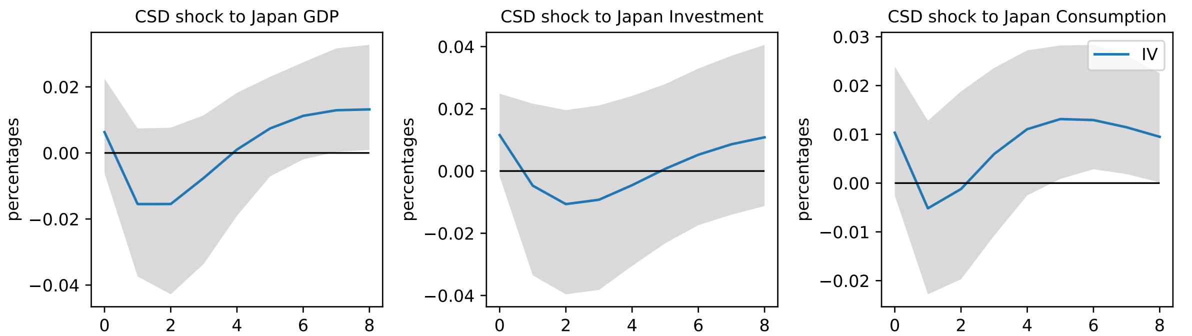
Figure A5: IRF of the CSD Shock with the Japan Macroeconomic Activity (JPY)

(a) Monthly Variables



First stage regression: Coefficient: 135.02; F-statistics: 140.23; R^2: 0.40.

(b) Quarterly Variables

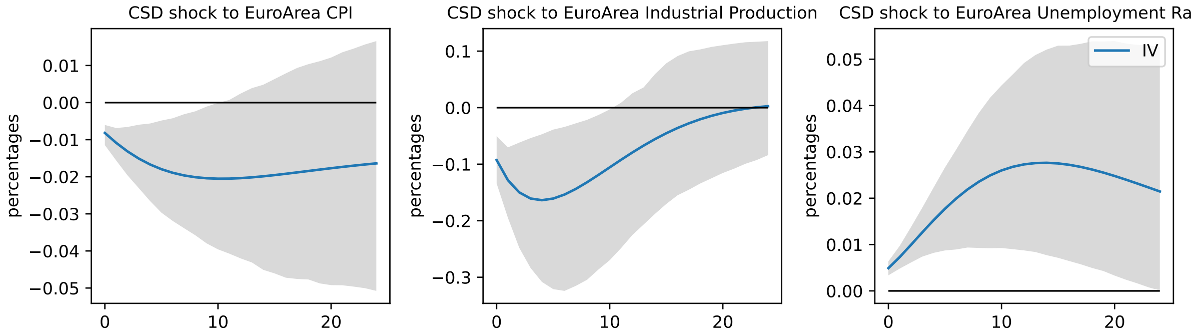


First stage regression: Coefficient: 98.9; F-statistics: 58.96; R^2: 0.47.

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 JPY data of CSD, CYD, CCB, Japan CPI, Japan Industrial Production, Japan Unemployment Rate, Japan Real GDP, Japan Real Investment and Japan Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

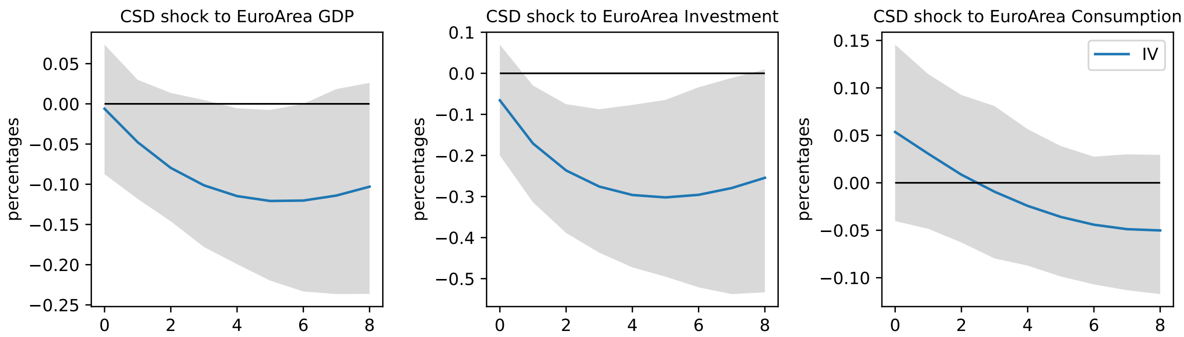
Figure A6: IRF of the CSD Shock with the Euro Area Macroeconomic Activity (EUR)

(a) Monthly Variables



First stage regression: Coefficient: 33.93; F-statistics: 19.13; R^2: 0.09.

