Corporate Basis and the International Role of the U.S. Dollar

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Abstract

The corporate basis measures the price differences between bonds issued in dollars and foreign currencies by the same corporate entity. In this paper, we propose a novel method to decompose the corporate basis into three components: credit spread differential, convenience yield differential, and deviation from covered interest rate parity. With this decomposition, we document several stylized facts, and in particular, the substitution effect between safe and risky dollar assets. We provide further evidences on the substitution effect using the structural VAR analysis, which shows that a negative shock to financial intermediaries' balance sheets causes a tightening of credit spread differential, a demand shift toward safe assets, and an appreciation of the dollar. We also find spillover effects to the equity and commodity markets, as well as to the domestic and international economic activities. Lastly, we provide consistent holdings-level evidences using foreign investors' aggregated holdings of safe and risky dollar assets. Our results highlight the important role of the dollar, which are further amplified by financial intermediaries, in the global financial markets.

Keywords: U.S. Dollar Assets Demands, Covered Interest Rate Parity, Financial Intermediaries

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

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1 Introduction

The corporate basis defines FX-hedged corporate bond pricing differences. To an institution that invests in both euro- and dollar-denominated corporate bonds, it reflects the differences between the yields of an Euro (EUR) bond and the synthetic EUR yields as constructed from a cash position in a dollar (USD) bond from the same issuer as well as a hedging position in the FX market. Under the no-arbitrage condition, the corporate basis should be zero in a frictionless financial market. However, as shown in Figure 1, the corporate basis is empirically sizable and exhibits substantial variation since the global financial crisis (GFC). The persistent but time-varying deviations from the corporate covered interest rate parity suggest that many economic forces—including demand for dollar-denominated assets as well as dollar scarcity in cross-border financing—potentially interact and jointly shape the corporate basis. In this paper, we study the effects of financial shocks, such as shocks to intermediary leverage and monetary policy, on the corporate basis, exchange rates, as well as spillovers to equity and commodity markets and real economic activity.

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

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

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

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

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

In addition to shocks to the CSD, we consider monetary policy surprises as an IV for the convenience yield component of the corporate basis. Monetary policy induces a shift in safe dollar asset demand through affecting the spread between USD treasuries and corporate bond yields. Following Kearns, Schrimpf and Xia (2020), we identify monetary policy surprises through high-frequency changes in inter-bank rates and the US Treasury yields around scheduled monetary announcements of the Federal Reserve. Coinciding with the results based on intermediary capital shocks, we note a substitution between safe and risky assets in response to a shock to the Treasury premium. Quantitatively, a one standard deviation increase in the US Treasury premium (18 basis points) leads to a 27.9 basis point increase in USD credit spreads relative to foreign currencies, and a short-term appreciation of the USD of 2.4 %.

Complementary to our findings from the pricing perspective, we also find quantity-based evidence for the substituting demand between dollar safe and risky assets for foreign investors.

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

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

It is noteworthy that our decomposition of corporate basis does not only allow us to examine the relation between the CSD and CYD, but also reveals other important stylized facts. First, we find that the U.S. Treasury premium declines substantially since the GFC, reflecting a decrease in the "specialness" of U.S. treasuries. Second, the correlation of CIP with the Treasury premium is dependent on the sample period, with a positive correlation in the crisis episode but negative in normal times. The positive relationship is attributable to the "flight to safety", and the negative relationship reflects the return-seeking behaviour of foreign investors because they want to invest in a higher return asset to compensate a rising FX hedging costs. Third, we show that CIP deviations reflect credit risk across currencies, with strong co-movement between our credit spread and CIP deviations, which provides supportive evidence for (Liao, 2020). [2]

Finally, we look at the spillover effect of dollar asset demand shocks to other asset classes and economic activity. In our IV specification based on shocks to dealers' equity capital, an increase

[2] We note that our measure of CSD is different from Liao (2020) because we use the government bond yield instead of the risk-free yield to measure the credit spread. Our co-movement between the CSD and CIP is still robust to our methodology, and the correlations are similar to using the risk-free rate.

in the USD credit spreads weakens risk-bearing capacity of financial institutions, resulting in negative returns in the equity and commodity markets. Moreover, we document macro-financial effects on a series of economic activity variables, including inflation, GDP and unemployment rate. To be more specific, a shock to the USD credit spreads depresses both the U.S. and non-U.S. economy activities because of a lower capacity of primary dealers in supplying credit to the economy (Gilchrist and Zakrajšek, 2012).

The remainder of the paper is structured as follows. We review our contribution to literature in section 2. In section 3, we discuss our framework for the determinants of the corporate basis and the data sources. We document our stylized facts in section 4. Section 5 presents our main empirical findings. Section 6 looks at the quantity-level evdiecen of the subtitution effect .Section 7 concludes.

