Corporate Basis and Demand for U.S. Dollar Assets

Grace Xing Hu [*] Zhan Shi [†] Ganesh Viswanath-Natraj [‡] Junxuan Wang [§] [¶]

This version: April 4, 2024

Abstract

This paper introduces a novel method to decompose the corporate basis, which measures price differences between bonds issued in dollars and foreign currencies by the same entity. Our approach uses credit spread and convenience yield differences to measure the relative demand for risky and safe dollar assets. We find that investors substitute between these assets in response to credit spread shocks. Our findings are robust when using credit-market illiquidity and sentiment as instrumental variables, and also align consistently with shifts in global investor holdings. Furthermore, we observe significant effects of credit spread shocks on FX, equity, 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, Bond Market Liquidity

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

[*]hux@pbcsf.tsinghua.edu.cn., PBC School of Finance, Tsinghua University

[†]shizh@pbcsf.tsinghua.edu.cn., PBC School of Finance, Tsinghua University

[‡]ganesh.viswanath-natraj@wbs.ac.uk, Warwick Business School

[§]j.wang@jbs.cam.ac.uk, University of Cambridge

[¶]We would like to thank Rodrigo Barria, Lorenzo Bretscher, Hui Chen, Andrea Gamba, Zhe Geng (discussant), Arie Gozluklu, Bing Han, Brandon Yueyang Han (discussant), Harald Hau (discussant), Marcin Kacperczyk, Tao Liu (discussant), Francis Longstaff, Dong Lou, Yiming Ma, Quan Qi (discussant), Giulio Rossetti and David Skeie; seminar participants at Renmin University, Tsinghua University, Xiamen University, Warwick Business School, Zhejiang University, 53rd MMF Annual Meeting, 2023 Asian Meeting of the Econometric Society, 2023 China International Conference in Macroeconomics, 2022 CIFER Annual Meeting, 2023 European Finance Association Annual Meeting, 2022 Finance Management Annual Meeting, 2023 FMA European Conference, 39th Conference of the French Finance Association, 2023 IFABS Annual Meeting, and 2022 New Zealand Finance Meeting for helpful comments and suggestions. We would also like to thank Gerardo Ferrara and Philippe Mueller for help with the data. We thank Gordon Y. Liao for kindly sharing his codes. All errors are our own.

1 Introduction

The corporate basis is a measure of price discrepancies between corporate bonds issued in different currencies by the same entity. It is supposed be zero in a frictionless financial market, reflecting the absence of arbitrage in cross-border corporate bond markets after hedging currency risk. However, since the global financial crisis, the corporate basis between the US dollar and foreign currencies 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 jointly drive the variation in the corporate basis. This study examines the effect of shocks to bond market liquidity and monetary policy on the corporate basis. Our key contribution is to document a substitution effect between risky and safe dollar assets. In addition, 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 links its variation with firms' currency preference in debt financing (Liao 2020; Caramichael, Gopinath, and Liao 2021; Galvez et al. 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 non-USD denominations and otherwise identical ones with USD denominations, and captures the relative demand for risky dollar assets. CYD measures the difference in government bond spreads between non-USD and USD denominations, and reflects the relative demand for safe dollar assets. CCB is defined as the difference between the synthetic and direct dollar funding costs and thus captures dollar scarcity in FX swap markets.

Using a universe of 30,926 corporate bonds spanning from January 2004 to March 2021, we estimate the corporate basis for six major funding currencies, namely the Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), British Pounds (GBP), and Japanese Yen (JPY), relative to the U.S. Dollar (USD). Unlike government bond yields, the corporate yield curve is relatively incomplete for individual bond issuers. To address this, we employ cross-sectional regressions to disentangle the currency impact on hedged corporate bond yields. This approach enables us to derive estimates for the corporate basis, which, together with estimates of CYD and CCB, collectively facilitates the determination of CSD through our three-way decomposition. As such, we uncover a substitution effect between safe and risky assets: foreign investors

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

balance their global bond portfolios not only between the US assets and local assets, but also between the risky and safe US assets. For example, an increase in the intensity of the US corporate bond market frictions relative to other economies could lead global investors to substitution of demand from risky to safe dollar assets.

To further establish this stylized fact, we firstly 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 us with monthly transaction data on cross-border purchases and sales of US assets from US-resident broker-dealers that are responsible for securities transactions with non-residents, issuers, investors, and money managers. This data allows us to observe foreign investors' holdings of US corporate bonds and Treasury securities. During the 2008 global financial crisis (GFC) and the 2011-2012 European debt crisis, we observed a positive surge in foreign investors' demand for safe dollar assets, accompanied by a sell-off of risky dollar assets during these periods. This observation is consistent with our narrative of a substitution effect.

Next, we conduct a structural VAR (SVAR) analysis to shed light on the joint dynamics of each component of the corporate basis. The estimation results validate the substitution effect: a negative shock to the CSD leads to an increase in the US Treasury convenience spread. In particular, we construct two instruments to identify the causal effect of shocks to the CSD. The first instrumental variable (IV) concerns the aggregate illiquidity of USD corporate bonds versus non-USD ones. The intuition is that active and elastic investors in the corporate bond market (e.g., bond mutual funds) have a strong preference for liquid bonds (Bretscher et al. 2022), especially given that asset illiquidity could amplify fragility of bond funds (Goldstein, Jiang, and Ng 2017). It follows that an increase in the USD bond illiquidity affects the corporate basis through raising dollar credit spreads relative to other currencies. Empirical findings based on this IV further reinforce our SVAR results. Quantitatively, we find a one standard deviation (18.2 basis points) increase in USD credit spreads relative to foreign currency spreads leads to a 3.56 basis point increase in CYD.

We also consider the relative sentiment of the US credit market as a second IV for CSD shocks. Following López-Salido, Stein, and Zakrajšek (2017), we hypothesize that high-sentiment periods are associated with low expected returns for taking on credit risk. Building on this hypothesis, we develop a proxy to capture fluctuations in the relative sentiment between USD and non-USD credit markets, which turns out to have strong explanatory power for CSD shocks. Consistent with the results based on corporate bond illiquidity shocks, we observe a substitution effect between the demand for safe and risky assets in response to sentiment shocks.

To further establish the substitution effect, we also construct an IV for CYD using the U.S. monetary policy shock. A tightening of U.S. monetary policy increases the holding return on U.S. Treasuries, resulting in a higher demand for safe dollar assets. This, in turn, affects the spread between U.S. Treasury and corporate bond yields through the substitution effect between the demand for risky and safe dollar assets. Following the methodology described at Nakamura and Steinsson (2018), we construct the monetary policy shock series as the first principal components of high-frequency changes in federal funds rates and Eurodollar futures interest rates around scheduled Federal Open Market Committee (FOMC) announcements. Consistent with the results based on IVs for CSD, we observe a substitution between safe and risky assets in response to monetary policy shocks. Quantitatively, an increase of one standard deviation (18 basis points) in CYD leads to a decrease of 11.18 basis points in CSD.

Lastly, we examine the spillover effects of shocks to dollar asset demand on other asset classes and economic activity. Specifically, in the foreign exchange (FX) markets, our findings indicate that an increase in the corporate basis results in a significant depreciation of the USD. This negative impact is primarily driven by the CSD component of the corporate basis. Conversely, the Treasury premium, which encapsulates the demand for safe dollar assets and factors related to cross-border liquidity scarcity, has a positive effect on the USD, consistent with the evidence presented in Jiang, Krishnamurthy, and Lustig (2021). Additionally, we investigate the spillover effects of shocks to the CSD on equity and commodity markets, as well as real economic activity. Our results reveal that shocks to the demand for risky dollar assets have a substantial impact on key macroeconomic variables, including the consumer price index (CPI), industrial production, unemployment rate, real gross domestic product (GDP), real investment, and real consumption. A negative shock to the CSD leads to a contraction in the economic activities of both the US and non-US economies. This finding is consistent with previous research on the impact of financial shocks, represented by (unexplained) credit spreads, on real economic activity (Gilchrist and Zakrajšek 2012; Gertler and Karadi 2015).

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 estimating 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 derives from the CIP deviation, which is a proxy for scarcity of cross-border dollar liquidity scarcity. Du, Tepper, and Verdelhan (2018) document a persistent CIP deviation after the GFC, and a number of studies provide explanations on banking regulation, heterogeneous funding costs, interest rate differentials, unconventional monetary policy, and effective funding rates in OTC markets.[2] Turning to works on the fixed-income market, Du, Im, and Schreger (2018), Liao (2020), and Caramichael, Gopinath, and Liao (2021) focus on the factors that affect CIP deviations measured using corporate and government bonds. This paper complements these studies by linking different forms of CIP violations together.

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.[3] 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. This merit of our decomposition is substantiated by Diamond and Van Tassel (2022), who find that corporate CIP deviations as documented by Liao (2020) is attributable to the difference in convenience yields.

Our study is also related to a literature understanding the role of the US dollar as a reserve currency and international investor demand for risky dollar assets. Maggiori, Neiman, and Schreger (2019, 2020) provide evidence of a surge in the dollar's share in the global bond market after 2008, as well as an overall rise of the US dollar as an international

2. These studies include, but are not limited to, 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), and Augustin et al. (2023).

3. 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).

currency. We contribute to this literature by documenting the prominent role of the US dollar in international investors' balance sheets, and how they substitute between risky and safe dollar assets especially when bond markets are distressed. We substantiate the 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, this paper contributes to the literature studying the impact of bond market frictions on corporate bond pricing. Despite the extensive empirical evidence from the US corporate bond market (Bao, Pan, and Wang 2011; Dick-Nielsen, Feldhütter, and Lando 2012; Friewald, Jankowitsch, and Subrahmanyam 2012; Friewald and Nagler 2019; He, Khorrami, and Song 2022), few studies explore pricing implications of bond illiquidity outside the US. A notable exception is Huang, Nozawa, and Shi (2023), who demonstrate the central importance of bond illiquidity in accounting for pricing errors of structural credit models across countries. However, they restrict their sample to corporate bonds issued in domestic currencies to minimize the currency effect on bond pricing, which is exactly the focus of our study. From this point of view, we provide complementary evidence that shocks to the USD bond liquidity (relative to non-USD ones) reduce the demand for risky dollar assets and thus increase the yield spread difference between USD and non-USD bonds even for the same issuer.

3 Definitions and Data

3.1 Decomposition of Corporate Basis

Consider corporate debts denominated in EUR and USD. In Equation (1), we represent the yield difference as the EUR bond yield minus the USD bond yield while controlling for FX risk. From an investor's perspective, this reflects the excess return obtained from holding a EUR-denominated corporate bond ($y_{\text{EUR},t}$) relative to the synthetic yield constructed by maintaining a cash position in a USD bond issued by the same entity ($y_{\$,t}$) and hedging the currency risk in the FX market. The cost of FX hedging is denoted as $-(f_t - s_t)$, where s_t and f_t represent the spot and forward (log) exchange rates quoted in EUR per USD. Additionally, we express the corporate basis in Equation (2) as the combination of a CSD, which captures variations in the demand for risky assets across currencies, and the U.S. Treasury premium (Du, Im, and Schreger 2018; Jiang, Krishnamurthy, and Lustig 2021).

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

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

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

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 key difference from previous studies on corporate bases is that we further decompose the Treasury premium into the relative expensiveness of the US Treasuries—which is denoted by the convenience yield differential—and deviation from the CIP condition. Therefore, our decomposition of the corporate basis constitutes three elements: differences in risky asset yields (credit spread differentials), differences in sovereign yields (convenience yields differentials), 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 *unhedged* demand for risky dollar assets, which may be attributed to heightened risk aversion among bond investors or increased FX hedging costs (such as during the financial crisis period).

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 risk-free 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 CSD 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 Equation (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. Also, corporate bond spreads are usually measured over government bond yields in practice. Indeed, credit spreads quoted in the *Wall Street Journal* and the three major US (investment-grade) corporate bond indices—the Bloomberg Barclays, ICE BofA, and FTSE IG indices—are calculated over government bond yields.[4]

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; (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. 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): 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 and winsorize it at 1% at the currency-month level to remove outliers.

The final data set consists of 30,926 bonds issued by 3,376 entities with a total notional of \$23.6 trillion. Following Liao (2020), we identify bond issuers by the borrower ultimate parent's 6-digit CUSIP. In other words, we link the 3,376 (residency-based) entities to their immediate parents by utilizing the UPCUSIP variable in the SDC database. Table 1 displays the monthly average of the number of bonds, the notional value in billion dollars, and the number of ultimate issuers by rating and maturity categories. On average, we have around 6,970 bonds with notional values of \$5,282 billion issued by 929 firms each

4. The option-adjusted spreads (OAS) in the three indices are all based on government bond rates, and the ICE BofA offer a variable named "Libor OAS" besides the standard "OAS" variable.

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 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% (2,798) of bonds and 47% ($2,508 billions) of notional values in our sample. They are followed in turn by EUR, JPY, GBP, CAD, CHF and AUD denominated bonds. Notably, more than 86% 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 43% are issued by foreign firms, and they jointly account for 47% of notional values of all dollar-denominated bonds.

In addition, we present a visual representation of cross-border bond issuance in Figure 2, based on cross-sectional observations of the outstanding amount at the end of our sample period (March 2021). Our analysis focuses on bond issuers located in the US, Euro Zone, the UK, Switzerland, Canada, Australia, and Japan. The size of the purple circle indicates the total notional principal of bonds issued by domestic firms. As expected, US firms account for the largest share of bond issuance in the global corporate bond markets, followed by issuers in the EU, Japan, and the UK.

The thickness of the arrow lines, such as those from the EU to the US, represents the total size of USD-denominated bonds issued by European firms. A comprehensive comparison of all the arrow lines in the figure reveals that EU-to-US, UK-to-US, and US-to-EU represent the most significant types of cross-border bond issuance. Lastly, the darkness of the EU-to-US arrow illustrates the proportion of foreign currency bonds issued by European firms that are denominated in USD. Our findings indicate that USD-denominated bonds dominate the category of foreign currency bonds in all countries except Australia. Among foreign currency bonds issued by Australian firms, the shares of USD and EUR denominations are equally substantial. Overall, Figure 2 highlights the dominant position of USD-denominated bonds in foreign currency bond issuance, 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. First, to construct a measure of aggregate illiquidity for each corporate bond market, we do not confine our data sample to issuers with multiple currency bonds outstanding. Instead, we include all bonds covered by the ICE BofA Global Corporate Index and High Yield Index to gather a representative sample for each currency.[5] We use daily quoted prices to estimate the Hasbrouck (2009) measure for each bond-month and then aggregate them to the currency level.

Second, in our inference of credit-market sentiment, we follow López-Salido, Stein, and Zakrajšek (2017) by quantifying bond yield spreads net of estimates of default risk and liquidity risk. Following Gilchrist and Zakrajšek (2012), we measure each issuer's default risk with the distance to default. To this end, we match month-end corporate bond prices from the ICE BofA database with their issuer's balance sheet data and equity data from Compustat NA (for the US and Canada) and Compustat Global (for other countries).

Finally, to provide quantity-based evidence on USD asset demand, we make use of monthly net purchases of the US long-term securities by foreign residents as provided by TIC database. Specifically, there are two components to the Treasury SLT filing: an external liabilities and an external claims component. We extract from the former aggregate monthly purchases and sales of US securities by foreign countries at an aggregate asset class level.

5. Huang, Nozawa, and Shi (2023) compare the BGN corporate bond data—our primary data source—with the ICE BofA data. For the bonds appearing in both databases, they find that the average credit spreads closely match each other regardless of currency denomination.

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 Liao (2020), we estimate corporate basis by running the following cross-section regression:[6]

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

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.[7]

Cross-currency basis (CCB)

Since we exclude corporate bonds with less than one year to maturity, CCB in our setting cannot be directly estimated from currency forward rates. Instead, we follow Du, Tepper, and Verdelhan (2018) by using spreads on Libor cross-currency basis swaps to quantify long-horizon CCB. The cross-currency swap involves a currency swap as well as exchanges of cash flow linked to floating interbank rates and thus offers a measure for long-term

6. We drop a bond-month observation if its remaining maturity is less than one year or 10% of full maturity to mitigate the illiquidity issue.

7. 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.

CIP deviations. As shown in Augustin et al. (2023), CIP deviations at short and long horizons exhibit different behavior and are driven by distinct economic forces.

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,

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

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 sample is around five years. The second approach follows our estimation of the corporate basis. Specifically, we replace $X_{i,t}$ in Equation (4) with $CS_{i,t}$,

$$CS_{i,t} = \alpha'_{c,t} + \beta'_{f,t} + \gamma'_{m,t} + \delta'_{r,t} + \epsilon'_{i,t}. \tag{5}$$

It follows that the CSD between currency c and USD could be calculated as $\mathrm{CSD}_{c,t}^{Reg} = \alpha'_{c,t} - \alpha'_{USD,t}$.

Summary statistics

Figure 1 illustrates the monthly time series of the corporate basis for currency pairs involving USD and non-USD currencies (AUD, CAD, CHF, EUR, GBP, or JPY) from January 2004 to March 2021. The corporate basis represents the difference between the yield of non-U.S. corporate bonds and the hedged yield of U.S. corporate bonds. It exhibits negative spikes during two crisis periods (the GFC and Covid-19), suggesting either increasing hedging costs or reduced demand for risky dollar assets. Prior to the GFC, the basis was close to zero, but it deviated significantly and experienced significant fluctuations following the crisis.

The three components of the corporate basis—CYD, CSD, and CCB—are analyzed separately in Figure 3. 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), are presented in Table 2. CSD reflects the demand for risky dollar assets. During the crisis period, CSD sharply declined, indicating a shift away from risky dollar assets due to decreased risk appetite and high FX risk and hedging costs. Among the currencies in our sample, JPY and CHF exhibited the most negative CSD, followed by EUR, GBP, CAD, and AUD. The CYD time series displayed 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 in CYD during the GFC reflected the *flight to safety*, while the spike during the Covid-19 period was less pronounced, consistent with the dash for dollars during the pandemic (Ma, Xiao, and Zeng 2022; He, Nagel, and Song 2022; Cesa-Bianchi, Robert, and Eguren-Martin 2023). CCB represents dollar liquidity stress in global financial markets, which was near zero before the GFC but has remained persistently high since.

Table 3 presents 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 in the corporate basis, with an average ratio of $\frac{var(\text{CSD})}{var(\Psi)}$ of 1.36. This contrasts with the variances of CCB and CYD, which have a much smaller impact. Of particular interest is the negative covariance between CSD and CYD, which has an average magnitude of 0.65 and is the second largest component contributing to the variance of the corporate basis. While CSD also exhibits a negative co-movement with CCB, this effect is smaller. The variances of CYD and CCB contribute significantly less to the variation in the corporate basis. The negative covariance between CSD and CYD is a significant driver of the variation in the corporate basis during our sample period.

Finally, Figure 4 presents a robustness test of our estimates by comparing alternative estimates of the CSD. Different estimation methods produce highly similar results for all currencies. The time series of the decomposition-based estimate (CSD^{Dec}) and the regression-based estimate (CSD^{Reg}) exhibit significant overlap. Furthermore, their correlation coefficient indicates a strong correspondence between the two estimates. Due to the robustness of our estimation results, we primarily focus on CSD^{Reg} in the subsequent discussion, unless specifically stated otherwise.

4 Empirical findings: substitution effect between safe and risky assets

4.1 Holdings-Level Evidence

We begin with holding-level data to motivate a substitution effect between the demand for safe and risky dollar assets among foreign investors. To obtain comprehensive information on foreign investors' overall transactions in U.S. assets, we rely on the TIC S-form data. Before we proceed with the quantity-based analysis, we acknowledge two limitations of the TIC data, as outlined in Bertaut and Judson (2014). First, the TIC data records transactions based on the country of the initial cross-border counterparty rather than the ultimate buyer, actual seller, or security issuer. Second, certain types of cross-border securities flows that do not follow the standard broker-dealer and other TIC reporter channels are not captured in the data. Despite these limitations, the TIC data still provides high-quality information regarding the aggregate transactions of foreign investors in U.S. Treasuries and corporate bonds.

To measure foreign investors' holdings of U.S. assets, we obtain historical data on their net purchases of the U.S. assets from *Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities*. To estimate foreign investors' net purchases of USD corporate bonds, we utilize the *Corporate Bonds: U.S. Corporate Bonds (Long-term), Net Purchases*. For foreign investors' net purchases in U.S. Treasuries, we utilize the *Treasury Bonds and Notes, Net Purchases*. Additionally, we look at foreign private investors focusing on their respective holdings of U.S. corporate bonds and Treasuries during two significant crisis periods: the 2008 financial crisis and the 2011-2012 European debt crisis.

We present our findings in Figure 5. The net purchases of U.S. assets are scaled by one standard deviation of the monthly net purchases from January 2004 to March 2021. We also add the VIX to reflect the stress in the overall financial market. Results in the top panel clearly indicate a substitution effect in foreign private investors' demand between risky and safe dollar assets during the 2008 financial crisis. Notably, foreign investors decreased their holdings of U.S. corporate bonds while increasing their holdings in U.S. Treasury bonds in March 2008. This shift coincided with the collapse of Bear Stearns due to serious mortgage-related losses. Additionally, from July 2008 to November 2008, when the financial crisis peaked with a spike in the VIX, foreign private investors continued to reduce their holdings of U.S. corporate bonds and amplified their investments in U.S. Treasury bonds.