(b) Quarterly Variables

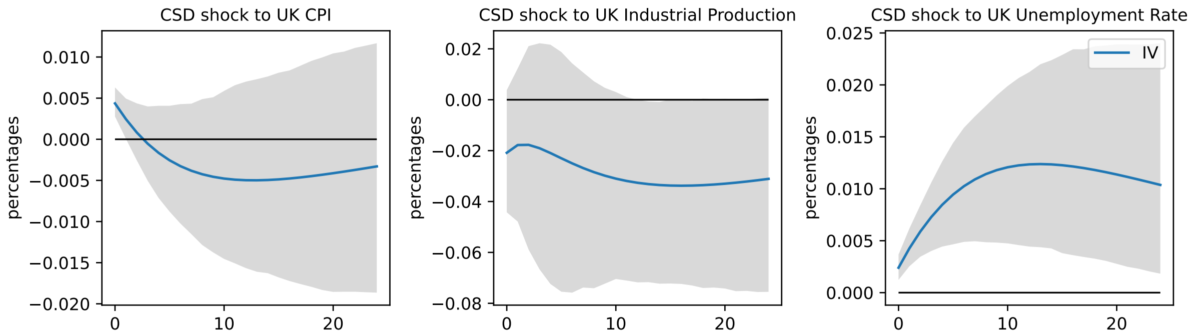


First stage regression: Coefficient: 26.43; F-statistics: 11.30; R^2: 0.15.

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 EUR data of CSD, CYD, CCB, Euro Area CPI, Euro Area Industrial Production, Euro Area Unemployment Rate, Euro Area Real GDP, Euro Area Real Investment and Euro Area Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

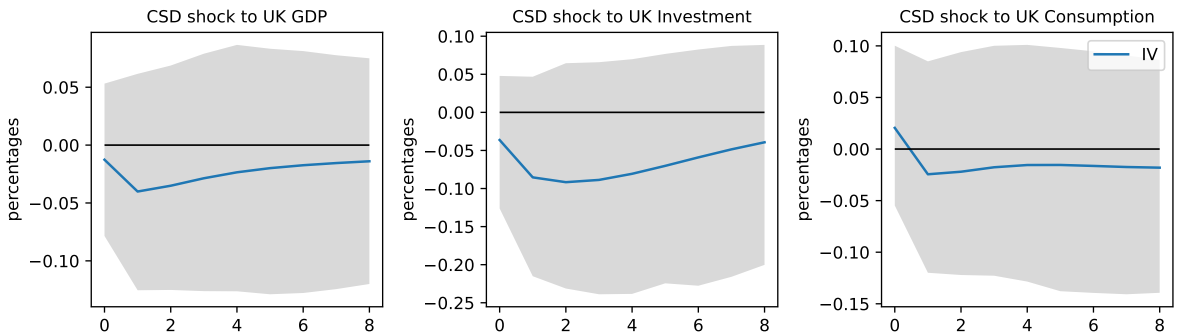
Figure A7: IRF of the CSD Shock with the UK Macroeconomic Activity (GBP)

(a) Monthly Variables



First stage regression: Coefficient: 43.00; F-statistics: 35.42; R^2: 0.15.

(b) Quarterly Variables

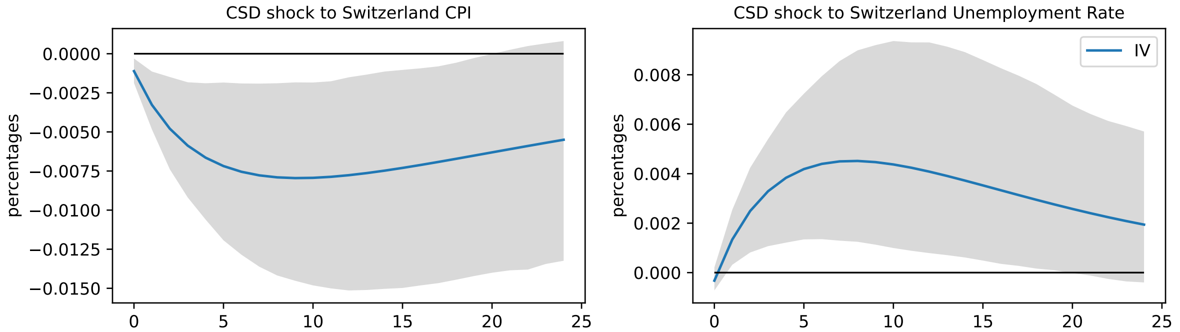


First stage regression: Coefficient: 37.45; F-statistics: 13.78; R^2: 0.18.