2 Related Literature

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

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

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

3 Definitions and Data

3.1 Decomposition of Corporate Basis

Consider corporate debts denominated in EUR relative to USD. In equation 1, we can express the difference in yields as the EUR bond yield less the USD bond yield after controlling for FX risk. From a bond investor's perspective, it reflects the promised return from holding a

EUR-denominated corporate bond ($y_{e,t}$) in excess of the synthetic yield as constructed from a cash position in a USD bond from the same issuer ($y_{\$,t}$) and a hedging position in the FX market. The FX-hedging cost is $-(f_t - s_t)$, where s_t and f_t as the spot and forward rate (log) exchange rate quoted in EUR per USD. We can also express the corporate basis in equation 2 as the sum of a credit spread differential, capturing innovations in risky asset demand across currencies, and the U.S. Treasury premium (Jiang, Krishnamurthy and Lustig, 2021; Du, Im and Schreger, 2018).

$$
\begin{aligned}
\Psi_t &= \underbrace{y_{e,t}}_{\text{EUR-denomination bond yield}} - \underbrace{(y_{\$,t} + f_t - s_t)}_{\text{FX-hedged USD-denomination bond yield}} && (1)\\
&= \underbrace{\left[(y_{e,t} - y^G_{e,t}) - (y_{\$,t} - y^G_{\$,t})\right]}_{\text{Credit spread differentials}} + \underbrace{\left[(y^G_{e,t} + s_t - f_t) - y^G_{\$,t}\right]}_{\text{U.S. treasury premiums}} && (2)\\
&= \underbrace{\left[(y_{e,t} - y^G_{e,t}) - (y_{\$,t} - y^G_{\$,t})\right]}_{\text{Credit spread differentials}} + \underbrace{\left[(y^G_{e,t} - y^{rf}_{e,t}) - (y^G_{\$,t} - y^{rf}_{\$,t})\right]}_{\text{Convenience yields differentials}} + \underbrace{\left[(y^{rf}_{e,t} + s_t - f_t) - y^{rf}_{\$,t}\right]}_{\text{CIP deviations}} && (3)
\end{aligned}
$$

The decomposition we use in our paper is equation 3. $y^{rf}_{e,t}$ and $y^{rf}_{\$,t}$ denote the euro and dollar risk-free rates, respectively, and $y^G_{e,t}$ and $y^G_{\$,t}$ are the corresponding government bond yields. The main difference is that the Treasury premium can be re-expressed as a difference in Treasury yields, which we denote the convenience yield differential, and FX risk using risk-free rates, which we denote the CIP deviation. Therefore our decomposition of the corporate basis relies on three elements: differences in risky asset yields (credit spread differential), differences in sovereign yields (convenience yield differential), and FX risk (CIP deviation). We provide more details on each component below.

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

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

Credit spread differentials (CSD): CSD is the difference between non-USD denomination corporate bonds' credit spread and USD-denomination corporate bonds' credit spread.

A decrease in CSD corresponds to an increase in the promised return from holding USD-denomination corporate bonds. From an investor's perspective, it indicates a decrease in the demand for *unhedged* risky dollar asset, which could be driven by greater risk aversion among bond investors or higher FX hedging costs (e.g. in the GFC).

We note that our decomposition of the corporate basis differs from Liao (2020), which measures the credit spread differential using the risk-free rate as the benchmark yield. [3] The innovation of our decomposition is that in using the government bond as an index, we can control for country-specific risks such as sovereign default risk, and we can examine the dynamics between the safe and risky asset demand by investors. [4]

3.2 Estimation on the CSD and Corporate Basis

We apply the same methodology to estimate the CSD and corporate basis used by Liao (2020); Galvez et al. (2021); Gopinath, Caramichael and Liao (2021).

To estimate the CSD, we run the following cross-section regression:[5]

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

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

We further measure the corporate basis Ψ_t based on the regression but replace $S_{i,t}$ with $S^{Adj.}_{i,t}$. For the USD denomination bonds, $S^{Adj.}_{\$,t}$ is the same bond credit spread $S_{\$,t}$ as before, but for non-USD denomination bonds, $S^{Adj.}_{i,t}$ is the credit spread $S_{i,t}$ added CYD and CIP as $S_{i,t} + \text{CYD}_{i,t} + \text{CIP}_{i,t}$ [6]. The corporate basis is calculated as $\Psi_{c,t} = \alpha_{c,t} - \alpha_{USD,t}$.