Next, we turn our attention to the period surrounding the European debt crisis, as depicted in the bottom panel of Figure 5. During this time, foreign investors significantly increased their holdings of U.S. Treasury bonds while reducing their holdings in U.S. corporate bonds. Notably, from August 2011 to September 2011, amid continuous financial market stress, there was a consistent flow of foreign investment towards U.S. Treasury bonds, accompanied by a corresponding reduction in investments in U.S. Corporate bonds.

Overall, the evidence at the holding level suggests a substitution effect between safe and risky dollar assets, as foreign investors concurrently acquire U.S. Treasuries while divesting from U.S. corporate bonds.

4.2 Joint dynamics of the corporate basis elements

Now, we provide yield-based evidence for the substitution effect. We present the time-series plot of the cross-currency mean of CYD and CSD in the top panel of Figure 6, covering the period from January 2004 to March 2021. The correlation between CSD and CYD for the entire sample is strongly negative, with a value of -0.48 for levels and -0.46 for monthly changes. This indicates a robust substitution effect between the demand for safe and risky dollar assets. During the global financial crisis, the negative correlation between CSD and CYD becomes even more pronounced, reaching -0.82 for levels and -0.57 for monthly changes. This intensified negative co-movement between CSD and CYD during the crisis reflects a *flight to safety* behavior among global investors, characterized by a decrease in CSD and an increase in CYD. We observe a similar pattern during the recent Covid-19 pandemic period, with a significant decline in CSD but only a moderate increase in CYD. This moderate increase in CYD aligns with recent literature suggesting that U.S. Treasuries have lost their specialness during the pandemic (Cesa-Bianchi, Robert, and Eguren-Martin 2023; Ma, Xiao, and Zeng 2022; He, Nagel, and Song 2022).

The robustness of the substitution effect is evident even when excluding the periods of the GFC and the Covid-19 pandemic from our sample. When excluding these periods, we find a statistically significant correlation of -0.33 between the monthly changes of CSD and CYD, at the 1% level. These results hold consistently across all currencies examined. In the remaining panels of Figure 6, we display the time-series of CSD and CYD for each of the six non-USD currencies included in our analysis. For all six currencies, we observe a negative co-movement between CSD and CYD, further confirming the presence of the substitution effect.

4.2.1 Structural VAR: Baseline Estimation

To analyze the simultaneous dynamics of CSD, CYD, and CCB, we estimate a structural vector autoregression (SVAR) model as shown in Equation (6):

$$AY_t = A_0 + \sum_{j=1}^{N} A_j Y_{t-j} + \epsilon_t, \tag{6}$$

Here, $Y_t = [CSD_t; CYD_t; CCB_t]'$ represents the vector of variables, and ϵ_t is a vector of orthogonal structural innovations with zero mean. We assume that ϵ_t follows a mutually uncorrelated and unit variance distribution, i.e., $E(\epsilon_t \epsilon_t') = \sum = \mathbb{1}$.

The parameter N is set to one based on the Bayesian information criterion (BIC) criteria for the VAR model. The vector ϵ_t includes shocks to the risky and safe components of asset demand ($\epsilon_t^{\text{CSD shock}}$ and $\epsilon_t^{\text{CYD shock}}$) as well as a shock to cross-border dollar liquidity ($\epsilon_t^{\text{CCB shock}}$). By multiplying both sides of Equation (6) by A^{-1}, we obtain the reduced form representation given by Equation (7):

$$Y_t = C_0 + CY_{t-1} + B\epsilon_t \tag{7}$$

In Equation (7), B represents the inverse of A, C_0 is computed as $A^{-1}A_0$, and C is calculated as $A^{-1}A_1$.

In our baseline estimations, we assume a causal relationship where CSD influences CYD and CCB contemporaneously, and CYD influences CCB contemporaneously. Figure

7 displays the impulse response function (IRF) of a one-unit shock to each variable, based on the mean values of CSD, CYD, and CCB across all currencies in our sample.[8] The IRF is estimated using 1,000 bootstraps. The results provide evidence of a substitution effect between safe and risky dollar assets, as shocks to CSD lead to a negative co-movement between CSD and CYD. Quantitatively, a one standard deviation increase in CSD (18.2 basis points) results in a 4.2 basis point decrease in CYD. Furthermore, positive shocks to both CSD and CYD lead to a contemporaneous decrease in CCB. Specifically, a one standard deviation increase in CSD (18.2 basis points) and CYD (18 basis points) corresponds to decreases in CCB of 2.46 and 2.50 basis points, respectively.

4.2.2 SVAR with Instrument Variable

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 IV for shocks to CSD. In other words, 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 Equation (9):

$$\begin{bmatrix} CSD_t \\ CYD_t \\ CCB_t \end{bmatrix} = \begin{bmatrix} c10 \\ c20 \\ c30 \end{bmatrix} + \begin{bmatrix} c11 & c12 & c13 \\ c21 & c22 & c23 \\ c31 & c32 & c33 \end{bmatrix} \begin{bmatrix} CSD_{t-1} \\ CYD_{t-1} \\ CCB_{t-1} \end{bmatrix} + \begin{bmatrix} b11 & b12 & b13 \\ b21 & b22 & b23 \\ b31 & b32 & b33 \end{bmatrix} \begin{bmatrix} \epsilon_t^{\text{CSD shock}} \\ \epsilon_t^{\text{CYD shock}} \\ \epsilon_t^{\text{CCB shock}} \end{bmatrix}. \tag{9}$$

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 (8):

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

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

8. We examine the IRFs for CSD, CYD, and CCB at the individual currency level, and the results remain robust. However, due to space limitations, we do not include the IRF plots for individual currencies in the paper.

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:[9]

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

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

4.2.3 Instrument Variable For CSD: Credit-Market Illiquidity and Sentiment

We employ the SVAR approach using two instrument variables (IVs) for the CSD. The first IV is based on the relative illiquidity differences between USD corporate bonds and non-USD ones. The idea is that active investors in the corporate bond market often exhibit a strong preference for liquid bonds, as shown in Bretscher et al. (2022). Corporate bond mutual funds, for example, prefer liquid corporate bonds because bond illiquidity amplifies mutual funds fragility, by exacerbating the sensitivity of fund performance to flows (Goldstein, Jiang, and Ng 2017) or magnifying the price impact of herding by mutual funds (Cai et al. 2019). It is therefore reasonable to assume that the relative liquidity differences between USD and non-USD corporate bonds (our IV) is related to investors' demand for USD corporate bonds (CSD), and does not directly reflect their preference for safe USD assets (CYD).

We follow Hasbrouck's (2009) approach to infer the effective transaction costs in both the USD and non-USD corporate bond markets. There are, of course, many alternative corporate bond liquidity measures. We base our results on the Hasbrouck measure for two reasons. Firstly, unlike the US corporate bond market, there is very limited regulatory requirements for reporting OTC-market bond transactions outside the U.S. until recent years.[10] For this reason, we are unable to construct liquidity measures based on high-

9. 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 $\gamma_2 = b31/b11$.

10. In Europe, MiFID II has recently introduced new transparency requirements for corporate bond trading to improve pre-trade and post-trade transparency. This regulation mandates investment firms and other trading institutions to submit reports for their trades in debt instruments permitted to trade on a venue, including regulated markets, multilateral trading facilities, and organised trading facilities.

frequency intra-day bond transactions or trading volumes—such as the Amihud (2002) measure for price impact and the Edwards, Harris, and Piwowar (2007) measure for effective bid-ask spreads—for most of our non-US data sample. Secondly, Schestag, Schuster, and Uhrig-Homburg (2016) have shown that the Hasbrouck measure has the best performance after empirically comparing various low-frequency measures of corporate bond liquidity based on daily pricing data in the US market.[11]

Consider bond i in month t, we perform Hasbrouck's (2009)'s Gibbs sampler estimation of the extended Roll model,

$$r_{i,u} = c_{i,t} \cdot \Delta D_{i,u} + \beta r^{M}_{i,u} + \epsilon_{i,u}, \tag{12}$$

where $r_{i,u}$ and r^{M}_{u} denote returns on bond i and the corporate bond market, respectively, at day u in month t. D is a sell side indicator, and c is half of the effective bid-ask spread. By making inference of the latent D_u with Gibbs sampling, this estimator overcomes the negative spread estimates associated with the Roll (1984) model. By estimating Eq. (12) on a monthly basis, we obtain $Gibbs_{i,t} = 2\hat{c_{i,t}}$ as an estimate of effective transaction costs.

In line with Bao, Pan, and Wang (2011), we aggregate $Gibbs_{i,t}$ to the currency level in each month and denote it by $Gibbs_{c,t}$. We include a currency-month into our IV formation only if there are at least 10 security-level observations for that currency in the month. Figure 8a shows the time-series of the aggregate Hasbrouck measure for each currency.[12] Consistent with the finding of Huang, Nozawa, and Shi (2023), the US corporate bond market consistently suffers higher levels of illiquidity compared to others throughout most of our sample period. Large pikes in the Hasbrouck measure are observed for all currencies during the GFC and the Covid-19 pandemic. But, it is clear that the transaction costs of USD bonds escalated much more rapidly than those for other currencies during the two crises, especially for the Covid-19 episode.[13] These patterns demonstrate the empirical relevance of our instrument variable, which leverages the difference in the aggregate Hasbrouck measures for the USD and non-USD corporate

The transaction reports on corporate bonds, effective from January 3, 2018, are submitted to regulatory authorities. Jurkatis et al. (2023) use data from transaction reports in corporate bonds obtained from the Bank of England to study the relationship discount in corporate bonds. Their dataset encompasses trades executed on a UK venue, involving at least one UK counterparty, or executed on an EU venue for a bond regulated by the Financial Conduct Authority. However, the consolidated trading data remains confidential and can only be accessed under the strict supervision of central banks in Europe.

11. These low-frequency liquidity measures refer to those of which the estimation only requires daily pricing data. According to Schestag, Schuster, and Uhrig-Homburg (2016), another winner in the low-frequency category is the high-low spread estimator of Corwin and Schultz (2012). However, its implementation requires daily high and low prices, which are also not available for most of the bonds in the non-US sector.

12. CHF-denominated bonds are excluded due to the limited observations in the ICE BofA corporate bond universe.

13. Using alternative liquidity measures, a number of studies document a sharp deterioration in the US corporate bond liquidity following the Covid-19 outbreak (Gilchrist et al. 2021; Haddad, Moreira, and Muir 2021; Kargar et al. 2021; O'Hara and Zhou 2021).

bond markets.

We then proceed to defining a non-USD liquidity proxy by averaging the currency-level Hasbrouck measure. This liquidity proxy is designed to capture liquidity variation in the entire international corporate bond market. Finally, we complete forming our illiquidity IV by taking the difference between $Gibbs_{usd,t}$ and $Gibbs_{non-usd,t}$, representing the relative illiquidity of international corporate bond markets. An increase in the illiquidity IV signifies greater transaction costs of non-USD corporate bonds compared to dollar-denominated ones, suggesting a positive shock to demand for risky dollar assets.

The second IV concerns the relative sentiment of the US corporate bond market. Following López-Salido, Stein, and Zakrajšek (2017), we make inference of credit market sentiment with proxies for the unexplained portion of expected returns on credit assets. The underlying assumption is that a high-sentiment period is associated with a decline in the returns required by investors to bear credit risk, or equivalently, aggressive pricing of credit risk. We modify their approach by incorporating liquidity risk in corporate bond markets, which has been considered in the formation of our first IV. In other words, we hypothesize that variation in corporate bond market sentiment reflects changes in investors' effective risk appetite for both default probabilities and bond illiquidity.

To be more specific, we extend the regression model of López-Salido, Stein, and Zakrajšek (2017) by introducing a security-level liquidity proxy,

$$\log CS_{i,t} = \alpha_i + \beta_1 DFT_{i,t} + \beta_2 ILLQ_{i,t} + \gamma' Z_{i,t} + \epsilon_{i,t}, \tag{13}$$

where DFT and $ILLQ$ denote measures of default risk and debt illiquidity, respectively. The vector Z is included to control for bond-specific characteristics. We follow Gilchrist and Zakrajšek (2012) by using distance to default as a proxy for default risk, and the Hasbrouck measure as discussed above is employed to measure bond illiquidity.

We estimate (13) for each currency using investment-grade bond yield spreads from the ICE BofA database. By aggregating the observed and fitted yield spreads at the currency level, we obtain a proxy for credit market sentiment by taking the difference and denote it by $Senti_{c,t}$. Figure 8b presents the time-series of this sentiment measure. Unlike the liquidity proxies, USD and non-USD bonds do not show a substantial discrepancy in terms of their sentiment. The sentiment proxy for the US market, $Senti_{usd,t}$, also does not deviate aggressively from others during the Covid-19 period. These findings imply that liquidity risk is adequately controlled in our estimation of the sentiment proxy. Similar to our construction of the first IV, we aggregate $Senti_{c,t}$ for all non-USD currencies and compute the sentiment-based IV as the difference between the non-USD and USD sentiment proxies.

We further construct shocks to these IVs by extracting innovations from the differences between the corresponding non-USD and USD measures. This process is based on an

AR(1) specification. Subsequently, within the SVAR framework, we introduce the derived shocks—namely, the illiquidity shock IV and the sentiment shock IV—as separate external instruments for CSD. Figure 8c displays the time series of both shock IVs, providing a visual representation of their dynamics.

Figure 10a examines the impact of CSD on CYD and utilizes the IRF derived from a negative shock to CSD, using the illiquidity shock IV. The first stage F-statistic is 48, with an R^2 of 0.19, indicating the absence of a weak instrument problem. The first-stage coefficient is positive, which is consistent with our hypothesis that an increase in the illiquidity of the USD corporate bond market relative to the global corporate bond market, thereby increasing U.S. corporate bond spreads relative to non-U.S. spreads (CSD $\downarrow$). Consequently, CYD rises as global investors shift towards safer dollar assets, indicating a substitution effect. Additionally, we observe a widening of CCB, indicating an expansion of the premium for borrowing dollars in FX swap markets. This might be linked with an increased global investors' demand for safe dollar assets resulting in a more imbalanced global dollar liquidity. Our quantitative analysis indicates that a one standard deviation decrease in CSD (18.2 basis points) corresponds to a 3.56 basis points increase in CYD and a 1.65 basis points increase in CCB. Our unreported results include testing the substitution effect by excluding the GFC period (December 2007 to May 2009), as well as constructing illiquidity shock IV using only bonds issued by firms that have issued both USD and non-USD corporate bonds. The results remain robust.

Figure 10b further examines the substitution effect using the sentiment shock IV. The first stage F-statistic is 263, with an R^2 of 0.56, indicating the absence of a weak instrument problem. The positive first-stage coefficient indicates that a low sentiment in the USD corporate bond market relative to the global corporate bond market results in a more significant increase in the expected return required by investors for USD corporate bonds than for global corporate bonds. This, in turn, increases U.S. corporate bond spreads relative to non-U.S. spreads (CSD $\downarrow$), leading to a substitution effect (CYD $\uparrow$) and a more pronounced imbalance in global dollar liquidity (CCB $\uparrow$). Quantitatively, a one standard deviation decrease in CSD (18.2 basis points) induced by the sentiment shock corresponds to a 1.70 basis point increase in CYD and a 2.36 basis point increase in CCB.

4.2.4 Instrument Variable For CYD: Monetary Policy Shock

We further extend our analysis by employing an instrument for CYD. The foreign demand for safe dollar assets could be influenced directly by U.S. monetary policy, particularly through its impact on the US Treasury market. When US monetary policy tightens, it leads to higher yields on US Treasuries, thereby increasing the holding period return on safe dollar assets. Consequently, there is a higher demand for safe dollar assets. To identify a shock to the demand for safe dollar assets, we employ the monetary policy shock as an external instrument.

Specifically, we employ the U.S. monetary policy shock constructed by Nakamura and Steinsson (2018). These are based on the first principal component of changes in five interest rates: the Federal funds rate immediately following the FOMC meeting, the expected Federal funds rate right after the next FOMC meeting, and the three-month Eurodollar interest rates at two, three, and four quarters ahead, within a 30-minute window surrounding scheduled FOMC announcements. We source the updated monetary policy shock data from Miguel Acosta's website, as used in Acosta (2022). Subsequently, we aggregate this data to a monthly level, assigning a value of 0 in the absence of scheduled monetary policy announcements. Figure 9 illustrates the monetary policy shock.

Employing our SVAR-IV methodology, we denote Z_t as a vector of instrument variables (IV) for CYD. To qualify as a valid instrument, Z_t must exhibit correlation with $\epsilon_t^{\text{CYD shock}}$ while being orthogonal to other shocks.[14]

$$E[Z_t\epsilon_t^{\text{CYD shock}}] = \phi; \quad E[Z_t\epsilon_t^{\text{CSD shock}}] = 0; \quad \text{and} \quad E[Z_t\epsilon_t^{\text{CCB shock}}] = 0. \tag{14}$$

Figure 10c illustrates the IRF of the CYD shock, utilizing our measure of monetary policy shock IV. The first stage F-statistic is 17, with an R^2 of 0.08, indicating the absence of a weak instrument problem. In line with the positive first-stage coefficient, a tightening of U.S. monetary policy leads to an increased demand for U.S. Treasuries (CYD $\uparrow$), subsequently resulting in a decrease in the value of risky dollar assets (CSD $\downarrow$). Quantitatively, a one standard deviation (18 basis points) increase in CYD contemporaneously leads to a 11.18 basis points decrease in CSD. Furthermore, shocks to the safe dollar demand has an insignificant effect on CCB in both the short and the long run. This finding is in line with the observation of a weak correlation between CYD and CCB throughout the entire sample.

14. Our application of the monetary policy shock as an IV for CYD follows a two-stage procedure. The first stage captures the variation in u^{CYD} that can be attributed to the IV. We estimate β as $cov(b22\epsilon_t^{\text{CYD shock}}, Z_t)/var(Z_t)$.

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

To identify the effect of the instrument on CSD and CCB, we need to estimate the ratio b12/b22 and b32/b22 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 $\gamma_1 = b12/b22$ and $\gamma_2 = b32/b22$ 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 b22 to 1. Parameters b12 and b32 are therefore equal to γ_1 and γ_2, respectively.

4.2.5 Robustness Tests

We conduct several robustness tests to reinforce the validity of our main findings. Below we summarize the results of robustness analysis, which are detailed in Appendix A. One concern about our baseline decomposition is the credit risk reflected in the London Interbank Offered Rate (LIBOR), which is by nature an unsecured lending rate, and coherent interest rate swap (IRS) rates. As such, using LIBOR as the default-free benchmark in the corporate basis decomposition might not be appropriate. To address this concern, we explore alternative benchmark interest rates that arguably have minimal credit risk. For instance, in the US market, we incorporate the Secured Overnight Financing Rate (SOFR), which provides a comprehensive measure of collateralized borrowing costs in OTC markets. The results with SVAR analysis confirm that an negative shock to risky dollar asset demand results in a substitution toward safe dollar assets, along with a widening of CIP deviations.

Another aspect of our empirical methodology relates to the estimation of the corporate basis and CSD through cross-sectional regressions. Accordingly, we consider a variety of alternative approaches to estimate CSD. For example, we use different default-free benchmarks in calculating CSD but keep unchanged the benchmark rates in the definition of CYD. As such, the issue of potentially mechanical negative correlation between CSD and CYD is alleviated .

As another notable robustness test on the CSD estimation, we construct a bottom-up measure of CSD to demonstrate that our main results are not sensitive to the CSD estimation method. That is, we firstly obtain regression-based estimates of firm-level CSD and then aggregate them to derive the currency-level CSD. Finally, we focus on a subset of issuers with EUR and USD denominated bonds outstanding, and a maturity-matched bond sample is selected from these issuers. We find that the CSD estimate based on the matched bond pairs is fairly close to the regression-based estimate.

5 Empirical findings: financial markets and real economic activity

5.1 FX Market

The relationship between foreign demand for U.S. assets and cross-border liquidity is closely tied to the FX market. In this section, we decompose the effect of each component of the corporate basis on the dollar. To achieve this, we start with a simple OLS regression, where the dependent variable is the monthly change in the log of the real spot dollar value against a basket of currencies.[15] The main independent variables include the

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

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 4. 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 (13.5 basis points) decrease in the corporate basis leads to a 0.91% (91 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 (18.2 basis points) decrease in CSD results in an appreciation of USD by 1.21%. 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 2.34% appreciation in the dollar value based on column (2) with a coefficient of 15.84. 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 2.37% appreciation in the USD, and a one standard deviation (10.7 basis points) increase in CCB leads to a 2.37% appreciation.