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 GBP data of CSD, CYD, CCB, UK CPI, UK Industrial Production, UK Unemployment Rate, UK Real GDP, UK Real Investment and UK Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

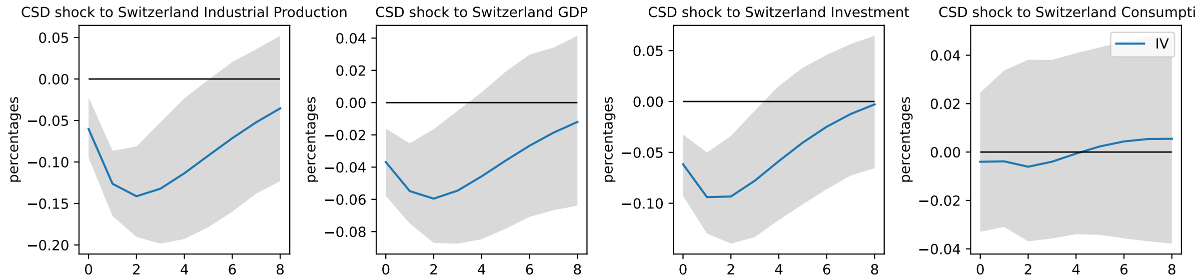
Figure A8: IRF of the CSD Shock with the Switzerland Macroeconomic Activity (CHF)

(a) Monthly Variables



First stage regression: Coefficient: 89.79; F-statistics: 78.77; R^2: 0.28.

(b) Quarterly Variables

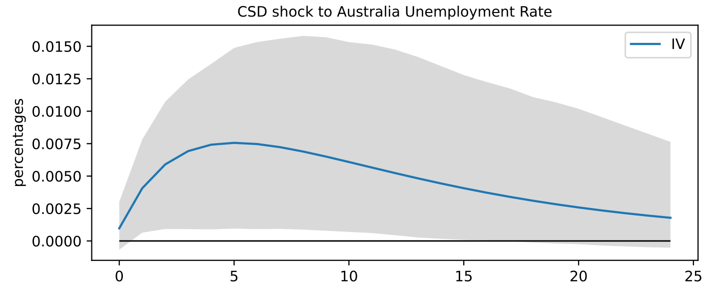


First stage regression: Coefficient: 53.08; F-statistics: 27.6; R^2: 0.29.

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 CHF data of CSD, CYD, CCB, Switzerland CPI, Switzerland Industrial Production, Switzerland Unemployment Rate, Switzerland Real GDP, Switzerland Real Investment and Switzerland Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.

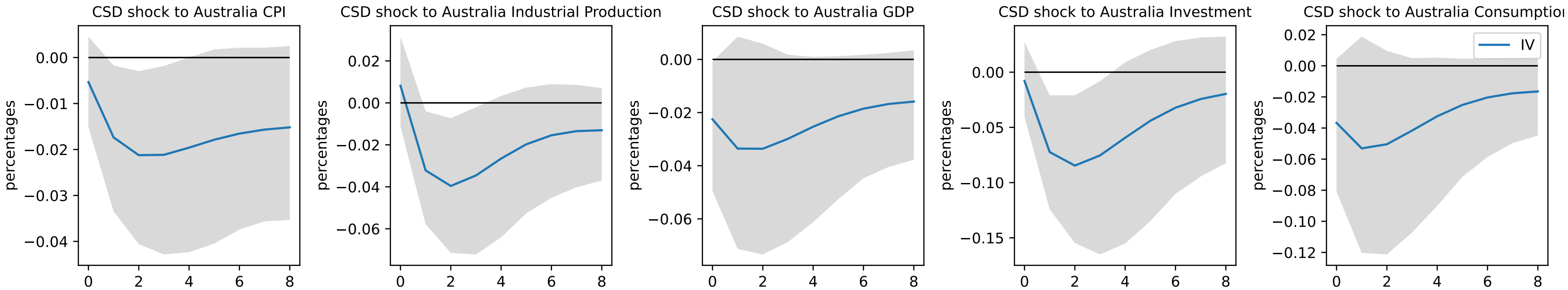
Figure A9: IRF of the CSD Shock with the Australia Macroeconomic Activity (AUD)

(a) Monthly Variables



First stage regression: Coefficient: 65.93; F-statistics: 39.74; R^2: 0.16.

(b) Quarterly Variables



First stage regression: Coefficient: 37.62; F-statistics: 15.51; R^2: 0.19.

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 AUD data of CSD, CYD, CCB, Australia CPI, Australia Industrial Production, Australia Unemployment Rate, Australia Real GDP, Australia Real Investment and Australia Real Consumption. The monthly and quarterly variables are estimated in the SVAR model separately.