[3] In Liao (2020) the credit spread differential is defined as $(y_{e,t} - y^{rf}_{e,t}) - (y_{\$,t} - y^{rf}_{\$,t})$. This is equivalent to the sum of our CSD and CYD in equation 3

[4] For example, Galvez et al. (2021) find evidence in support of the substitution channel as high rated bond are an alternative safe asset for investors.

[5] We drop the bond-month data if its remaining maturity is less than one year or 10% of full maturity to eliminate the illiquidity impact

[6] We match the CIP deviation maturity 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

3.3 Data

Corporate Bond Data

We build our corporate bond data set on the bond issuance information as retrieved from the SDC Platinum Global New Issues database. This database contains various characteristics of each issue, including the notional principal, maturity date, coupon structure, currency of denomination, the issuer's country of origin, and indicators for option-like features. We filter the bond data with the following criteria: (1) the bond is denominated in one of the seven major funding currencies: AUD, CAD, CHF, EUR, GBP, JPY or USD; (2) the ultimate parent of the issuer has outstanding bonds denominated in multiple currencies, and at least one of them is a USD bond; (3) the bond is unsecured, non-putable, non-convertible, non-perpetual, and has fixed-rate coupons; (4) the issuer is not in a government-related industry such as City government or National Government or City agency;[7] (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)'s approach: we first look up its credit rating in the Standard & Poor's Global Ratings database; if its rating in that month is missing, we turn to the Moody's Default & Recovery Database; if the rating information is still unavailable, we use the rating from other agencies as displayed in Bloomberg (e.g., Fitch and Dominion). Finally, we calculate yield-to-maturity (yield-to-worst for callable bonds) and winsorize it at 1% at the currency-month level to remove outliers.

The final data set consists of 32,008 bonds issued by 3,464 firms with a total notional of $24.2 trillion. Table 1 displays the monthly average of the number of bonds, the notional value in $ billions, and the number of corresponding firms by rating and maturity categories. On average, we have around 7,190 bonds with notional values of $5,400 billion issued by 1,438 firms each month. The A rating class and the maturity group of 3-7 years take the largest share in terms of both the issue and the outstanding notional.[8] Regarding the market size of

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.

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

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

each currency, USD-denominated corporate bonds account for around 40% (2,891) of bonds, 48% ($2,582 billions) of notional values, 58% (829) of issuers in our sample. They are followed in turn by EUR-, JPY-, GBP-, CAD-, CHF- and AUD-denominated bonds. Notably, more than 88% 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 39% are issued by foreign firms and they jointly account for 42 % of notional values of all dollar-denominated bonds.

In addition, we visualize the cross-border bond issuance in Figure 2, using the cross-sectional observations of outstanding amount at the end of our sample period (March 2021). We focus on bond issuers located in the US, Euro Zone, the UK, Switzerland, Canada, Australia and Japan. The size of purple circle reflects the total notional principal of bonds issued by local firms. As expected, the US firms take up the largest portion of bond issuance in the global corporate bond markets, followed by issuers in the EU, Japan, and the UK. The thickness of the arrow line, for example, from the EU to the US shows the total size of USD-denominated bonds issued by European firms. A broad comparison of all arrows in the figure reveals that EU-to-US, UK-to-US, and US-to-EU represents the most important types of cross-border bond issuance. Finally, the darkness of the EU-to-US arrow captures the proportion of foreign currency bonds issued by European firms that are denominated in USD. We find that USD-denominated bonds are the dominant category of foreign currency bonds in Japan, Canada, and the EU. Overall, figure 2 indicates that USD-denominated bonds show a dominant position when firms issue foreign currency bonds, followed by EUR-denominated bonds.

Default-Free Interest Rates and Exchange Rates

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

One potential concern using the Libor rate is the credit risk because it is an unsecured lending rate. In addition, the Libor will no longer be a benchmark rate because of the problem on its reliability such as the Libor manipulation scandal. In the U.S., the Libor is replaced by the Secured Overnight Financing Rate (SOFR) which has negligible credit risks because it measures the cost of borrowing cash overnight collateralized by U.S. Treasury securities.

analysis.

Other countries are also replacing the Libor rate with a new benchmark rate, similar to the SOFR. We have AUD Overnight Index Average (AONIA), Canadian Overnight Repo Rate Average (CORRA), Swiss Average Rate Overnight (SARON), Euro short-term rate (ESTR), Sterling Overnight Index Average (SONIA) and Tokyo Overnight Average Rate (TONA) using in Australia, Canada, Switzerland, Euro Area, the U.K. and Japan, respectively. In particular, Bloomberg has traced back SOFR, CORRA, ESTR, SONIA and TONA to before 2004 but, currently, the maximum maturity is only 1 year. Therefore, we use the 5-year Libor rates as the risk-free rate in our baseline analysis but use the new benchmark rate with a 1-year maturity in our robustness tests.