To further investigate the effects of CSD and CYD shocks, we expand our SVAR analysis from Section 4 to include the real spot value of the USD vis-à-vis our basket of currencies. As demonstrated in Figure 11a, a shock indicating increased illiquidity in the USD corporate bond market relative to the global corporate bond market leads to a decreased demand for risky dollar assets and an increased demand for safe dollar assets. This shift in demand causes an imbalance in global dollar liquidity, resulting in a widening of CCB. Reflecting USD scarcity in funding markets, our findings show that a one standard deviation negative shock to the CSD leads to a 1.94% appreciation of the USD against our basket of currencies. The results are consistent when employing the sentiment shock IV for CSD, as depicted in Figure 11b. Similarly, Figure 11c reveals that a positive shock to the demand for safe dollar assets, indicated by our monetary policy shock, results in an appreciation of the USD. This appreciation is accompanied by a widening of CCB and excess returns on the dollar. Overall, our results align with the findings of Jiang, Krishnamurthy, and Lustig (2021), suggesting that an increase in demand for safe dollar assets, as marked by a rise 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 dollar asset demand translates to effects on the equity and commodity markets. We hypothesize that a shock, indicating increased illiquidity in the USD corporate bond market relative to the global corporate bond market, induces a persistent impact on other asset classes due to the reduced risk-bearing capacity of investors overall. We examine spillover effects of shocks to the CSD on the S&P 500 index (SPX), non-US stock market indices, and the Bloomberg commodity index (BCOM). To track the overall stock market performance of the six economies, we construct a composite non-US stock index by aggregating the Austrian Traded Index, S&P/TSX Composite Index, Swiss Market Index, Euronext 100 Index, FTSE 100 Index and Nikkei 225 Index.

Results in Figure 12a indicate that a one standard deviation (18.2 basis points) decrease in CSD contemporaneously leads to a decline of 7.8%, 9% and 7.1% in the SPX index, the non-US stock index and the BCOM index, respectively. These spillover effects are economically large, provided that the monthly return standard deviation of the three indices is in turn 4.20%, 4.16%, and 4.78%. This finding is consistent when employing the sentiment shock IV for CSD, as depicted in Figure 12b.

5.3 Economic Activities

Besides the spillovers to other asset classes, we also hypothesize that a decline in demand for risky dollar assets can lead to significant consequences for the macroeconomy. In our analysis, we consider macroeconomic variables such as the CPI, industrial production, the unemployment rate, real GDP, real investment, and real consumption. CPI, industrial production, and the unemployment rate are measured at the monthly level, while real GDP and other variables are observed quarterly. Figure 13 displays the IRF of a negative CSD shock on US economic activity, using both the illiquidity shock IV and the sentiment shock IV separately. We find nontrivial spillovers to macroeconomic activity, with a decline in the inflation, industrial production, real investment, real consumption and real GDP with a rise in the unemployment rate. Our results are broadly consistent with previous studies examining the effect of financial shocks, represented by (unexplained) credit spreads, on real economic activity (Gilchrist and Zakrajšek 2012; Gertler and Karadi 2015).

In Appendix B, we also find significant spillovers to economic activities of other economies in our sample, including Canada, Japan, Euro Area, the UK, Switzerland and Australia.[16] 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.

16. 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 the last values of CSD, CYD, and CCB each quarter, and for IVs, we also get the innovation based on the AR(1) model using the quarterly-level variables. The unemployment rate is in percentage terms, and all other variables are expressed in log terms.

6 Conclusion

Since the global financial crisis, the corporate basis has shown substantial deviations from zero and significant fluctuations over time. This study aims to identify the factors behind these variations and to understand how shocks in financial markets affect its dynamics. We analyze the corporate basis through three key components: credit spread differential (CSD), convenience yield differential (CYD), and cross-currency basis (CCB). These components respectively capture the demand for risky dollar assets, the demand for safe dollar assets, and cross-border dollar liquidity.

Utilizing a comprehensive dataset of 30,926 corporate bonds issued in major funding currencies, our investigation uncovers a pronounced substitution effect between the demand for safe and risky dollar assets. Particularly during times of increased risk aversion, investors shift their preferences away from risky dollar assets and towards safer alternatives. We first show this shift through the holdings-level data, examining foreign investors' net purchases of safe and risky dollar assets during both the 2008 financial crisis and the European debt crisis. We then use the structural Vector Autoregression (VAR) analysis to further validate the substitution effect, employing credit market illiquidity and market sentiment as instrumental variables for CSD, and monetary policy shocks as instrumental variables for CYD.

Lastly, our research identifies significant spillover effects stemming from shifts in the demand for dollar-denominated assets, which influence broader economic activities and the foreign exchange (FX) market. Notably, we find that shocks to CSD and CYD—representing the demand for risky and safe dollar assets respectively—have opposite effects on the U.S. dollar exchange rates. These findings highlight the importance of the U.S. dollar as the dominant funding currency in global financial markets.

References

Abbassi, Puriya, and Falk Bräuning. 2020. "Demand Effects in the FX Forward Market: Micro Evidence from Banks' Dollar Hedging." *The Review of Financial Studies, forthcoming.*

Acosta, Miguel. 2022. "The perceived causes of monetary policy surprises." *Published Manuscript.*

Amihud, Y. 2002. "Illiquidity and stock returns: cross-section and time-series effects." *Journal of Financial Markets* 5 (1): 31–56.

Augustin, Patrick, Mikhail Chernov, Lukas Schmid, and Dongho Song. 2021. "Benchmark interest rates when the government is risky." *Journal of Financial Economics* 140 (1): 74–100.

———. 2023. "The term structure of covered interest rate parity violations." *Journal of Finance.*

Avdjiev, Stefan, Wenxin Du, Catherine Koch, and Hyun Song Shin. 2019. "The dollar, bank leverage, and deviations from covered interest parity." *American Economic Review: Insights* 1 (2): 193–208.

Bahaj, Saleem, and Ricardo Reis. 2021. "Central bank swap lines: Evidence on the effects of the lender of last resort." *Review of Economic Studies.*

Bao, Jack, Jun Pan, and Jiang Wang. 2011. "The illiquidity of corporate bonds." *Journal of Finance* 66 (3): 911–946.

Bertaut, Carol C, and Ruth Judson. 2014. "Estimating US cross-border securities positions: New data and new methods." *Available at SSRN 2483922.*

Borio, Claudio EV, Robert N McCauley, Patrick McGuire, and Vladyslav Sushko. 2016. "Covered interest parity lost: understanding the cross-currency basis." *BIS Quarterly Review September.*

Bräuning, Falk, and Victoria Ivashina. 2020. "Monetary policy and global banking." *The Journal of Finance* 75 (6): 3055–3095.

Bretscher, Lorenzo, Lukas Schmid, Ishita Sen, and Varun Sharma. 2022. *Institutional Corporate Bond Demand.* Swiss Finance Institute Research Paper Series 21-07. Swiss Finance Institute.

Cai, Fang, Song Han, Dan Li, and Yi Li. 2019. "Institutional herding and its price impact: Evidence from the corporate bond market." *Journal of Financial Economics* 131 (1): 139–167.

Caramichael, John, Gita Gopinath, and Gordon Y Liao. 2021. "Us dollar currency premium in corporate bonds." *IMF Working Papers* 2021 (185).

Cenedese, Gino, Pasquale Della Corte, and Tianyu Wang. 2021. "Currency mispricing and dealer balance sheets." *The Journal of Finance* 76 (6): 2763–2803.

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

Cesa-Bianchi, Ambrogio, Czech Robert, and Fernando Eguren-Martin. 2023. "Dash for dollars."

Chen, L., P. Collin-Dufresne, and R.S. Goldstein. 2009. "On the relation between the credit spread puzzle and the equity premium puzzle." *Review of Financial Studies* 22 (9): 3367–3409.

Corwin, Shane A, and Paul Schultz. 2012. "A simple way to estimate bid-ask spreads from daily high and low prices." *Journal of Finance* 67 (2): 719–760.

Diamond, William, and Peter Van Tassel. 2022. "Risk-Free Rates and Convenience Yields around the World." *Federal Reserve Bank of New York Staff Reports, No. 1032.*

Dick-Nielsen, Jens, Peter Feldhütter, and David Lando. 2012. "Corporate bond liquidity before and after the onset of the subprime crisis." *Journal of Financial Economics* 103 (3): 471–492.

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

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan. 2018. "Deviations from covered interest rate parity." *The Journal of Finance* 73 (3): 915–957.

Duffie, Darrell. 2020. "Still the World's Safe Haven?" *Redesigning the US Treasury market after the COVID-19 crisis', Hutchins Center on Fiscal and Monetary Policy at Brookings, available online at https://www. brookings. edu/research/still-the-worlds-safe-haven.*

Edwards, Amy K, Lawrence E Harris, and Michael S Piwowar. 2007. “Corporate bond market transaction costs and transparency.” *Journal of Finance* 62 (3): 1421–1451.

Ferrara, Gerardo, Philippe Mueller, Ganesh Viswanath-Natraj, and Junxuan Wang. 2022. “Central bank swap lines: micro-level evidence.” *Bank of England Working Paper No. 977.*

Friewald, N., R. Jankowitsch, and M.G. Subrahmanyam. 2012. “Illiquidity or Credit Deterioration: A Study of Liquidity in the US Corporate Bond Market during Financial Crises.” *Journal of Financial Economics* 105 (1): 18–36.

Friewald, Nils, and Florian Nagler. 2019. “Over-the-Counter Market Frictions and Yield Spread Changes.” *Journal of Finance* 74 (6): 3217–3257.

Galvez, Julio, Leonardo Gambacorta, Sergio Mayordomo, and Jose Maria Serena. 2021. “Dollar borrowing, firm credit risk, and FX-hedged funding opportunities.” *Journal of Corporate Finance* 68 (C): 101945.

Geng, Zhe. 2021. “Foreign Discount in International Corporate Bonds.” *Available at SSRN.*

Gertler, Mark, and Peter Karadi. 2015. “Monetary policy surprises, credit costs, and economic activity.” *American Economic Journal: Macroeconomics* 7 (1): 44–76.

Gilchrist, Simon, Bin Wei, Vivian Yue, and Egon Zakrajšek. 2021. *The Fed Takes on Corporate Credit Risk: An Analysis of the Efficacy of the SMCCF.* NBER Working Papers 27809. National Bureau of Economic Research.

Gilchrist, Simon, and Egon Zakrajšek. 2012. “Credit spreads and business cycle fluctuations.” *American economic review* 102 (4): 1692–1720.

Goldstein, Itay, Hao Jiang, and David T. Ng. 2017. “Investor flows and fragility in corporate bond funds.” *Journal of Financial Economics* 126 (3): 592–613.

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2021. “When Selling Becomes Viral: Disruptions in Debt Markets in the COVID-19 Crisis and the Fed’s Response.” *Review of Financial Studies* 34 (11): 5309–5351.

Hasbrouck, Joel. 2009. “Trading costs and returns for US equities: Estimating effective costs from daily data.” *Journal of Finance* 64 (3): 1445–1477.

He, Zhiguo, Paymon Khorrami, and Zhaogang Song. 2022. "Commonality in Credit Spread Changes: Dealer Inventory and Intermediary Distress." *Review of Financial Studies* 35 (10): 4630–4673.

He, Zhiguo, Stefan Nagel, and Zhaogang Song. 2022. "Treasury inconvenience yields during the covid-19 crisis." *Journal of Financial Economics* 143 (1): 57–79.

Huang, Jing-Zhi, Yoshio Nozawa, and Zhan Shi. 2023. "The Global Credit Spread Puzzle." *Journal of Finance,* forthcoming.

Jiang, Zhengyang, Arvind Krishnamurthy, and Hanno Lustig. 2020. *Dollar safety and the global financial cycle.* Technical report. National Bureau of Economic Research.

———. 2021. "Foreign safe asset demand and the dollar exchange rate." *Journal of Finance* 76 (3): 1049–1089.

Jurkatis, Simon, Andreas Schrimpf, Karamfil Todorov, and Nicholas Vause. 2023. "Relationship discounts in corporate bond trading."

Kargar, Mahyar, Benjamin Lester, David Lindsay, Shuo Liu, Pierre-Olivier Weill, and Diego Zuniga. 2021. "Corporate Bond Liquidity during the COVID-19 Crisis." *Review of Financial Studies* 34 (11): 5352–5401.

Klingler, Sven, and Suresh M Sundaresan. 2020. "Diminishing Treasury Convenience Premiums: Effects of Dealers' Excess Demand in Auctions." *Available at SSRN 3556502.*

Liao, Gordon Y. 2020. "Credit migration and covered interest rate parity." *Journal of Financial Economics* 138 (2): 504–525.

López-Salido, David, Jeremy C Stein, and Egon Zakrajšek. 2017. "Credit-market sentiment and the business cycle." *Quarterly Journal of Economics* 132 (3): 1373–1426.

Ma, Yiming, Kairong Xiao, and Yao Zeng. 2022. "Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity." *Review of Financial Studies* 35 (10): 4674–4711.

Maggiori, Matteo, Brent Neiman, and Jesse Schreger. 2019. "The rise of the dollar and fall of the Euro as international currencies." In *AEA Papers and Proceedings,* 109:521–26.

Maggiori, Matteo, Brent Neiman, and Jesse Schreger. 2020. "International currencies and capital allocation." *Journal of Political Economy* 128 (6): 2019–2066.

Nakamura, Emi, and Jón Steinsson. 2018. "High-frequency identification of monetary non-neutrality: the information effect." *The Quarterly Journal of Economics* 133 (3): 1283–1330.

O'Hara, Maureen, and Xing?(Alex) Zhou. 2021. "Anatomy of a liquidity crisis: Corporate bonds in the COVID-19 crisis." *Journal of Financial Economics* 142 (1): 46–68.

Rime, Dagfinn, Andreas Schrimpf, and Olav Syrstad. 2022. "Covered interest parity arbitrage." *Review of Financial Studies* 35 (11): 5185–5227.

Roll, Richard. 1984. "A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market." *Journal of Finance* 39 (4): 1127–1139.

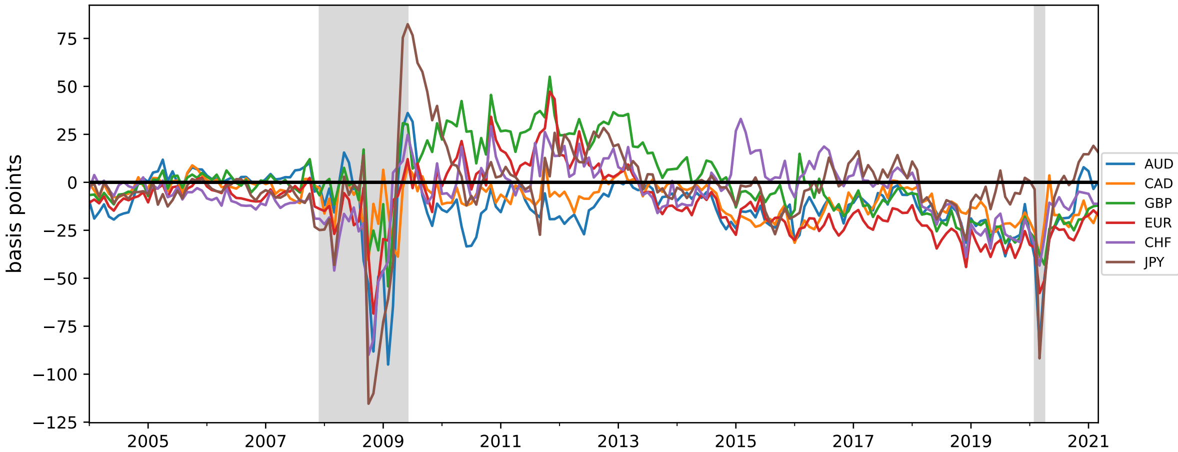
Schestag, Raphael, Philipp Schuster, and Marliese Uhrig-Homburg. 2016. "Measuring liquidity in bond markets." *Review of Financial Studies* 29 (5): 1170–1219.

Valenzuela, Patricio. 2016. "Rollover Risk and Credit Spreads: Evidence from International Corporate Bonds." *Review of Finance* 20 (2): 631–661.

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

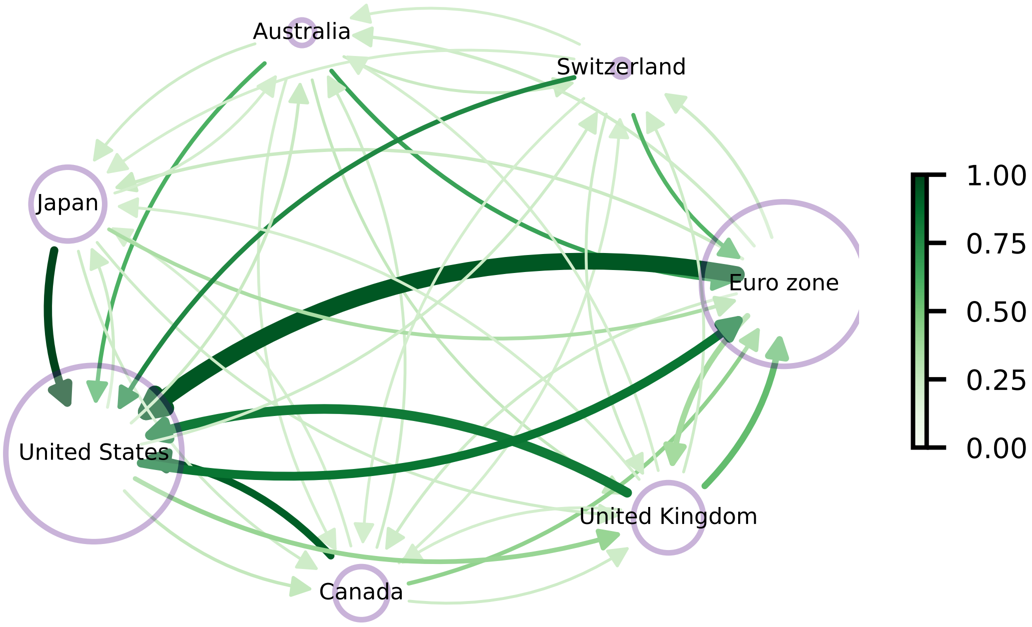
Viswanath-Natraj, Ganesh. 2020. "Unconventional Monetary Policy and Covered Interest Rate Parity Deviations: is there a Link?"

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 Equation (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.