Other Data

VIX, equity indexes and the commodity index data are from Bloomberg. We use the "intermediary capital risk factor"[9] proposed by He, Kelly and Manela (2017) to identify the financial intermediary constraints shock. The high-frequency interest rates on 1-month Overnight Indexed swaps (OIS) are from Thomson Reuters TickHistory. Monthly Holdings of U.S. Long-term Securities by Foreign Residents are from Treasury International Capital (TIC) database[10]. The macroeconomic variables are from Federal Reserve Economic Data.

3.4 The Corporate Basis and Its Components

We estimate the corporate basis and CSD based on equation 4, and the R^2 of cross-section regression is over 85%. The average maturity of corporate bonds across time is close to 5 years. Then, we use CYD and CIP at the five-year maturity in our analysis, estimated based on equation 3.

Figure 1 shows the monthly time-series of the corporate basis from January 2004 to March 2021 for currency pairs with one leg in USD and one leg in non-USD (AUD, CAD, CHF, EUR, GBP or JPY). The basis indicates the difference between non-U.S. corporate yield and hedged U.S. corporate yield, and it has negatively spiked during two crisis periods (the GFC and the Covid-19), probably reflecting either a surging hedging cost or a lower risky dollar asset demand. Also, the basis was close to zero before the GFC, and it turns to be a significant deviation from zero with a large fluctuation afterwards. The rising volatility could be driven by several factors such as the hedging costs, safe dollar or risky asset demand. Therefore, we decompose the corporate basis into three components: CIP, CYD and CSD. Table 2 shows a simple variance

[9]The data is available at Zhiguo He's personal website.

[10]https://home.treasury.gov/data/treasury-international-capital-tic-system-home-page/help-files/estimating-holdings-of-treasury-securities

decomposition of the corporate basis. The variance of CSD has contributed most of the variation of the corporate basis. CYD and CIP followed. Also, the CSD is negatively co-move with CYD and CIP, but the correlation between CIP and CYD are heterogeneous and weak. We will discuss more details in section 4.

Next, we look at the time-series variation of each component. Figure 3 shows the monthly time-series of CYD, CIP and CSD from January 2004 to March 2021. Table 1 presents the corresponding summary statistics with the full sample, Pre-GFC (Jan 2004 to November 2007), GFC (December 2007 to May 2009) and post-GFC (June 2009 to March 2021). CIP reflects the stress of dollar liquidity in the cross-border market, and it was close to zero before the GFC but have been persistently large since the GFC. The spike of CYD in the GFC reflects the "flight to safety" (e.g. Krishnamurthy and Vissing-Jorgensen, 2012), but the spike was less prominent in the Covid-19, which is consistent with the "dash for dollar" (e.g. Cesa-Bianchi and Eguren Martin, 2021). A download trend in CYD indicates that the U.S. safe asset is less "specialness" after the GFC. Also, the mean of CYD for most pairs after GFC turns to be negative. CSD reflects the risky dollar asset demand. It dropped sharply during the crisis period (the GFC and Covid-19), indicating a run on the risky dollar asset because of a lower risk appetite, high FX risk or hedging costs. Also, the CSD is consistently and persistently negative for the currency pair with a positive CIP. In other words, the dollar liquidity stress plays an important role in the risky dollar asset demand.

4 Stylized Facts

We document three stylized facts on the three components of our decomposition. We focus on the mean value of the seven currency pairs for each variable our baseline analysis. Appendix A provides supplementary details on stylized facts for individual currency pairs.

Fact 1: A substitution effect between safe and risky dollar assets

Figure 4 shows the variation of CYD and CSD from January 2004 to March 2021 in the full sample (-0.48). This negative correlation reflects a substitution effect between safe and risky dollar assets. This negative correlation is -0.83 during the global financial crisis. We explain this negative co-movement between CSD and CYD due to a 'flight to safety' by foreign investors. This can jointly explain an increase in CYD, as US Treasury premia increase, and a decrease in CSD as dollar credit spreads increase relative to foreign currency credit spreads.

Fact 2: A decline in the U.S. Treasury premium

Figure 5 plots the CYD, CIP and U.S. Treasury premium (as CYD + CIP) from January 2004 to March 2021. A positive U.S. treasury premium indicates that the foreign investors are willing to hold U.S. treasuries at a discount after hedging the FX risk, reflecting the "specialness" of U.S. treasuries compared with non-U.S. government bonds. The U.S. Treasury premium spiked during the crisis period (the GFC and the Covid-19) but has had a trend decline since the GFC. We decompose the U.S. treasury premium into two components: the CYD and the CIP. We note that the CYD has the same trend as the U.S. treasury premium, reflecting a decrease in relative convenience yield of U.S. treasury compared with non-U.S. governments bonds. The trend in convenience yields and the treasury premium finds empirical support in Du, Im and Schreger (2018), and can be linked to an increase in sovereign default risk of U.S. government bonds since the GFC (Augustin et al., 2021). A relative decline in safe dollar asset demand could be induced by a falling willingness of primary dealers to absorb the Treasuries' supply due to tight balance constraints or uncertainty in the secondary market (Klingler and Sundaresan, 2020).