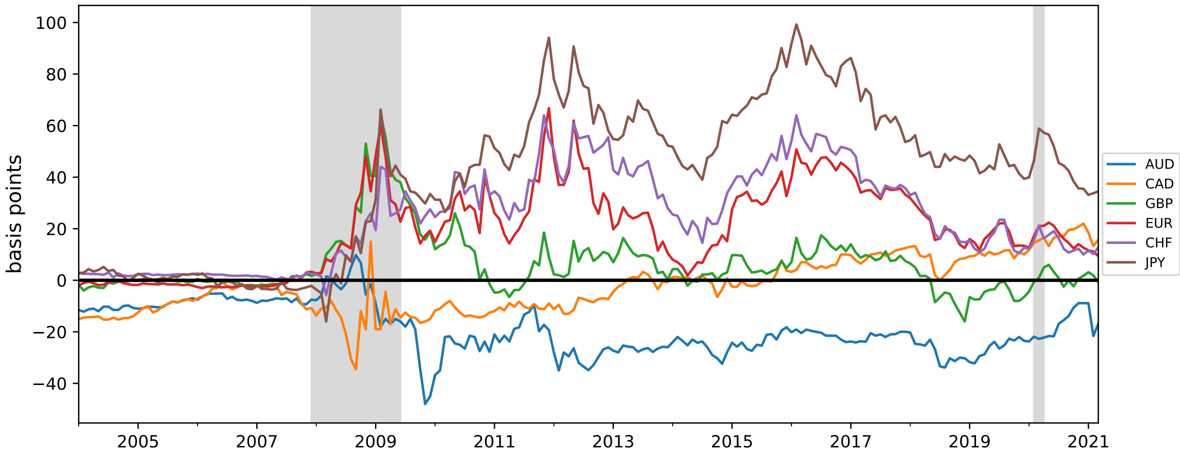
Figure 2: Cross-border Bond Issuance



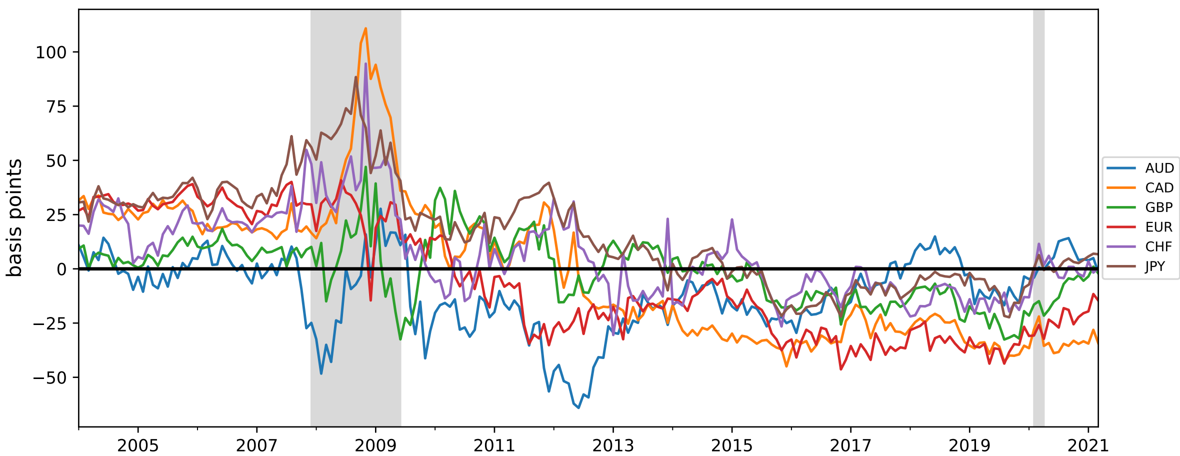
This figure presents the cross-border issuance of corporate bonds with currency denominations in AUD, CAD, CHF, EUR, GBP, JPY, and USD, based on the bond outstanding data in March 2021. Purple circles depicts the total notional principal of outstanding bonds issued by the domestic firms. Green arrows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

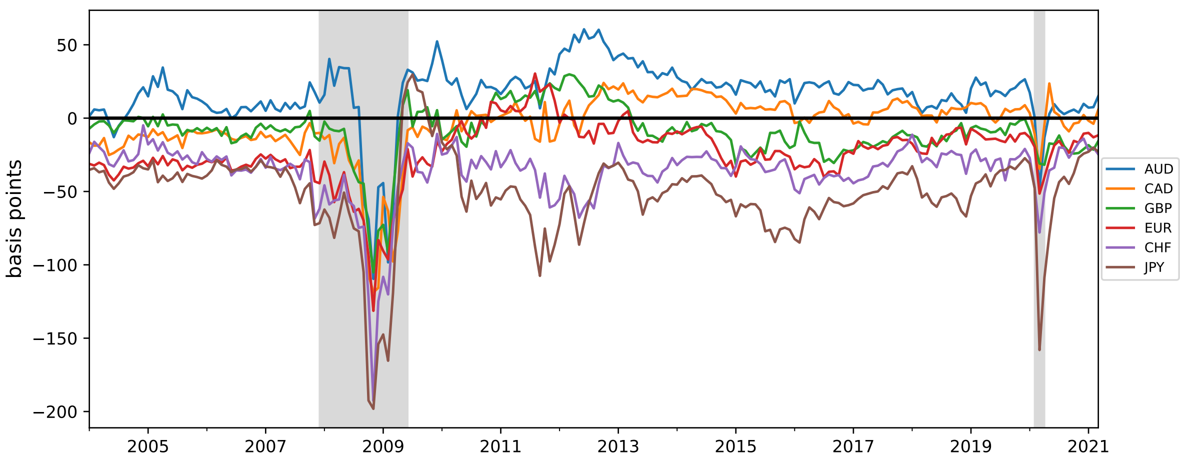
(a) Cross-currency Basis (CCB, 5-year)



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

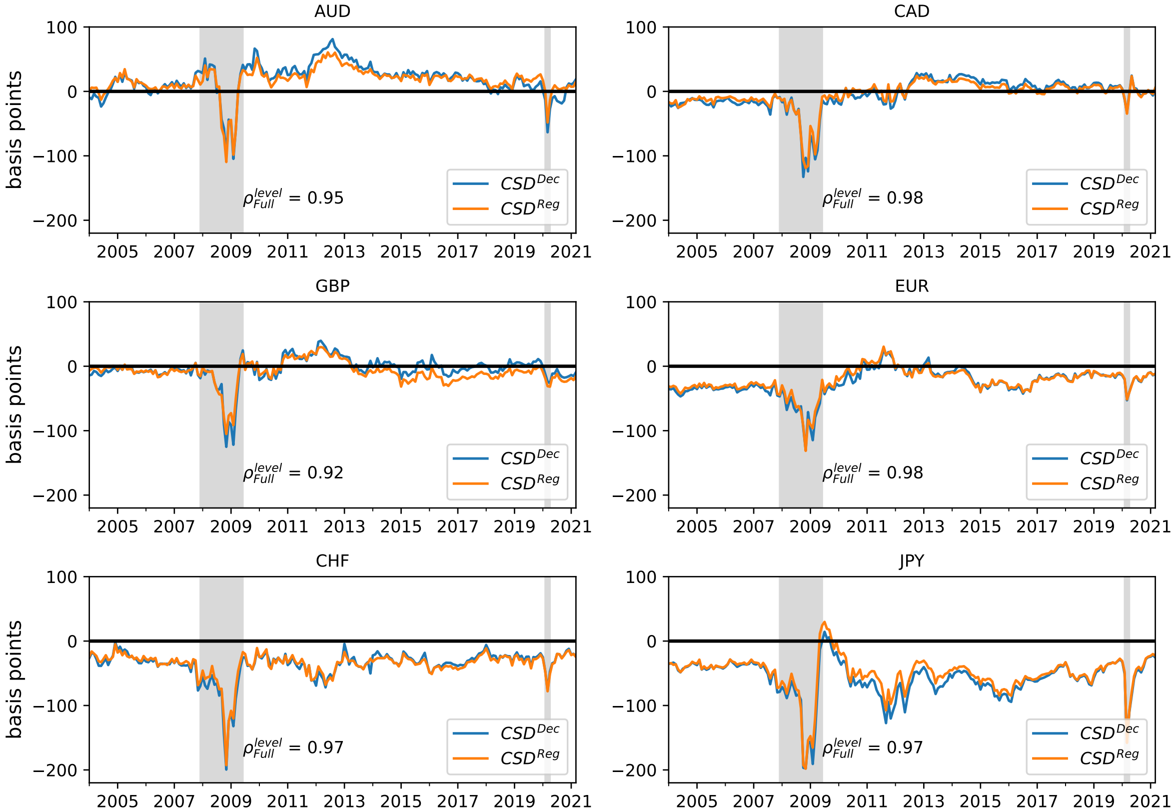


(c) Credit Spread Differentials (CSD)



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.

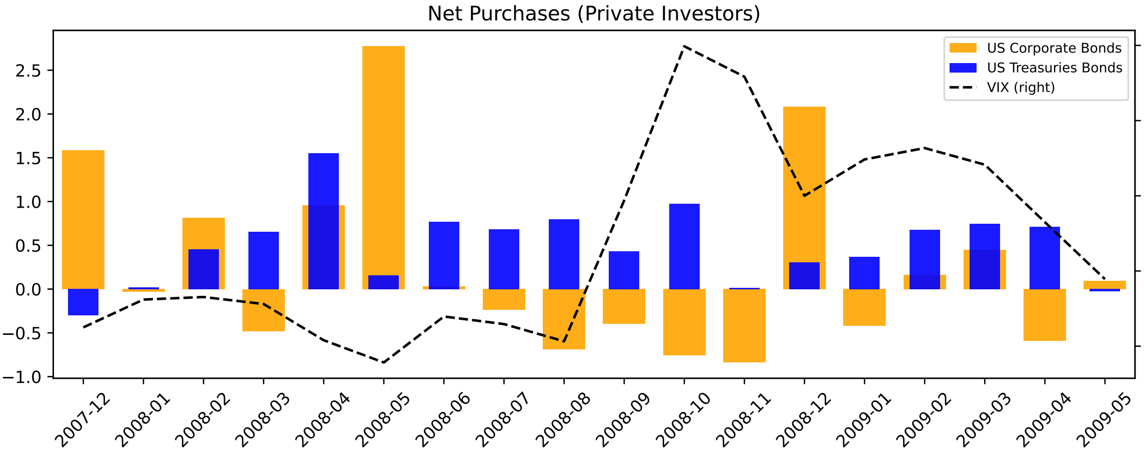
Figure 4: Alternative Estimates of Credit Spread Differentials



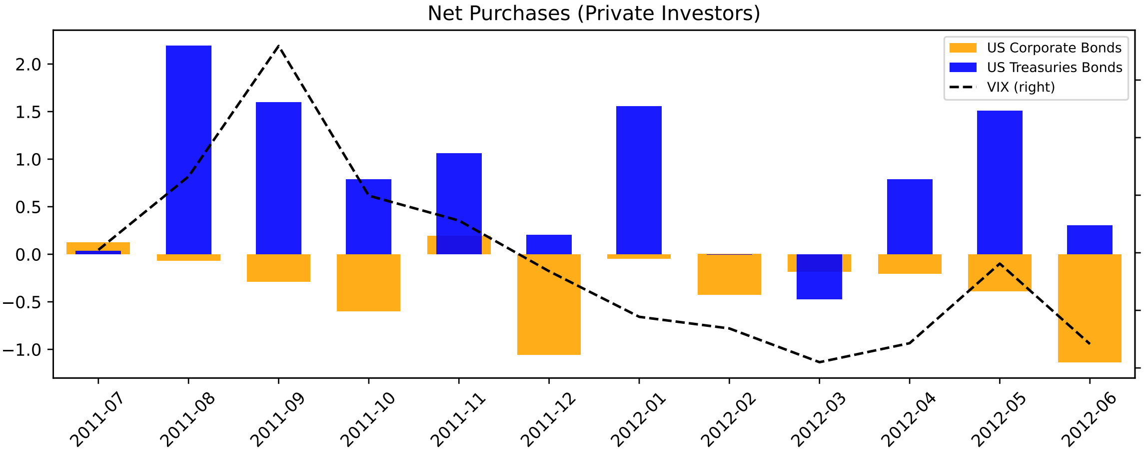
This figure compares the decomposition-based estimate of CDS (CSD^{Dec}) and regression-based estimate (CSD^{Reg}). CSD^{Dec} is derived from the decomposition as presented in equation (3) and thus involves the estimate of corporate basis, CYD and CCB. CSD^{Reg} is directly estimated from the cross-sectional regression of equation (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: Holding Level Evidence

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

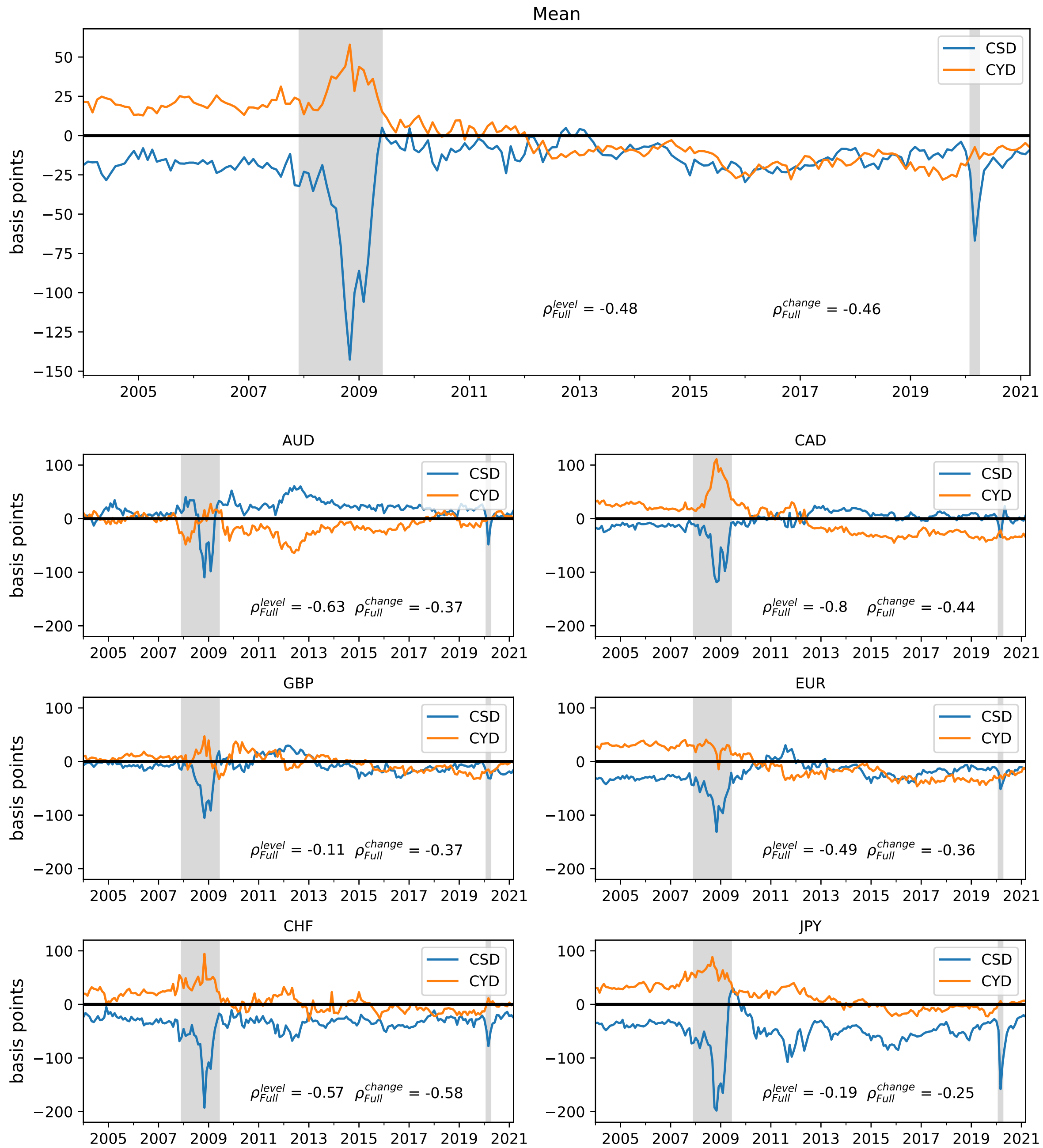


(b) Foreign Investors' Net Purchases of U.S. Assets



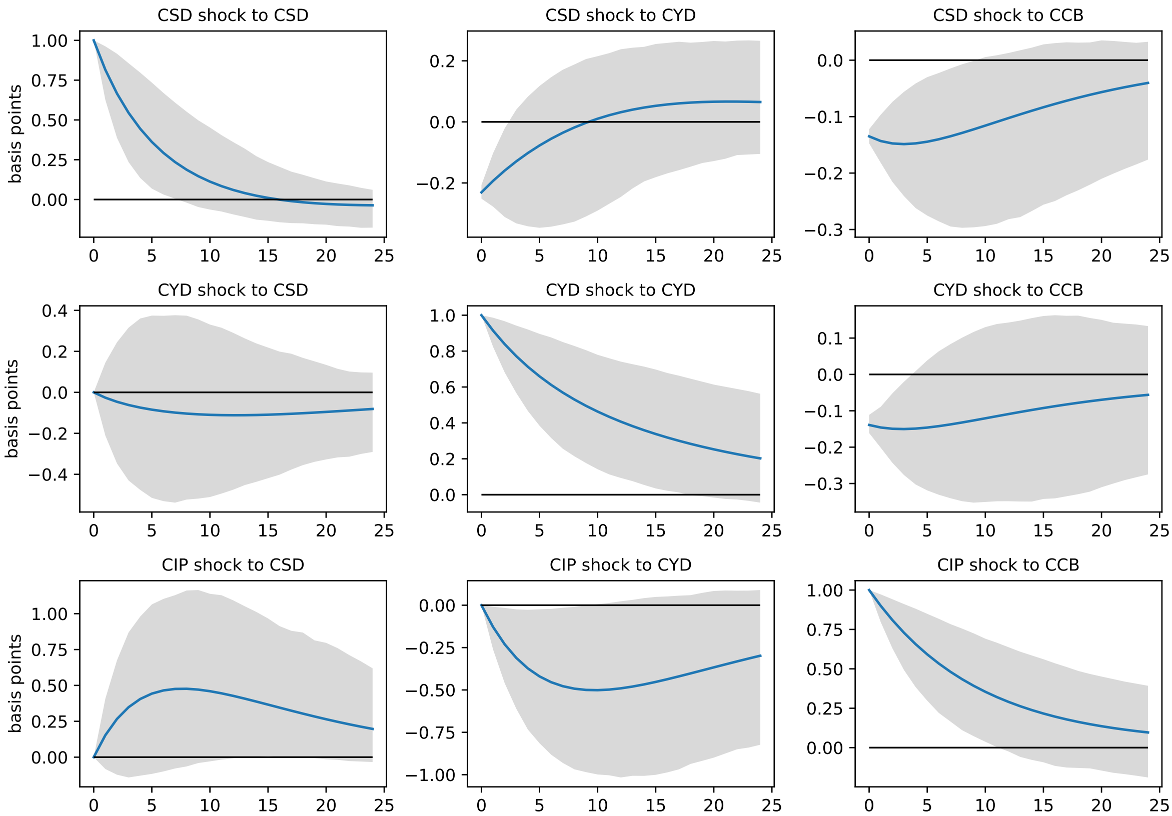
The top figure shows the foreign investors' net purchases of U.S. assets during the 2008 Global Financial Crisis, while the bottom figure presents these purchases during the European Debt Crisis period. The net purchases are scaled by one standard deviation of the monthly net purchases from January 2004 to March 2021. Data is sourced from the TIC S Form - Securities (A): U.S. Transactions with Foreign Residents in Long-Term Securities. Additionally, the VIX values are included in each figure, with the corresponding values shown on the right y-axis.

Figure 6: 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.

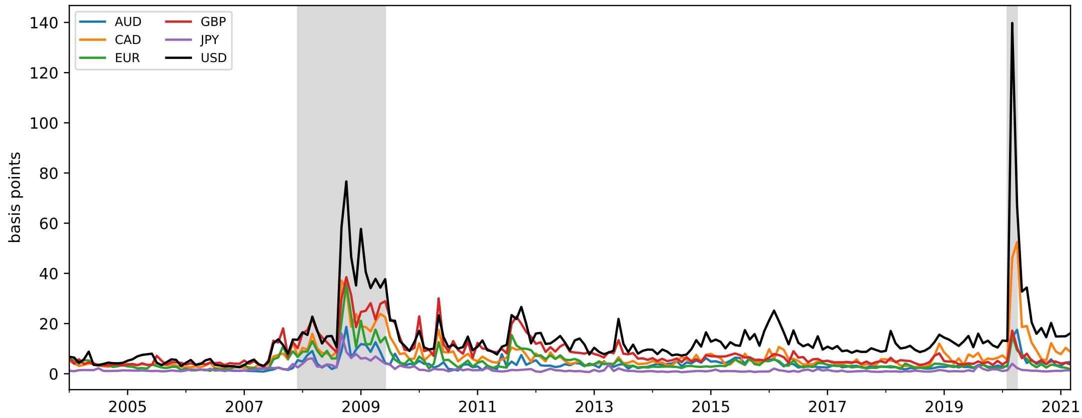
Figure 7: IRF of the Unrestricted SVAR Model (Mean)



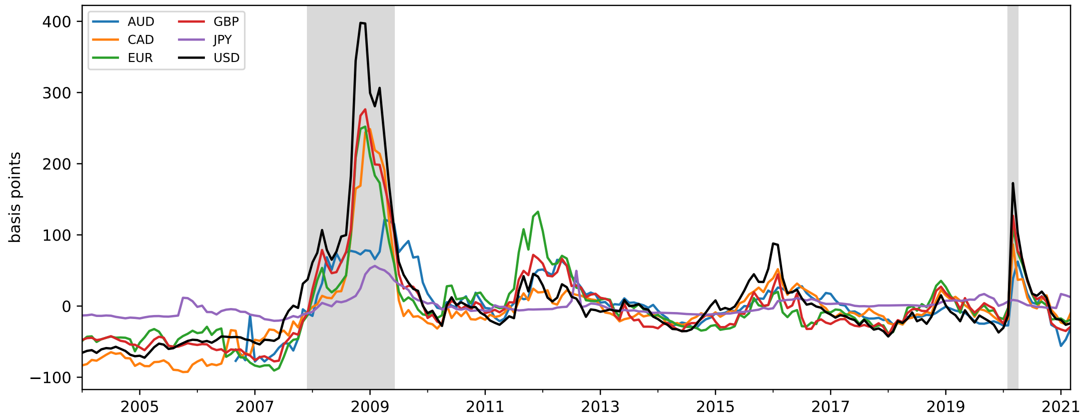
This figure presents the impulse response function (IRF) of one unit corresponding shock to each variable in the corporate basis decomposition. The plots are based on 1,000 wild bootstraps. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is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

Figure 8: Instrumental Variables for CSD

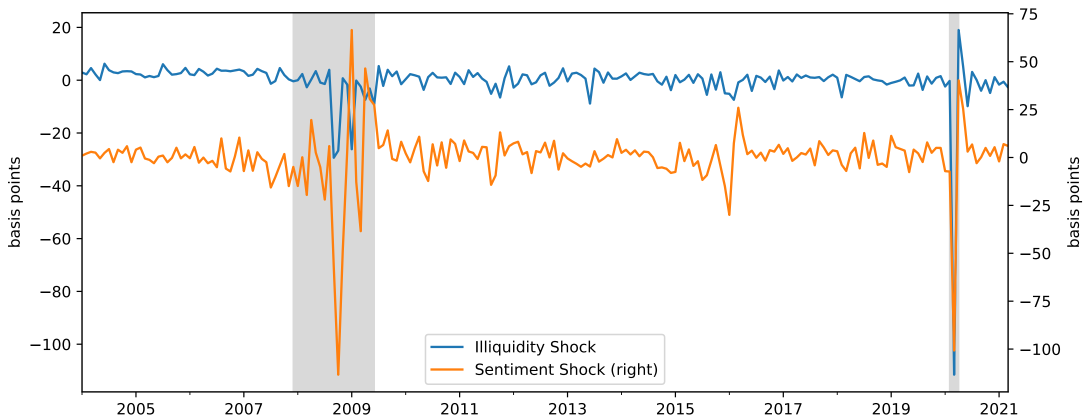
(a) Illiquidity Measure (Gibbs)



(b) Sentiment Measure (EBP)

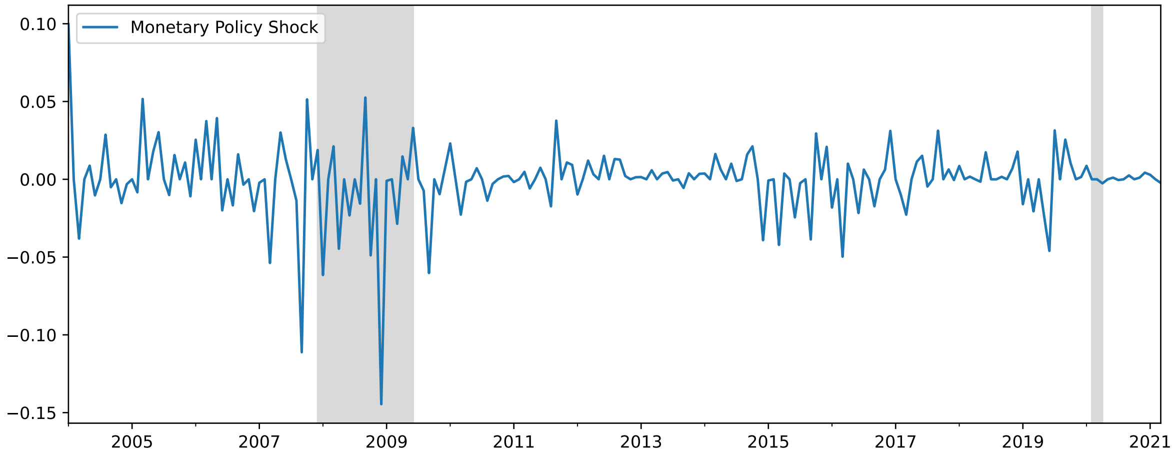


(c) Instrumental Variables



This figure presents the time series of instrumental variables for CSD. Panel (A) presents the illiquidity measure for the bond market at the currency level, using the Hasbrouck's (2009) Gibbs measure. Panel (B) presents the sentiment measure for the bond market at the currency level, using the excess bond premium (EBP) following the methodology of Gilchrist and Zakrajšek (2012). Panel (C) displays the time series of the illiquidity shock IV and the sentiment shock IV. To construct the IVs, we first aggregate the currency-level measures to a non-USD level measure by taking the sample average. Then, we derive the innovation from the difference between the non-USD measure and the USD measure, based on the AR(1) model. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

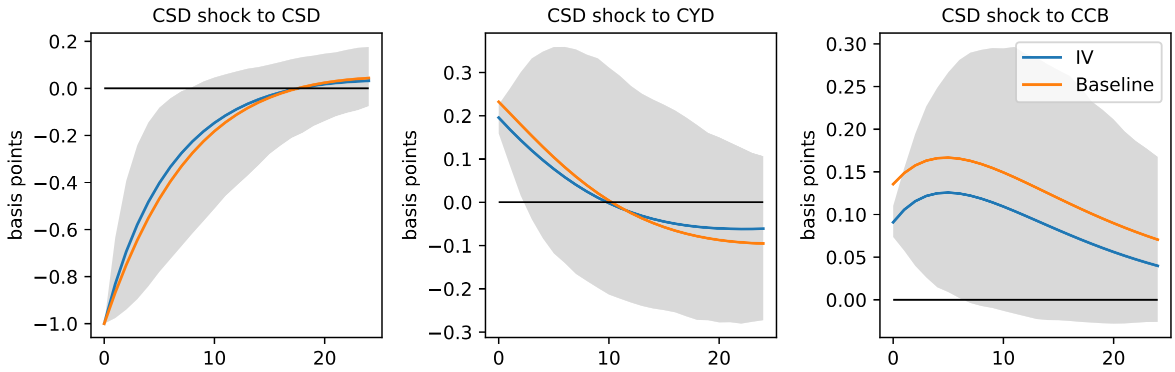
Figure 9: Instrumental Variables for CYD: Monetary Policy Shock



This figure presents the time series of monetary policy shock, following the method proposed by Nakamura and Steinsson 2018. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

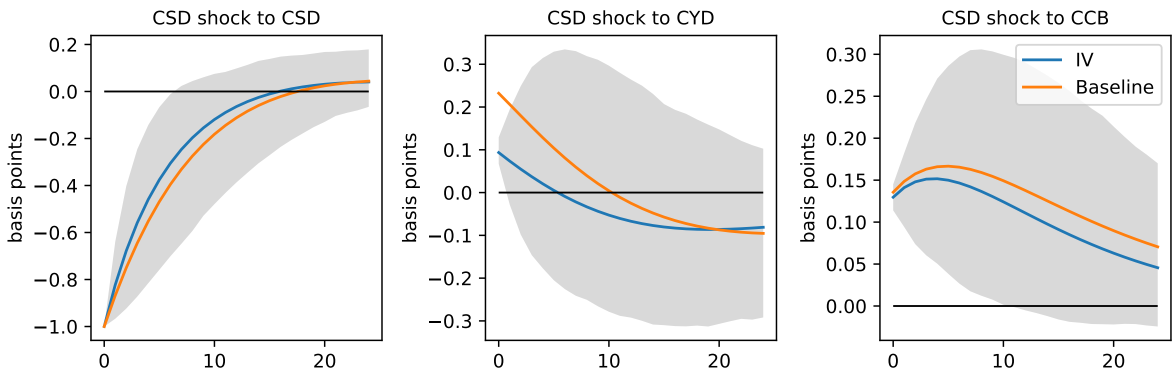
Figure 10: IRF of the SVAR Model with Instrumental Variables

(a) IRF of the CSD Shock with Illiquidity IV (Mean)



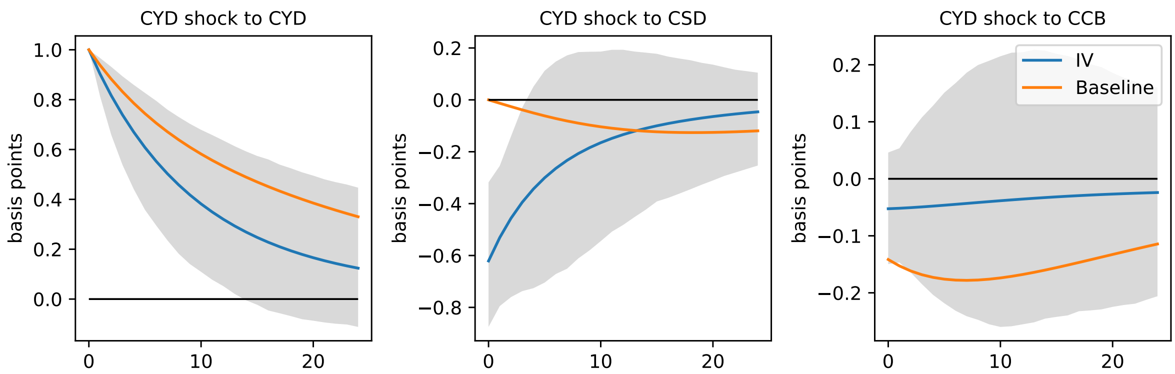
First-stage regression: Coefficient: 0.42; F-statistics: 48; R^2: 0.19.

(b) IRF of the CSD Shock with Sentiment IV (Mean)



First-stage regression: Coefficient: 0.42; F-statistics: 263; R^2: 0.56.

(c) IRF of the CYD Shock with Monetary Policy IV (Mean)

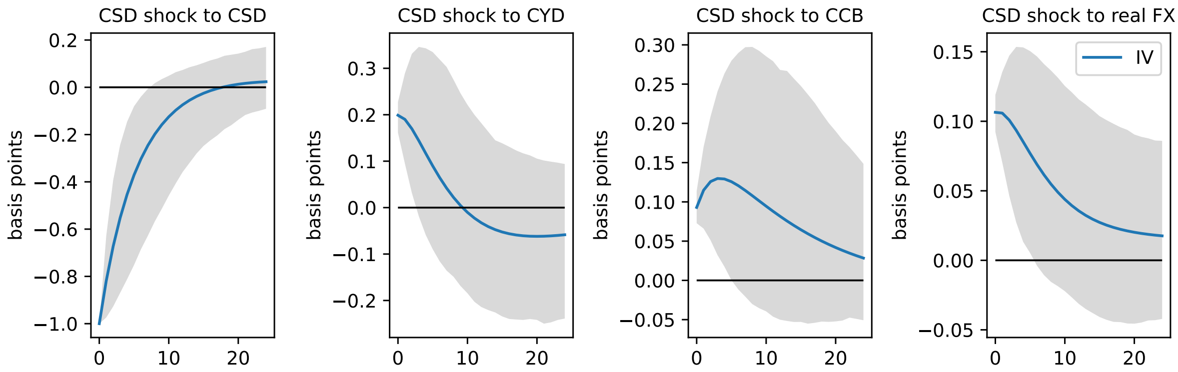


First-stage regression: Coefficient: 59.60; F-statistics: 17.36; R^2: 0.08.

This figure presents the impulse response function (IRF) of one negative/positive unit CSD shock (Panel A and B)/CYD shock (Panel C) to each variable in the corporate basis decomposition. Panels A, B and C are based on 1,000 wild bootstraps with the illiquidity shock IV, sentiment 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.

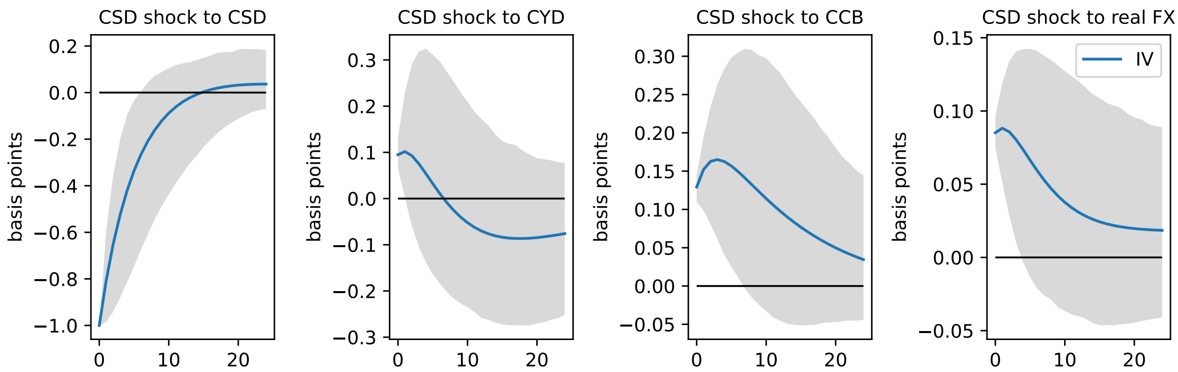
Figure 11: IRF of SVAR Model Incorporating the FX Market

(a) IRF of the CSD Shock with Illiquidity IV (Mean)



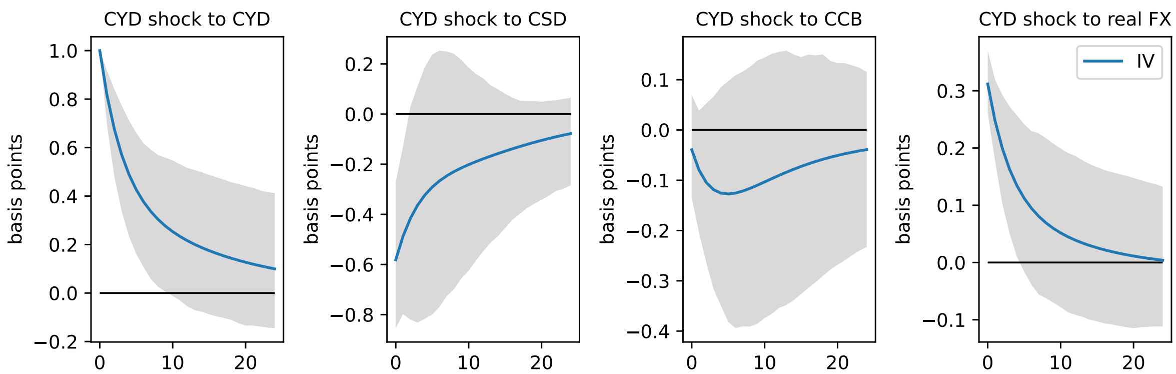
First stage regression: Coefficient: 0.42; F-statistics: 48; R^2: 0.19.

(b) IRF of the CSD Shock with Sentiment IV (Mean)



First stage regression: Coefficient: 0.42; F-statistics: 263; R^2: 0.56.

(c) IRF of the CYD Shock with Monetary Policy IV (Mean)

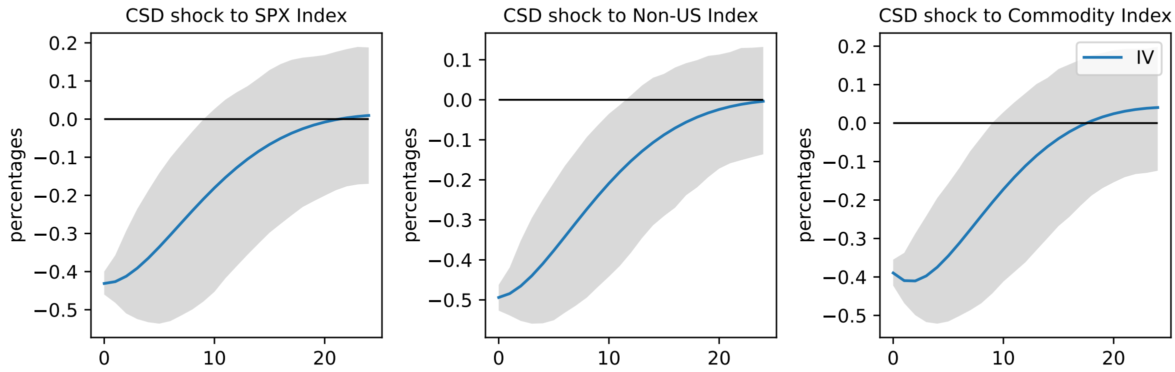


First stage regression: Coefficient: 61.56; F-statistics: 19.2; R^2: 0.09.

This figure presents the impulse response function (IRF) of one negative/positive unit CSD shock (Panel A and B)/CYD shock (Panel C) to the real USD exchange rate as well as the corporate basis components. Panels A, B ans C are based on 1,000 wild bootstraps with the illiquidity shock IV, sentiment shock IV and Sovereign CDS 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 real spot USD exchange rate.

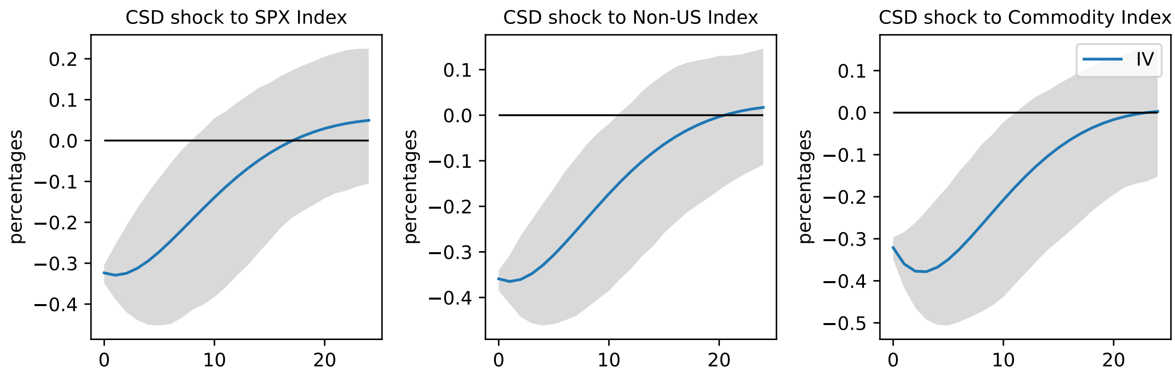
Figure 12: IRF of the CSD Shock with the Other Assets Classes (Mean)

(a) IRF of the CSD Shock with Illiquidity IV (Mean)



First stage regression: Coefficient: 0.41; F-statistics: 49; R^2: 0.19.

(b) IRF of the CSD Shock with Sentiment IV (Mean)

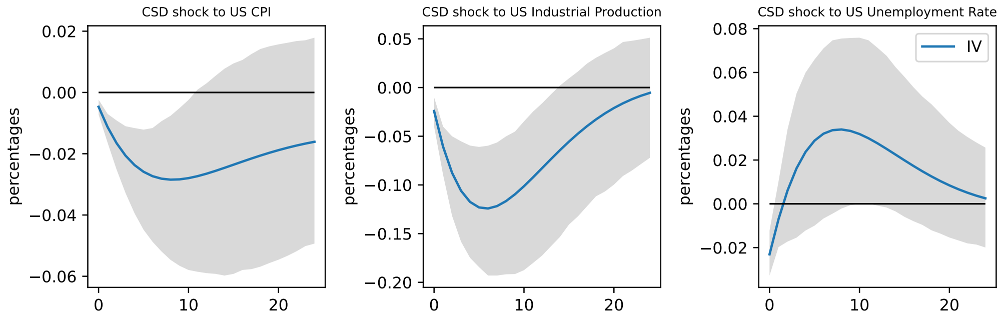


First stage regression: Coefficient: 0.39; F-statistics: 215; R^2: 0.51.