CIP is positive since the GFC, reflecting a scarcity of dollars in cross-border interbank markets. The correlation between CYD and CIP is 0.6 during period of a 'flight to safety' such as the 2008 financial crisis. During these periods, we observe a joint increase in the demand for safe dollar assets and dollars in cross-border interbank markets, increasing CYD and CIP. The correlation between CYD and CIP is -0.3 in normal times (after the GFC and before the Covid). The mute correlation could be due to a higher CIP deviation potentially lower demand on U.S. Treasuries by foreign investors becasue of a higher FX hedging costs. Figure 6 documents a negative correlation between CIP and foreign residents' holding on long-term U.S. Treasuries, supporting our inference on lower U.S. safe asset demand when hedging costs are higher in FX markets.

Fact 3: Alignment of CIP and CSD

Liao (2020) demonstrates that the global debt issuers and investors are natural cross-market arbitrageurs. For example, high credit spreads in USD relative to foreign currencies, measured with respect to a risk-free rate, implies issuing dollar bonds is costly for the firm. Therefore, to obtain dollars a firm needs to issue a foreign currency bond and swap into dollars. All else equal, this puts upward pressure on swapping foreign currency into dollars in the FX swap market, widening CIP deviations. Therefore a direct implication is that credit spread differences across currencies and CIP deviations are highly negatively correlated with a correlation of -0.65 in the full sample (Figure 7). In our decomposition, we uncover the same sign but with a smaller magnitude of the correlation between our CSD and CIP (-0.1 in the full sample) because our CSD uses a benchmark rate of the Treasury yield.

5 Empirical Findings

5.1 Structural VAR and Shocks' Effects

We start with structural VAR (SVAR) to understand the causal effect of structural shocks on each variable in equation 5.

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

where $Y_t = [CSD_t\ CYD_t\ CIP_t]'$ and ϵ_t is a vector of orthogonal structural innovations with zero mean [11]. ρ is 1 based on the BIC criteria of VAR model. ϵ_t consists of a shock to the risky component of dollar asset demand ($\epsilon_t^{\text{CSD shock}}$), a shock to the safe dollar asset demand($\epsilon_t^{\text{CYD shock}}$), and a shock to the cross-border dollar liquidity ($\epsilon_t^{\text{CIP shock}}$). Multiplying each side of the equation by A^{-1} yields the reduced form representation in equation 6.

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

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

We assume causality runs from CSD to CYD and CIP. Therefore shocks to CSD contemporaneously affect CYD and CIP, and shocks to CYD contemporaneously affect CIP. Figure 8 presents the impulse response function (IRF) of one unit corresponding shock to each variable based on the Mean value of CSD, CYD and CIP. The plots of each individual pair are in appendix B. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The IRF is estimated based on 1,000 bootstraps. The results support the stylized facts: we find evidence of a substitution between risky and safe dollar assets as shocks to CSD induce a negative co-movement between the CSD and CYD components. Quantitatively, a one standard deviation (18.6 basis points) increase in CSD leads to a 4.5 basis point decrease in CYD. A positive shock to CSD and CYD can both result in a contemporaneous decrease in CIP. A one standard deviation increase in CSD (18.6 basis points) and CYD (18 basis points) results in a decrease in CIP with 2.46 and 2.45 basis points, respectively. This is consistent with observing a negative correlation between CSD and CIP (Fact 3) and a negative correlation between CYD with CIP (Fact 2). In summary, the SVAR model with contemporaneous restrictions confirm

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

our stylized facts on the co-movement between CSD, CYD and CIP.

5.2 Structural VAR with External Instruments

A limitation of the SVAR with restrictions on timing is that it assumes a direction of causality from credit spreads to convenience yields and CIP violations. The joint determination of the components of the corporate basis suggest an alternative specification is required to identify the causal effects of each component of the corporate basis. We add external instruments to identify shocks to components of the corporate basis. For example, let Z_t be a vector of instrument variable (IV) for risky dollar asset demand (CSD). To be a valid instrument, Z_t must be correlated with $\epsilon_t^{\text{CSD shock}}$ but orthogonal to other shocks (equation 7).

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

The reduced-form VAR representation is expressed in equation 8:

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

Let u^{CSD}, u^{CYD} and u^{CIP} be the reduced form residual for the CSD, CYD and CIP, 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, equation 7.

The first stage regression:

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

To identify the effect of the instrument on CYD and CIP, we need to estimate the ratio b21/b11 and b31/b11 from the two stage least squares regression of u^{CYD} and u^{CIP} on u^{CSD}, where $\widehat{u_t^{CSD}}$ is fitted value from the first stage regression. We can get $\gamma_1 = b21/b11$ and $\gamma_2 = b31/b11$ under the identifying assumption that shocks to CYD and CIP are transmitted through the instrument's effect on CSD.

[12]

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

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

The second stage regression:

$$u_t^{CYD} = \alpha + \gamma_1 \widehat{u_t^{CSD}} + w_t \tag{10}$$

$$u_t^{CIP} = \alpha + \gamma_2 \widehat{u_t^{CSD}} + w_t \tag{11}$$

Finally, we can normalize b11 to 1, then b21 and b31 equal to γ_1 and γ_2, respectively.

5.2.1 Financial Intermediaries' Balance Sheet Constraints Shocks

We use the SVAR with external instruments to identify the effect of financial intermediaries' balance sheet constraints. We hypothesize that banks with balance sheet constraints need to lower their risky asset demand to meet minimum requirements such as the Tier 1 capital ratio. Therefore, we use the "intermediary capital risk factor" proposed by He, Kelly and Manela (2017). This measure the monthly growth rate of primary dealers' capital ratio, and is an external instrument to identify the risky component of dollar asset demand.

Figure 9 presents the IRF of a standard deviation shock to the CSD based on the financial intermediaries' balance sheet constraints shock IV. The plots of each individual pair are in appendix C. The first stage F-statistic is 98 with 0.32 of R^2, and this is above the threshold of 10 suggested by Stock, Wright and Yogo (2002) which rules out the weak instrument problem. When dealers are financially constrained, a negative shock to capital ratio increases the marginal value of a dollar to capital. Dealers then cut back on risky dollar corporate bonds due to the tight banking regulation. The reduction in risky dollar asset demand increases U.S. corporate bond spreads relative to non-U.S. spreads (CSD $\downarrow$). A substitution toward safe dollar assets has opposite effects on the convenience yield (CYD $\uparrow$). This substitution effect is only significant contemporaneously, which indicates that primary dealers immediately react to the tightening of balance sheet constraints. Dealers are also limited in exploiting the CIP arbitrage (acts as dollar supplier side in the FX market) because of a higher marginal value of the dollar to capital. This translates to an increase in the premium to borrow dollars in FX swap markets, widening CIP. Quantitatively, we find a one standard deviation (18.6 basis points) decrease in CSD leads to a 2.41 basis points increase in CYD, and a 4.64 basis points increase in CIP.

5.2.2 Monetary Policy Shocks

Monetary policy could directly affect the U.S. Treasuries market and transmit to the foreign demand on safe dollar assets. For example, a tight U.S. monetary policy shock leads to a

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 $\gamma_2 = b31/b11$.

higher yield on U.S. treasuries, lifting up the return on holding safe dollar assets, which in turn leads to a higher safe dollar asset demand. Therefore, we use monetary policy shock as an external instrument to identify the safe dollar asset demand shock. Following Kearns, Schrimpf and Xia (2020) , we construct the monetary policy shock as the 1-month OIS rate changes around U.S. scheduled monetary policy announcements. We calculate the change in an event window that is 15 minutes before and after the announcement, with a 5 minute adjustment to account for potential mismatch of the announcement timestamp with the data. $\Delta r_t = \overline{r_{t+5\,\text{min}\to t+20\,\text{min}}} - \overline{r_{t-20\,\text{min}\to t-5\,\text{min}}}$. We then convert the high-frequency monetary policy shock to a monthly level by taking a mean of the Δr_t within the month. We set values to 0 if the month has no scheduled monetary policy announcements.

Figure 10 presents the IRF of CYD shock based on the monetary policy shock IV for the average across currency pairs. The plots of each individual pair are in appendix D. Compared to the IRF with standard SVAR, the external instrument methodology helps us to separate the substitution effect channel from the safe dollar asset demand to the risky dollar asset demand. Quantitatively, a one standard deviation (18 basis points) increase in CYD contemporaneous leads to a decrease in CSD of 27.9 basis points. In addition, the safe dollar demands shock results in an insignificant effect on the CIP in both the short- and long run. This result is consistent with stylized fact 1 as we observe a low correlation between CYD and CIP over the full sample. One limitation of our IV is that the F-statistics is only 3.3, indicating a potential weak IV problem. This is a common problem when using a high-frequency shock at a monthly frequency. However, in terms of the economic intuition on the link between the monetary policy shock and safe dollar asset demand shock, our results offer some insight on the effects of US monetary policy on the substitution between safe and risky dollar assets.