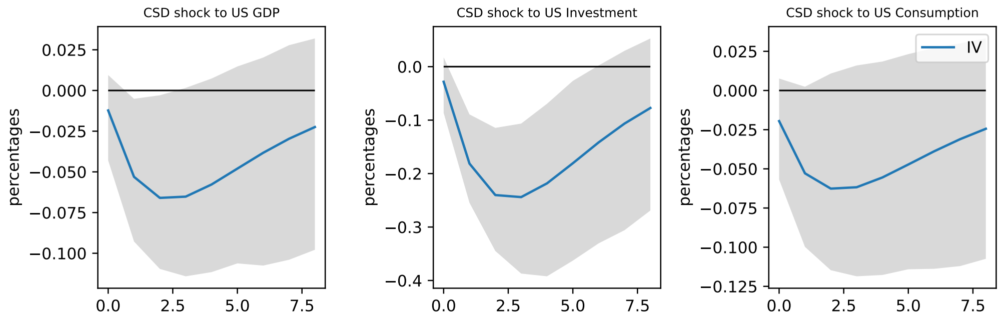
This figure presents the impulse response function (IRF) of one negative unit CSD shock (Panel A and B) to indices of the equity and commodity sectors. Panels A ans B are based on 1,000 wild bootstraps with the illiquidity shock IV and sentiment shock IV, respectively. The solid lines are the mean value 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)

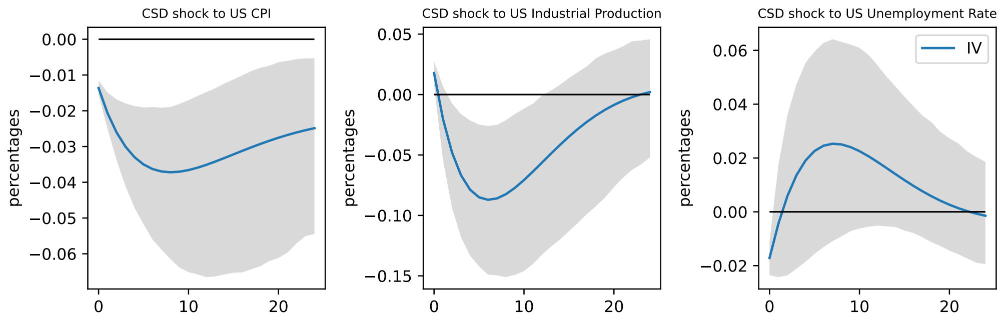
(a) IRF of the CSD Shock with Illiquidity IV: Monthly Variables



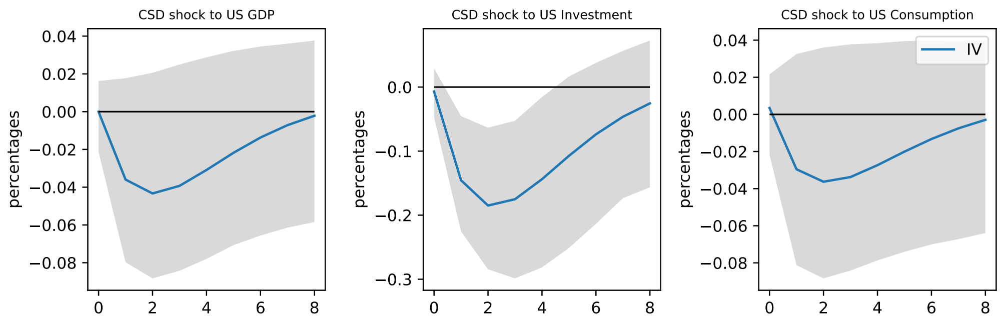
(b) IRF of the CSD Shock with Illiquidity IV: Quarterly Variables



(c) IRF of the CSD Shock with Sentiment IV: Monthly Variables



(d) IRF of the CSD Shock with Sentiment IV: Quarterly Variables



This figure presents the impulse response function (IRF) of one negative unit CSD shock (Panel A through D) to measures of real economic activities. Panels A through D are based on 1,000 wild bootstraps with the illiquidity shock IV and sentiment shock IV, respectively. 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	6,969.6	5,281.7	929.1	Total	2,798.0	2,508.0	587.1
Rating				**Rating**			
AAA&AA	2,066.9	1,792.2	166.1	AAA&AA	641.0	748.8	102.8
A	2,780.5	1,933.6	347.4	A	1,032.5	884.6	199.0
BBB	1,694.4	1,248.0	357.5	BBB	852.3	677.5	220.7
HY (BB and below)	427.9	307.9	159.3	HY (BB and below)	272.2	197.1	115.3
Maturity				**Maturity**			
1-3 yrs	1,742.5	1,414.8	522.8	1-3 yrs	725.3	687.1	306.3
3-7 yrs	2,744.1	2,196.3	703.8	3-7 yrs	1061.7	972.6	420.4
7-10 yrs	1,194.9	893.1	468.7	7-10 yrs	499.3	444.8	278.0
10+ yrs	1,288.1	777.5	340.0	10+ yrs	511.7	403.5	184.3
% by Foreign Firms				**% by Foreign Firms**	43.5%	47.0%	55.4%
AUD				**CAD**			
Total	230.6	69.9	72.7	Total	259.9	108.7	75.6
Rating				**Rating**			
AAA&AA	147.3	50.2	30.7	AAA&AA	66.4	32.5	22.7
A	58.7	14.0	28.7	A	93.6	40.3	27.6
BBB	23.5	5.4	14.5	BBB	95.4	34.6	25.1
HY (BB and below)	1.2	0.2	0.9	HY (BB and below)	4.5	1.3	2.9
Maturity				**Maturity**			
1-3 yrs	81.5	23.2	41.9	1-3 yrs	70.2	32.5	39.6
3-7 yrs	102.6	33.3	49.1	3-7 yrs	96.4	48.5	49.4
7-10 yrs	36.7	10.6	20.6	7-10 yrs	31.6	12.0	21.8
10+ yrs	9.9	2.8	5.6	10+ yrs	61.7	15.6	22.4
% by Foreign Firms	69.2%	56.7%	72.2%	**% by Foreign Firms**	35.3%	28.9%	48.2%
CHF				**EUR**			
Total	287.8	68.3	105.6	Total	1,679.7	1,900.0	386.2
Rating				**Rating**			
AAA&AA	150.3	34.0	42.5	AAA&AA	491.1	718.1	83.7
A	95.7	23.3	41.5	A	650.3	682.8	151.5
BBB	37.4	9.7	23.7	BBB	435.1	411.6	125.0
HY (BB and below)	4.4	1.3	3.2	HY (BB and below)	103.3	87.5	54.6
Maturity				**Maturity**			
1-3 yrs	83.5	21.1	58.3	1-3 yrs	428.1	517.5	206.5
3-7 yrs	136.5	32.9	72.4	3-7 yrs	778.1	904.8	292.0
7-10 yrs	41.0	9.4	29.0	7-10 yrs	287.4	318.7	149.9
10+ yrs	26.8	4.8	16.3	10+ yrs	186.2	158.9	89.9
% by Foreign Firms	86.7%	79.2%	86.4%	**% by Foreign Firms**	34.0%	31.5%	51.2%
GBP				**JPY**			
Total	456.5	289.5	195.1	Total	1,257.1	337.6	113.5
Rating				**Rating**			
AAA&AA	157.1	88.1	55.1	AAA&AA	413.7	120.6	33.9
A	158.5	112.2	73.4	A	691.1	176.4	57.3
BBB	124.7	80.3	67.5	BBB	126.0	28.9	23.1
HY (BB and below)	16.1	8.9	11.1	HY (BB and below)	26.2	11.6	4.8
Maturity				**Maturity**			
1-3 yrs	86.3	49.1	61.4	1-3 yrs	267.6	84.2	74.1
3-7 yrs	131.6	77.3	91.0	3-7 yrs	437.2	126.9	86.2
7-10 yrs	60.1	39.7	52.1	7-10 yrs	238.9	57.9	55.9
10+ yrs	178.5	123.3	94.1	10+ yrs	313.4	68.6	30.7
% by Foreign Firms	65.0%	65.0%	65.0%	**% by Foreign Firms**	9.1%	10.9%	39.1%

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 principal in $ billions (Notl. $ bil) and the average number of bond issuers (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	16.56***	9.46***	-14.11	22.79***
	SEs	[1.51]	[1.27]	[11.53]	[1.19]
CAD	Mean	-4.54***	-13.58***	-51.67***	4.43***
	SEs	[1.48]	[0.69]	[8.9]	[0.81]
GBP	Mean	-9.35***	-6.30***	-37.93***	-6.73***
	SEs	[1.26]	[0.67]	[8.13]	[1.23]
EUR	Mean	-22.92***	-31.42***	-65.21***	-14.75***
	SEs	[1.4]	[0.61]	[6.06]	[1.15]
CHF	Mean	-35.94***	-28.58***	-77.85***	-33.06***
	SEs	[1.42]	[1.34]	[9.6]	[0.95]
JPY	Mean	-51.36***	-38.75***	-96.80***	-49.78***
	SEs	[2.05]	[1.11]	[13.02]	[2.0]
Average	Mean	-17.92***	-18.19***	-57.26***	-12.85***
	SEs	[1.27]	[0.66]	[9.0]	[0.74]
N		207	47	18	142

The table summarize the estimate of CSD (CSD^{Reg}), CYD (5-year maturity) and CCB (5-year maturity). The reported statistics include the average value in basis point (Mean), heteroscedasticity-robust standard errors (SEs), and number of monthly 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

	$\frac{var(CSD)}{var(\Psi)}$	$\frac{var(CYD)}{var(\Psi)}$	$\frac{var(CCB)}{var(\Psi)}$	$\frac{2cov(CSD,CYD)}{var(\Psi)}$	$\frac{2cov(CSD,CCB)}{var(\Psi)}$	$\frac{2cov(CCB,CYD)}{var(\Psi)}$
AUD	1.27	0.50	0.09	-0.58	0.01	-0.04
CAD	1.71	0.67	0.34	-0.93	-0.53	-0.15
GBP	0.72	0.63	0.21	-0.50	-0.21	0.00
EUR	1.05	0.59	0.42	-0.58	-0.37	-0.05
CHF	1.43	0.94	0.24	-1.36	-0.32	0.18
JPY	1.09	0.14	0.14	-0.20	-0.24	0.06
Average	1.36	0.37	0.15	-0.65	-0.34	0.01

This table reports the variance decomposition results. For each currency, the variance of its corporate basis is decomposed into the variances of CSD, CYD and CCB, as well as their pairwise covariances. The full sample is composed of monthly observations from January 2004 to March 2021.

Table 4: Effects on the FX Market: Evidence of OLS models

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\Psi$	-6.71***					
	(2.55)					
ΔU.S. Treasury Premium		15.84***	9.60***			
		(2.55)	(3.35)			
ΔCSD			-6.66***		-6.46***	-5.26**
			(2.32)		(2.42)	(2.52)
ΔCYD				13.15***	7.53*	7.31*
				(3.58)	(4.12)	(3.97)
ΔCCB				22.14***	15.09***	14.41***
				(3.54)	(4.27)	(4.10)
Δlog(VIX)						0.01**
						(0.01)
constant	6.20	7.45	7.29	6.67	6.63	6.49
	(14.29)	(13.36)	(12.95)	(13.28)	(12.95)	(12.81)
R^2	0.06	0.18	0.24	0.19	0.24	0.26
N	206	206	206	206	206	206

The table reports the regression results in which the dependent variable is the monthly change in the logarithm of the real 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, as well as the logarithm of VIX. We use the simple change as the innovation. The input data is in basis points. Parentheses include the White heteroscedasticity-robust standard errors. 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 interest rates as the risk-free benchmark in our baseline analysis. Since LIBOR might contain a credit risk component relating to banks' creditworthiness, we test the robustness of our findings using alternative measures of risk-free rates. To be more specific, 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 US, Canada, Euro Area, the UK and Japan, respectively. These rates serve as the new benchmark rates to replace 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. Owing to the data availability, we only include the currency of CAD, EUR, GBP and JPY in this robustness tests. For the same reason, the corporate basis components are estimated only for the one-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 -0.34, 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. Figures A1b and A1c plot the IRF to a CSD shock using the illiquidity shock IV and Sentiment shock IV, respectively. A negative risky dollar asset shock results in a substitution toward safe dollar assets, a widening of CCB. 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 CCB, confirming the robustness of our baseline results.

A.2 Regression-Based Estimates of CSD

We examine the robustness of our CSD estimates using several alternative regression specifications. First, we include several extra controls into Equation (5) 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 foreign firms. We denote this CSD as "CSD with non-US". Third, we construct a bottom-up measure of CSD: we estimate the firm-specific CSDs in the first step and then aggregate them to obtain the currency-specific CSD. We denote this CSD as "Bottom-up CSD"'.

Fourth, we replace the government bond yield with the AAA corporate bond yield for the corresponding currency 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 yields 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.[17] We denote the resultant CSD as "CSD with AAA Yield". Fifth, we replace the government bond yield with the maturity-matched LIBOR interest rates when calculating credit spreads. This is in line with Liao (2020)'s CSD, based on the two-way decomposition. We denote this CSD as "CSD with LIBOR-based". The use of AAA yields and LIBOR rates addresses the concern that, given both CSD and CYD depend on the government yield, the variation in government bond yield may drive a mechanical substitution effect.

Sixth, considering that firms have cost advantages in issuing local currency bonds, we exclude all such bonds and further require firms to have issued bonds in at least two different currencies, of which one is USD. We denote this as "CSD without LocalCurrency". Finally, we categorize bonds into two types. A bond is classified as "offshore issued" if the market in which it was issued is different from the parent firm's nationality. Otherwise, the bond is classified as "onshore issued". Then, we denote these CSDs based on these two types, as "CSD Offshore Issued" and "CSD Onshore Issued", respectively.

As shown in Figure A2a, the CSD estimated with alternative approaches moves closely with our baseline CSD. We further examine the substitution effect using the alternative CSD measures and report the IRF of one negative unit of CSD shock to CYD in Figure A2b. All results are consistent with the baseline results and support the substitution effect between safe and risky dollar assets.

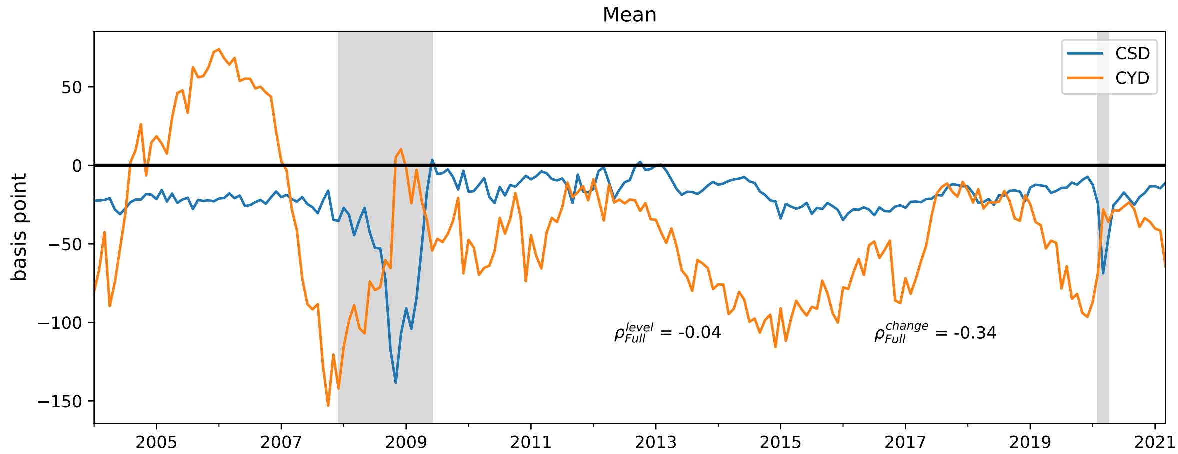
A.3 CSD Based on Matched Bonds

We provide some anecdotal examples to provide some additional insights intn 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 Equation (5). The baseline CSD we used in the paper is quite close to the CSD estimated based on matched bond pairs. Therefore, its robustness is further validated with these model-free CSD estimates, which do not rely cross-sectional regressions to control the maturity effect.

17. Due to the data availability, we drop the sample with CHF-denominated bonds.

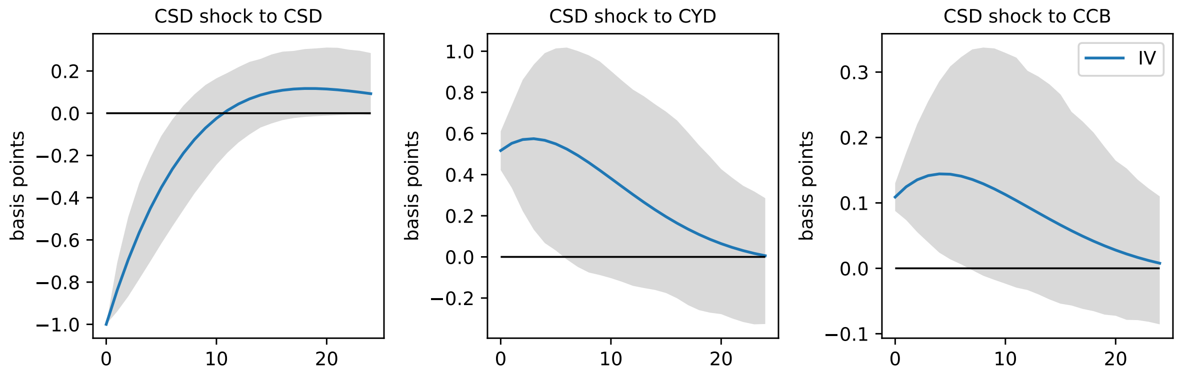
Figure A1: Robustness check using Alternative Risk-Free Rates (ARR)

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



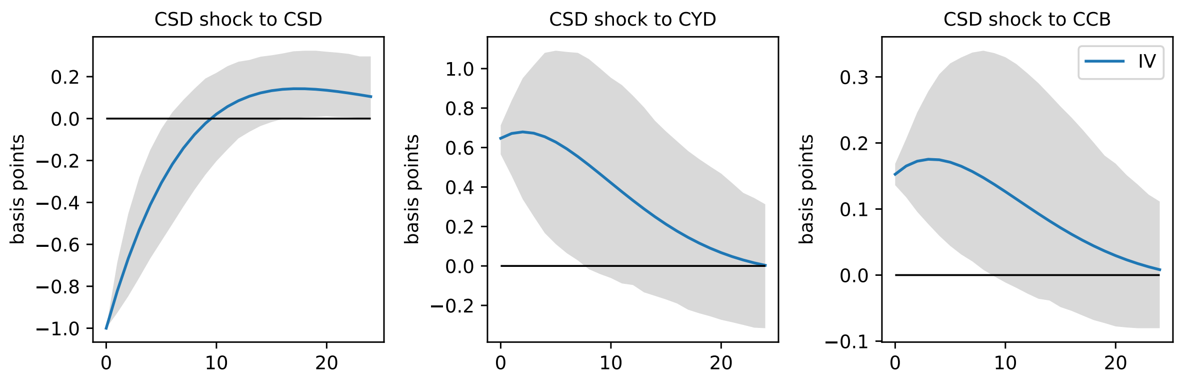
SVAR Model Analysis using Alternative Risk-Free Rates (ARR) (Mean)

(b) IRF of the CSD Shock with Illiquidity IV



First stage regression: Coefficient: 0.40; F-statistics: 52; R^2: 0.20.

(c) IRF of the CSD Shock with Sentiment IV

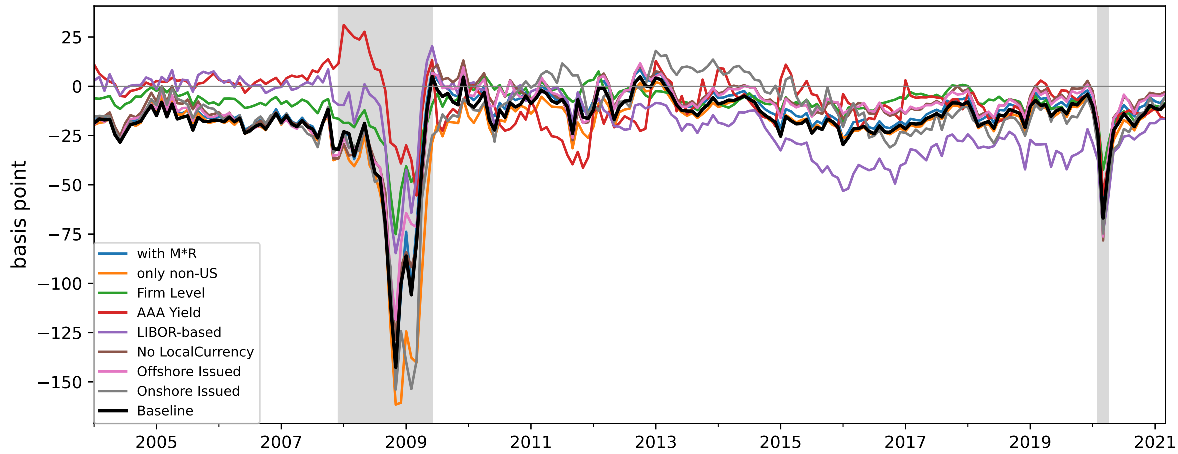


First stage regression: Coefficient: 0.39; F-statistics: 264; R^2: 0.56.