5.3 FX markets

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

We start with a simple OLS regression. The dependent variable is the monthly change in the log of spot dollar value against a basket.[13] The main independent variables include the first difference in the corporate basis, the U.S. Treasury Premium, CSD, CYD and CIP. In addition,

[13] AUD, CAD, CHF, EUR, GBP and JPY

we control the market risk by the VIX. Table 4 presents the regression results. Column (1) indicates that the corporate basis has a negative impact with a coefficient of -7.12 on the dollar value with a 5% significance level. One standard deviation (13.7 basis points) decrease in the hedged risky dollar asset demand (the corporate basis) would lead to 0.98% (98 basis points) appreciation in the dollar value. This effect is mainly attributed to CSD as shown in columns (3), (5) and (6). For example, column (3) shows that one standard deviation (18.6 basis points) decrease in CSD results in an appreciation of USD by 1.34%. Columns (2) and (3) find the Treasury premium has a positive and significant effect on the dollar appreciation, supporting evidence in Jiang, Krishnamurthy and Lustig (2021). A one standard deviation (14.8 basis points) increase in the Treasury premium leads to a 2.39% appreciation in the dollar value based on column (2) with a coefficient of 16.18. We can decompose the U.S. Treasury premium into the safe dollar asset demand (CYD) and the cross-border dollar liquidity scarcity (CIP). A one standard deviation increase (18 basis points) in CYD leads to a 2.4% appreciation in the USD, and a one standard deviation (10.7 basis points) increase in CIP leads to a 2.55% appreciation.

We extend our SVAR results for the IRF of a CSD and CYD shock in Figures 11 and 12. Figure 11 presents the IRF of CSD shock using the financial intermediaries' balance sheet constraints shock IV. A negative shock on primary dealers' balance sheet constraints results in lower demand on risky dollar assets (CSD) due to the tight regulation and an increase in the demand for safe dollar assets due to the substitution between safe and risky assets. The limited dealer leverage reduces the capacity to arbitrage in FX swap markets, resulting in a widening of CIP deviations. The declining risk-bearing capacity of financial intermediaries also results in excess returns on the dollar. Figure 12 presents the IRF of CYD shock based on the monetary policy shock IV. Consistent with the OLS regression, there is a safe asset demand channel where a positive shock on the safe dollar asset demand leads to an appreciation of the dollar. The plots for each individual pair are in the Appendix E.

5.4 Equity and Commodity Markets

In addition to the FX market, we also examine the connection between dollar asset demand and cross-border dollar liquidity with the equity and commodity market. We examine spillover effects of shocks to the corporate basis on the SPX (S&P 500) index, Non-U.S. index and commodity index. The non-U.S. index is the mean of the Austrian Traded Index, S&P/TSX Composite Index, Swiss Market Index, EURONEXT 100, FTSE 100 and Nikkei 225, and the commodity index is the Bloomberg commodity index. All indices are in log terms. Results for the SVAR model with the financial intermediaries' balance sheet constraints shock IV is presented in Figure 13. A one standard deviation (18.6 basis points) decrease in CSD contemporaneously leads to a decline of 10.6%, 11.4% and 5.7% in one month of the SPX index, non-U.S. index and commodity index, respectively.[14] This is consistent with the literature on intermediary asset pricing, in which the tightening of dealer leverage constraints increases the marginal value of a dollar of wealth, and leads to excess asset returns as risk compensation to the U.S investor (He, Kelly and Manela, 2017). A negative shock on the primary dealer leverage causes a persistent impact on other asset classes because of a lower risk-bearing capacity.

5.5 Economic Activities

Gilchrist and Zakrajšek (2012) show that shocks to the corporate bond credit spreads have a persistent impact on the economic activity. A decline in the risk-bearing capacity of primary dealers results in significant consequences for the macroeconomy. We can use our framework to study the effects of a dealer leverage shock on credit spreads and macroeconomic activity. In our analysis, we consider macroeconomic variables such as CPI, industrial production, unemployment rate, real GDP, real investment and real consumption. CPI, industrial production and unemployment rate are at the monthly level, and real GDP, others are at the quarterly level. However, we only have quarterly data on the industrial production for Switzerland and Australia and quarterly data on the CPI for Australia. We match the quarterly level by taking a quarterly average of CSD, CYD, and CIP, and there is the intermediary capital risk factor at the quarter level. The unemployment rate is in percentage terms, and all other variables are expressed in log terms.