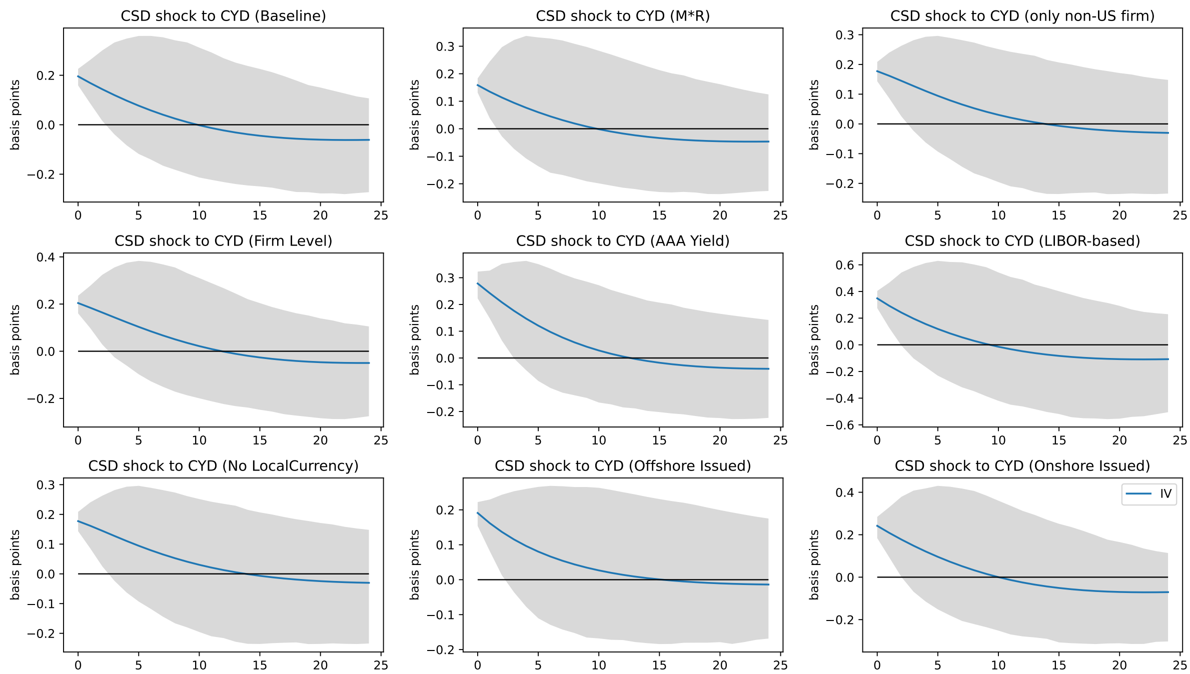
The top figure redraws the substitution effect with the CSD and CYD_{ARR}. The bottom figure redraws the SVAR model analysis with the ARR. The IVs are the illiquidity shock IV and sentiment shock IV for CSD shock, respectively. The sample is from January 2004 to March 2021 with the currency of CAD, EUR, 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

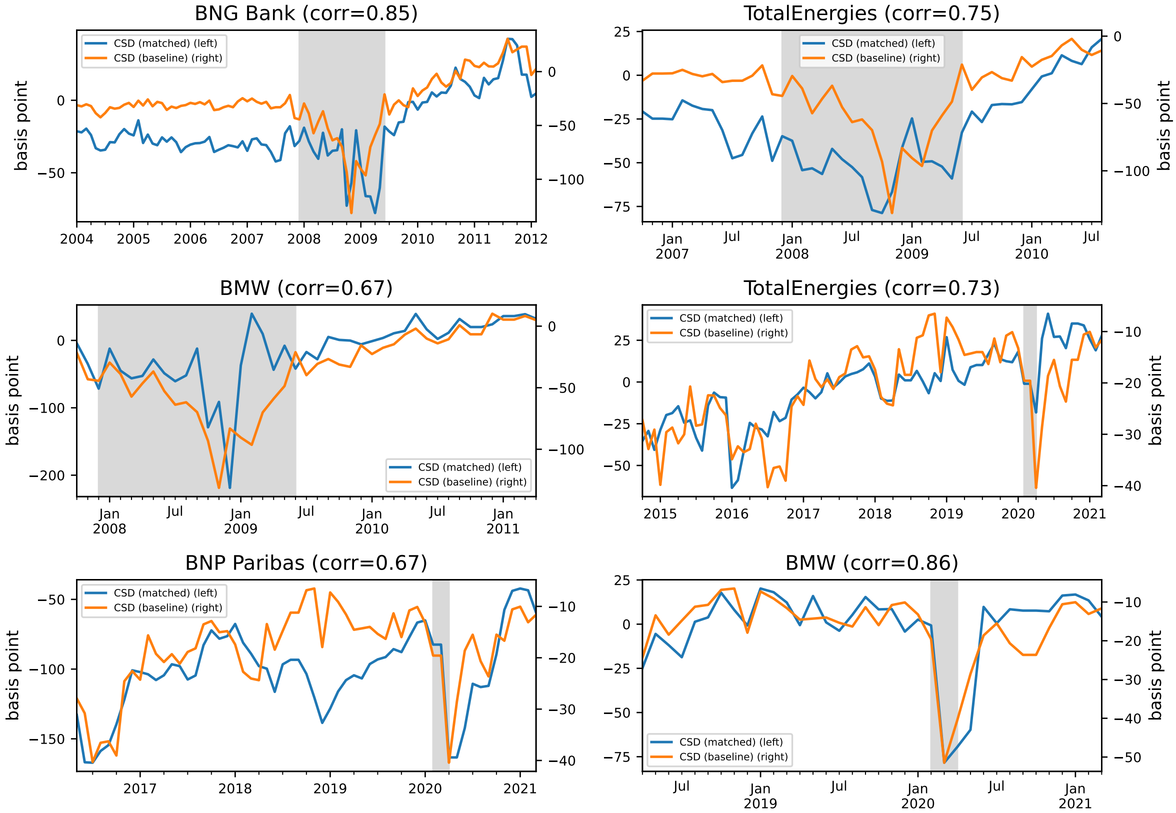


(b) SVAR Model Analysis with Illiquidity IV (Mean)



The top figure compares the baseline CSD with eight 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 label *LIBOR-based* line shows the CSD, which calculates the corporate bond credit spread as the bond yield net of the maturity-matched LIBOR rates. The label *No LocalCurrency* line represents the CSD that excludes firms' local currency bonds. The label *Offshore Issued* line denotes the CSD that includes bonds issued in a market different from the parent firm's nationality. The label *Onshore Issued* line refers to the CSD that includes bonds issued in the same market as the parent firm's nationality. 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 Illiquidity shock IV. The monthly sample is from January 2004 to March 2021. Shaded bars in the top figure denote months designated as recessions by the National Bureau of Economic Research.

Figure A3: Credit Spread Differentials Based on Matched Pairs of Bond



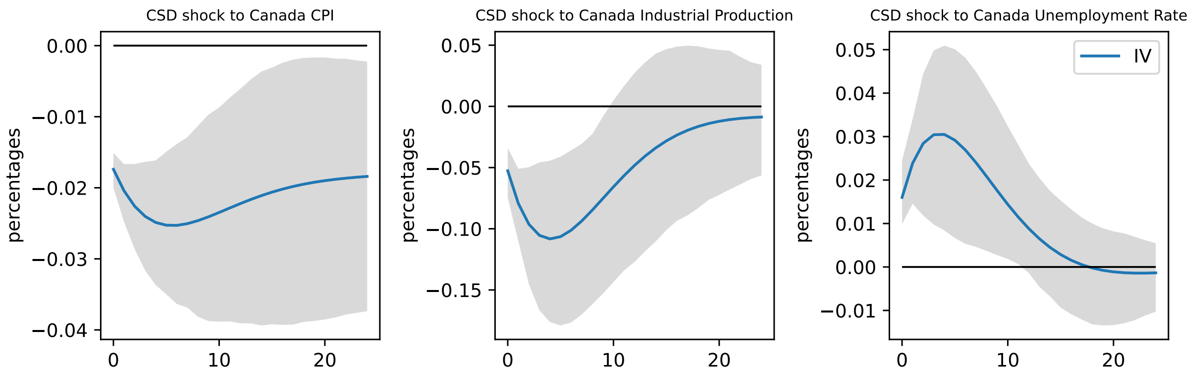
This figure presents the CSD at the bond pair-level. The bond pair-level (matched) CSD is the credit spread difference between a EUR-denomination bond and a USD-denomination bond issued by the same firm with similar remaining maturity and duration. The sub-figure title shows the parent firm's name and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

B.1 SVAR with Illiquidity IV

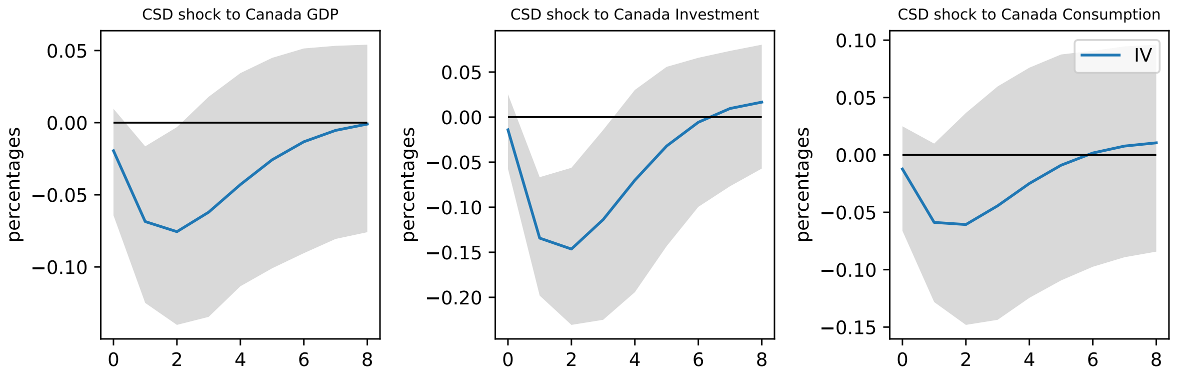
Figure A4: IRF of the CSD Shock with the Canada Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.38; F-statistics: 41; R^2: 0.17.

(b) Quarterly Variables

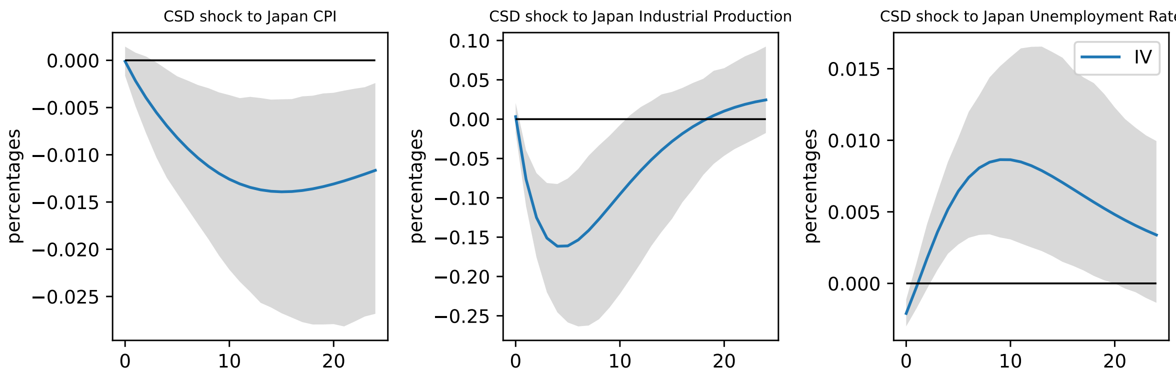


First stage regression: Coefficient: 0.51; F-statistics: 27; R^2: 0.29.

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 Gibbs 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.

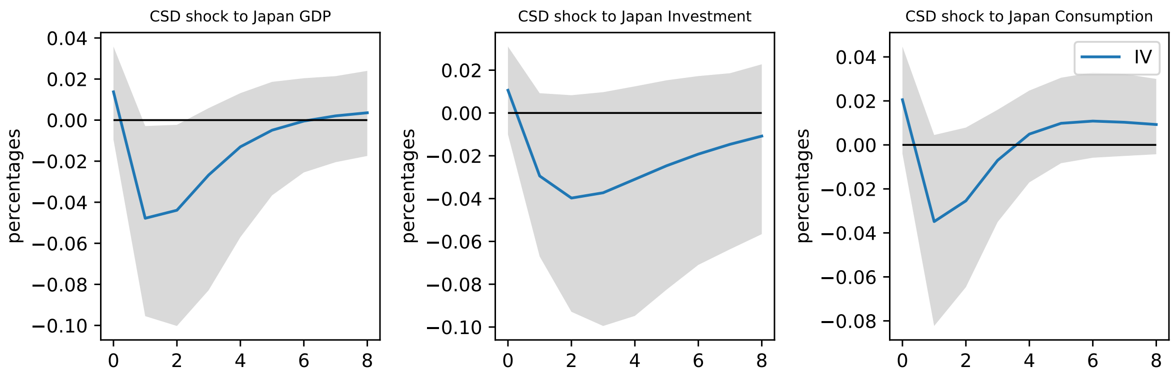
Figure A5: IRF of the CSD Shock with the Japan Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.40; F-statistics: 49; R^2: 0.19.

(b) Quarterly Variables

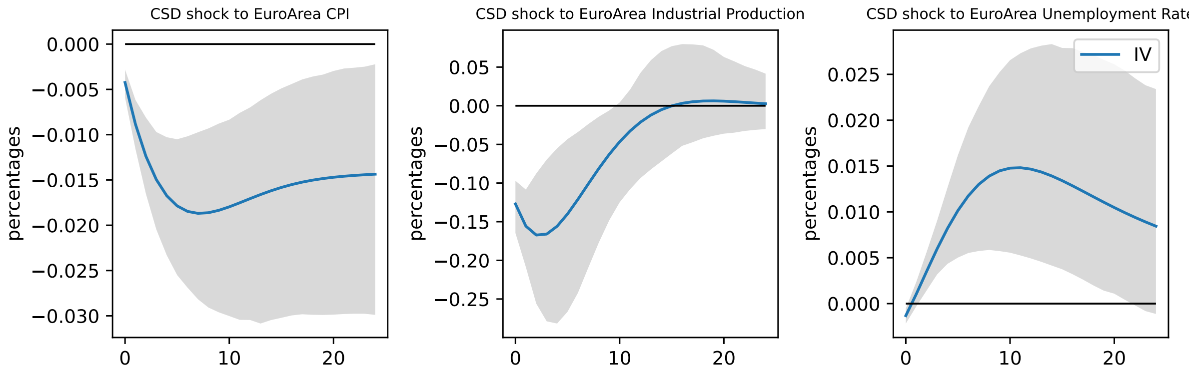


First stage regression: Coefficient: 0.50; F-statistics: 30; R^2: 0.31.

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 Gibbs 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.

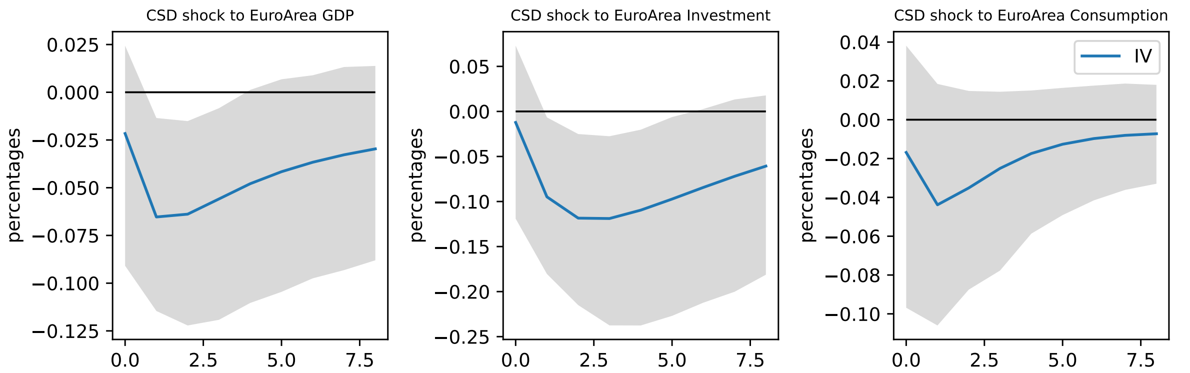
Figure A6: IRF of the CSD Shock with the Euro Area Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.40; F-statistics: 46; R^2: 0.18.

(b) Quarterly Variables

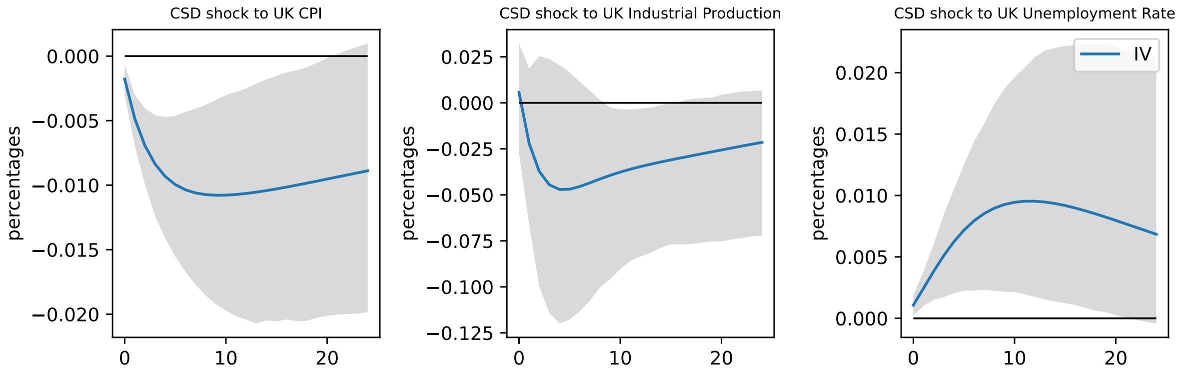


First stage regression: Coefficient: 0.49; F-statistics: 26; R^2: 0.28.

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 Gibbs 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.

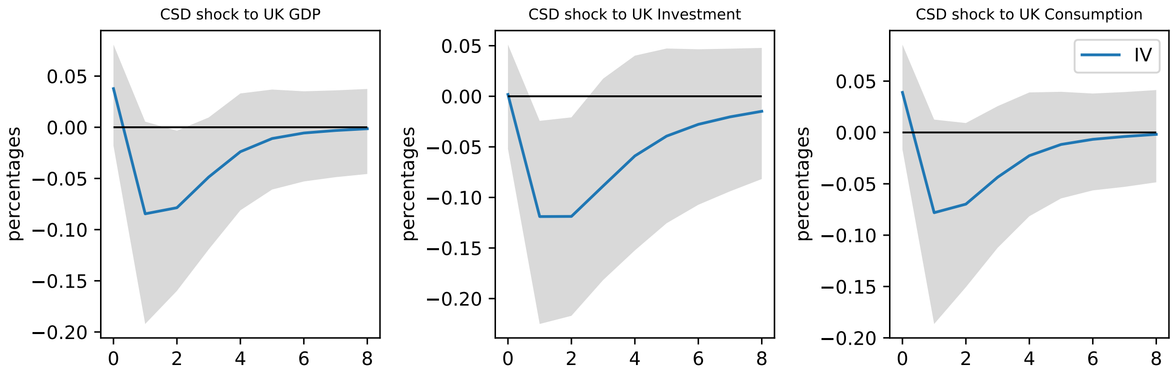
Figure A7: IRF of the CSD Shock with the UK Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.40; F-statistics: 43; R^2: 0.17.

(b) Quarterly Variables

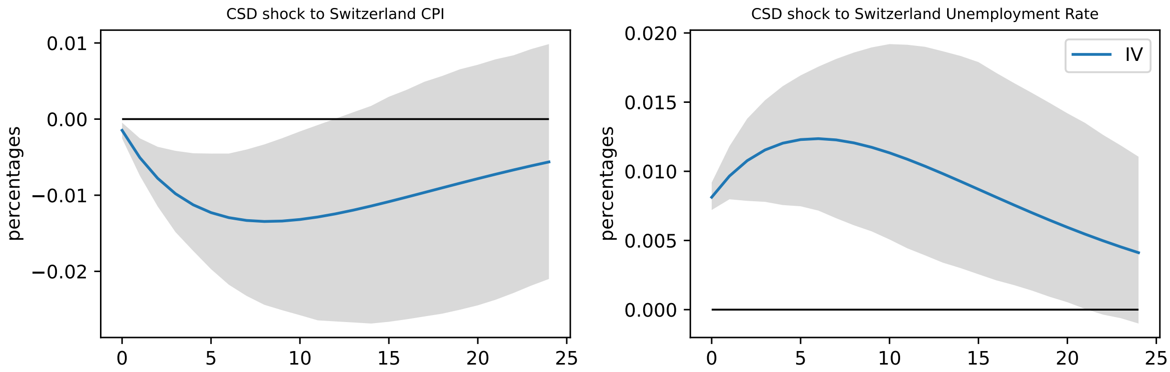


First stage regression: Coefficient: 0.51; F-statistics: 29; R^2: 0.30.

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 Gibbs 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.

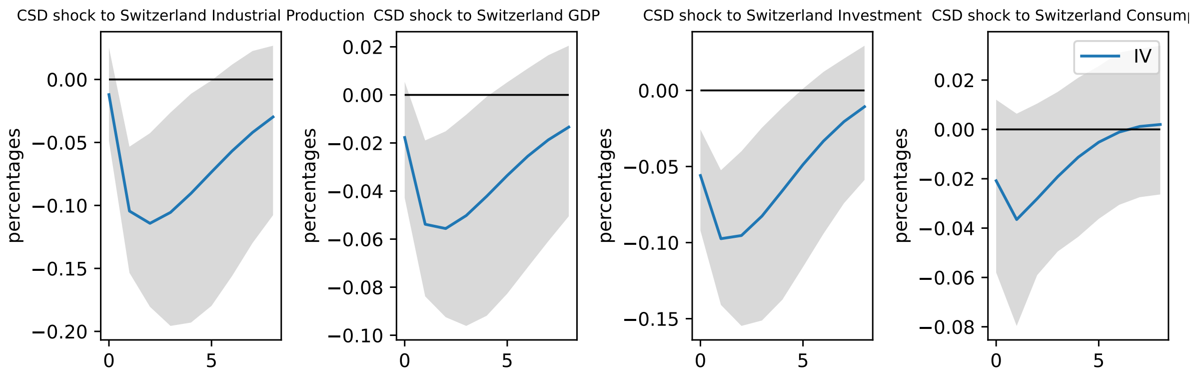
Figure A8: IRF of the CSD Shock with the Switzerland Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.39; F-statistics: 42; R^2: 0.17.

(b) Quarterly Variables

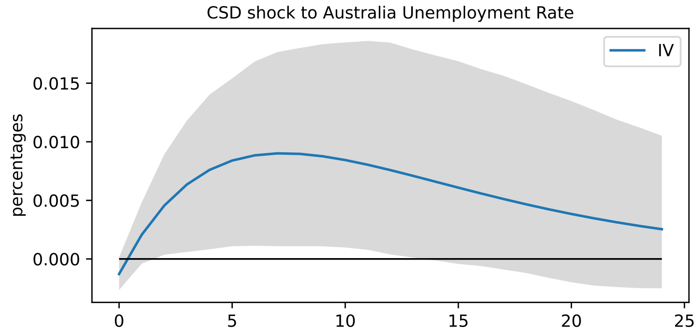


First stage regression: Coefficient: 0.48; F-statistics: 27; R^2: 0.29.

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 Gibbs 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.

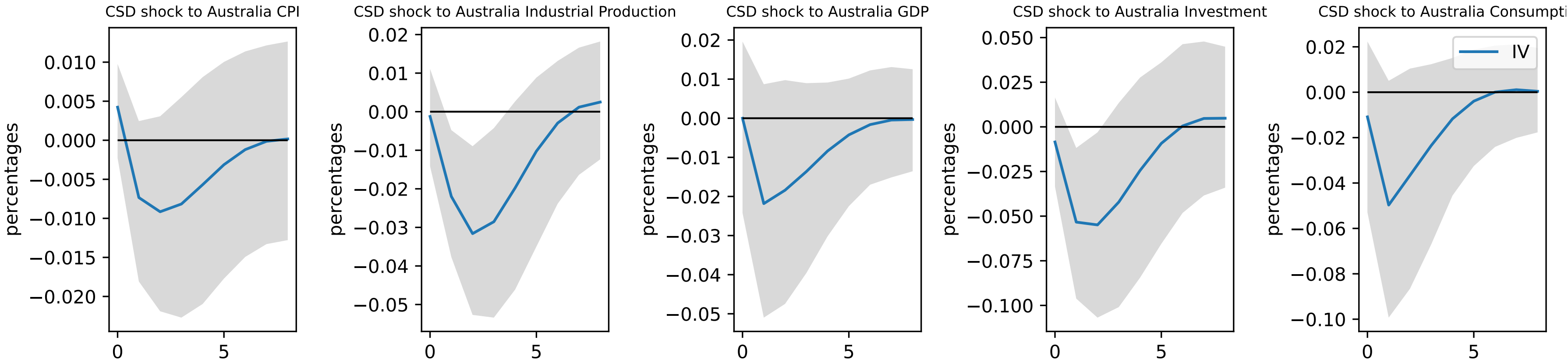
Figure A9: IRF of the CSD Shock with the Australia Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.41; F-statistics: 47; R^2: 0.19.

(b) Quarterly Variables



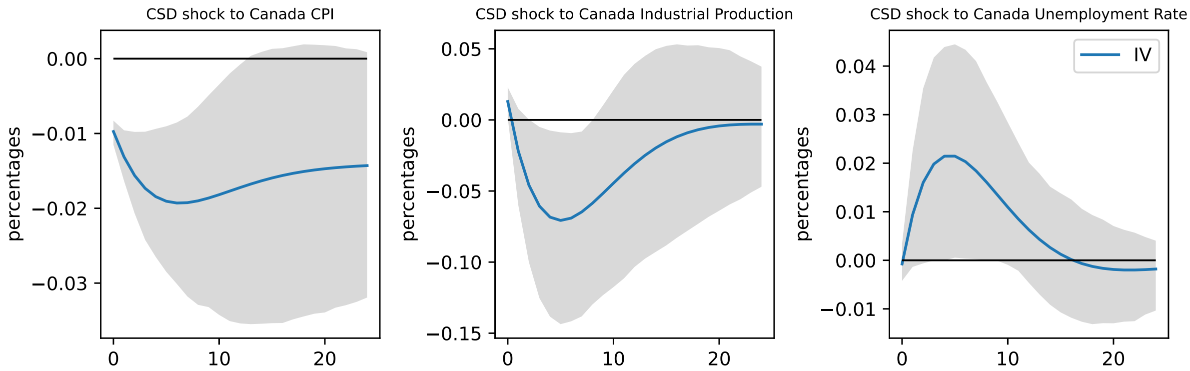
First stage regression: Coefficient: 0.49; F-statistics: 30; R^2: 0.32.

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 Gibbs 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.

B.2 SVAR with Sentiment IV

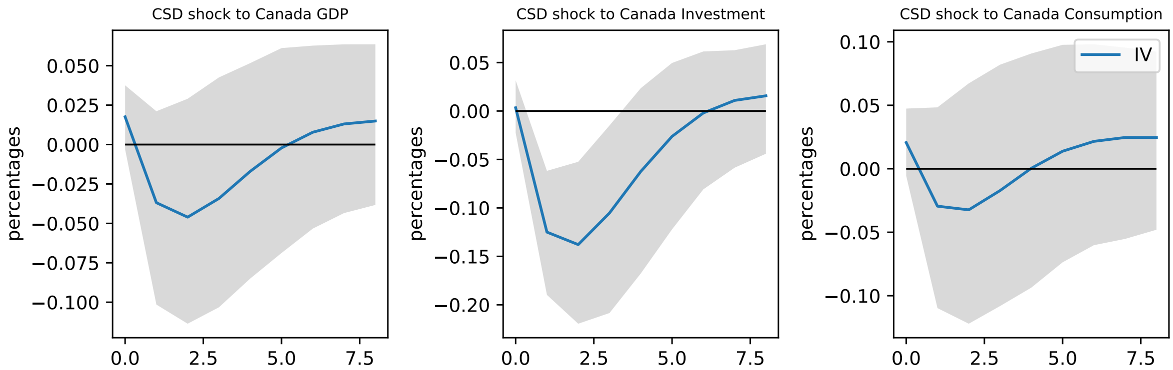
Figure A10: IRF of the CSD Shock with the Canada Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.38; F-statistics: 197; R^2: 0.49.

(b) Quarterly Variables

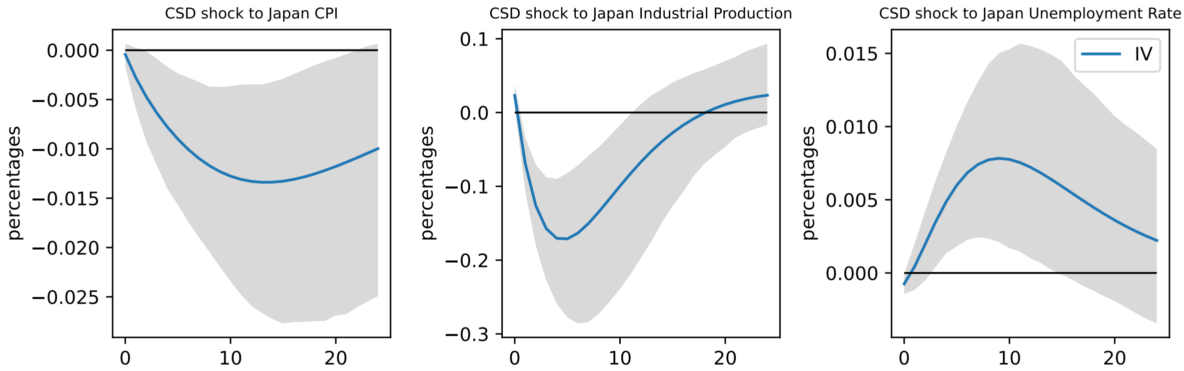


First stage regression: Coefficient: 0.39; F-statistics: 128; R^2: 0.66.

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 EBP 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.

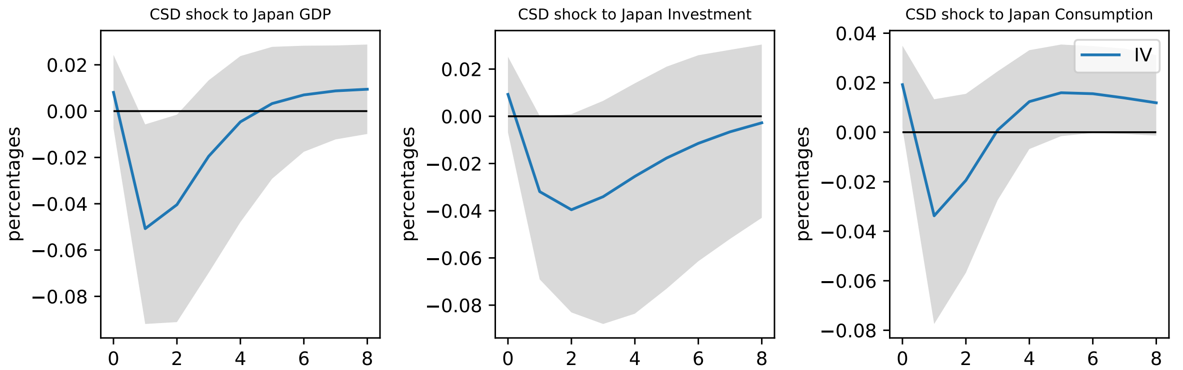
Figure A11: IRF of the CSD Shock with the Japan Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.38; F-statistics: 210; R^2: 0.51.

(b) Quarterly Variables

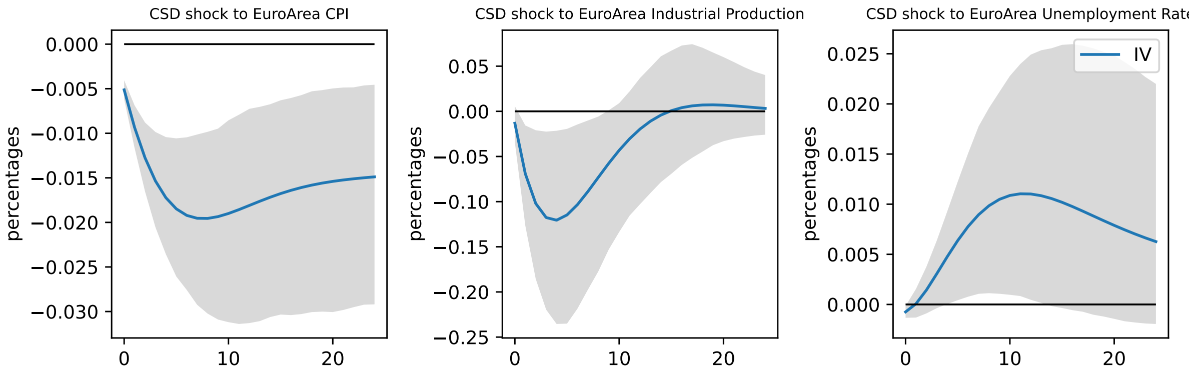


First stage regression: Coefficient: 0.36; F-statistics: 118; R^2: 0.64.

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 EBP 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.

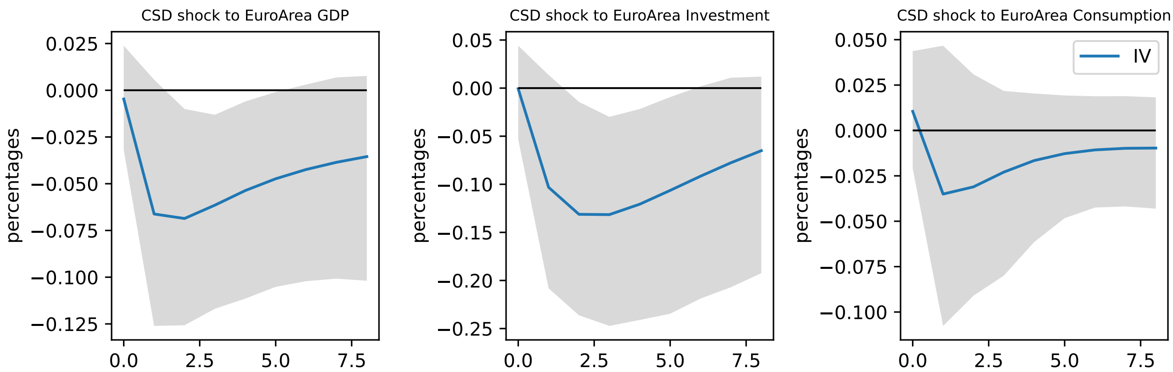
Figure A12: IRF of the CSD Shock with the Euro Area Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.37; F-statistics: 185; R^2: 0.48.

(b) Quarterly Variables

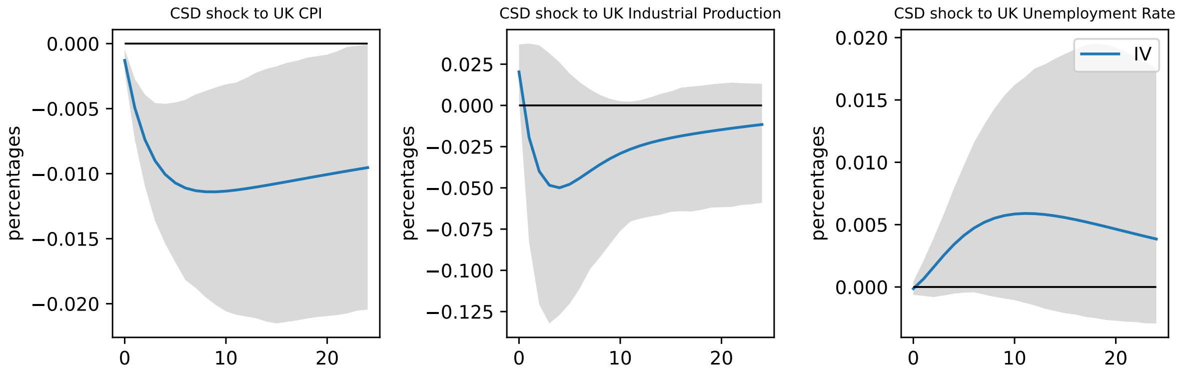


First stage regression: Coefficient: 0.38; F-statistics: 121; R^2: 0.65.

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 EBP 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.

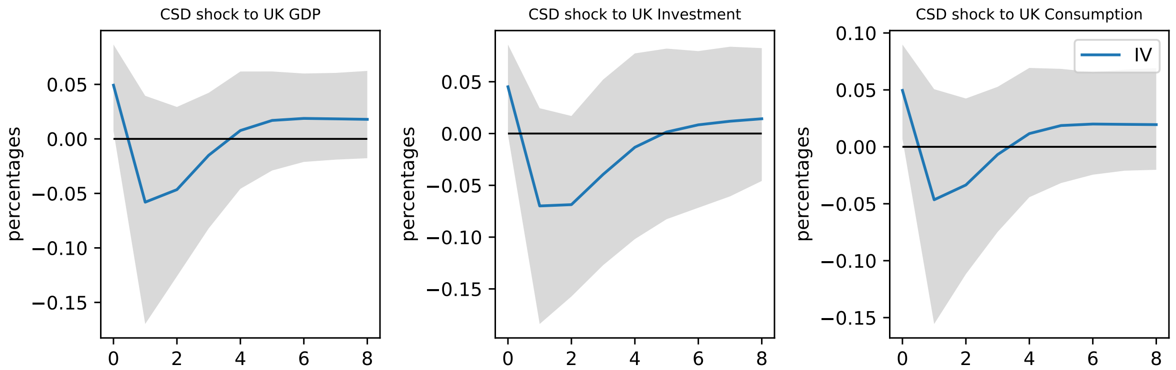
Figure A13: IRF of the CSD Shock with the UK Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.41; F-statistics: 241; R^2: 0.54.

(b) Quarterly Variables

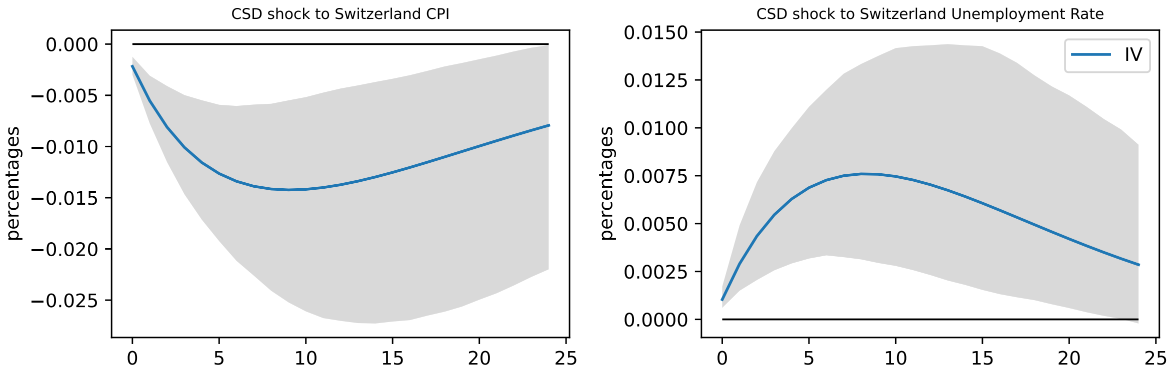


First stage regression: Coefficient: 0.38; F-statistics: 129; R^2: 0.66.

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 EBP 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.

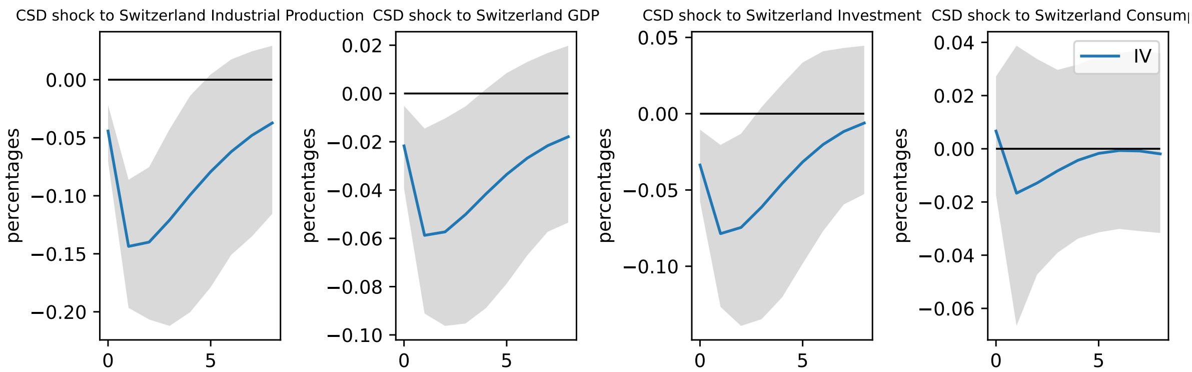
Figure A14: IRF of the CSD Shock with the Switzerland Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.40; F-statistics: 221; R^2: 0.52.

(b) Quarterly Variables

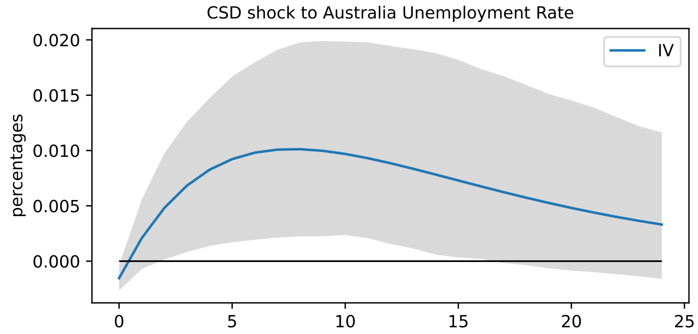


First stage regression: Coefficient: 0.35; F-statistics: 103; R^2: 0.61.

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 EBP 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.

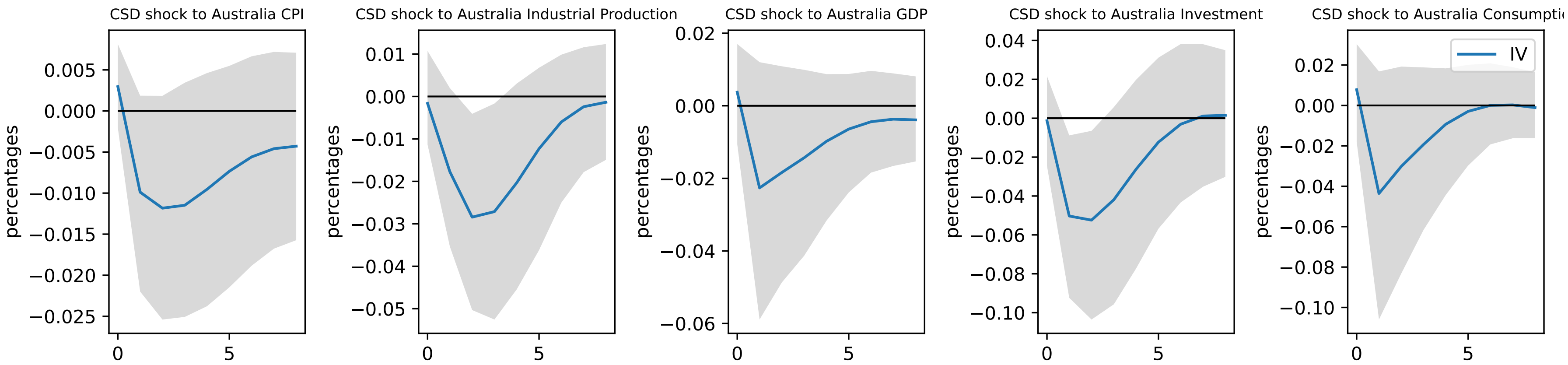
Figure A15: IRF of the CSD Shock with the Australia Macroeconomic Activity

(a) Monthly Variables



First stage regression: Coefficient: 0.41; F-statistics: 244; R^2: 0.54.

(b) Quarterly Variables



First stage regression: Coefficient: 0.33; F-statistics: 87; R^2: 0.57.

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 EBP 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.