Figure 14 shows the IRF of a negative CSD shock on U.S. economic activity. In the SVAR with external instruments, using financial intermediaries' balance sheet constraint shock as an IV, we find spillovers to macroeconomic activity, with a decline in the U.S. CPI, industrial production, real investment, real consumption and real GDP with a rise in unemployment rates. We also find significant spillovers to non-U.S. economic activities (Canada, Japan, Euro Area, UK, Switzerland and Australia). [15] Figure 15, 16, 17, 18, 19 and 20 reports the IRF of a negative CSD shock on Canada, Japan, Euro Area, the UK, Switzerland and Australia macroeconomic activity respectively. Consistent with the results in U.S. economic activity, a negative shock on risky dollar asset demand leads to a contemporaneous and subsequent deterioration in economic activity, with a decline in CPI, industrial production, real GDP, real

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

[15] In the non-U.S. analysis, I use each country's corresponding CSD, CYD, and CIP instead of the Mean value.

investment, real consumption and a higher unemployment rate.

5.6 Robustness Tests

5.6.1 Alternative Measures of Risk-free Rates

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

Figure 21 reports the stylized facts for the basis components estimated using the alternative risk-free rates. Consistent with our baseline results, there is a negative correlation between the CYD and CSD, which is more pronounced during the crisis (e.g. the GFC) periods. Second, the gradual decline of the U.S. Treasury premium since the GFC is mainly driven by the decline of CYD. Third, the CSD is negatively correlated with CIP. Figure 22 plots the IRF to a CSD shock. A negative risky dollar asset shock results in a substitution toward safe dollar assets, a widening of CIP deviations, and a USD appreciation. We also find that a higher safe asset demand would result in an appreciation in the USD spot rate. The only observation different from our baseline results is the effect of the CSD shock on the CIP measure. One possible explanation for the difference is that the risk-free rates are at one-year maturity, but other rates are at 5-year maturity. The maturity mismatch would affect our estimation results. In summary, the estimation results based on alternative risk free rates are consistent our main stylized facts and the key empirical findings on the dynamics of CSD, CYD and exchange rates, confirming the robustness of our findings.

5.6.2 Alternative Measures of CSD

We examine the robustness of CSD using four alternative measures in the regression 4. First, we add several extra controls to mitigate the potential omitting variables biases. The additional controls are the interaction terms between maturity buckets and rating buckets. We denote this CSD as "CSD with M*R". Second, we perform the tests on the sub-sample of non-US firms, which enables us to examine the validity of the USD-denomination effect for bonds issued only by non-US firms. We denote this CSD as "CSD with non-US". Third, we estimate the firm-level CSD and then take the average value as the aggregate-level CSD. We denote this CSD as "CSD with Firm Level". Lastly, we replace the government bond yield with the AAA corporate bond yield to calculate the credit spread of corporate bonds. [16] We denote this CSD as "CSD with AAA Yield". This is to address the concern that, given that both CSD and CYD depend on the government yield, the variation of government bond yield may drive the substitution effect between the two.

The CSD estimated with alternative methods move closely with the baseline CSD, as shown in Figure 23. We further examine the substitution effect using the alternative CSD measures and report the IRF of one negative unit of CDS shock to CYD in Figure 24. All results are consistent with the baseline results and demonstrate the substitution effect between dollar safe and risky assets.

6 Substitution Effect: Holdings-level Evidence

Based on the decomposition of the corporate basis, our early results suggest that there is a substitution effect between foreign investors' demand for dollar safe and risky assets. In this section, we investigate the holdings level evidences for the substitution effect.

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

[16] The AAA corporate bond yield is from Bloomberg and Markit. Due to the data available, we drop the sample with the CHF-denomination bonds.

investors in U.S. Treasuries and corporate bonds.

To measure the foreign investors' holdings of U.S. assets, we obtain the historical foreign investors' net purchases of U.S. assets from *Securities (A): U.S. Transactions with Foreign-Residents in Long-Term Securities.*[17] We proxy foreign investors' net purchases on USD corporate bonds using the column of *Corporate Bonds: U.S. Corporate Bonds (Long-term), Net Purchases*. Net purchase is the purchase net of the sales. We assume most U.S. corporate bonds are denominated in USD because of the dominant position of dollar bonds in the international market. We measure foreign investors' net purchases in U.S. Treasuries as the sum of *Treasury Bonds and Notes, Net Purchases* and *U.S. Treasury Bills, Net Purchases*. Moreover, we separate the foreign investors into foreign private investors and foreign sovereign investors. Our focus is on foreign investors' holdings of U.S. corporate bonds and Treasuries during two crisis periods: the 2008 financial crisis and the 2020 Covid pandemic periods.

Figure 25a shows the foreign private investors' substitution demand between dollar risky and safe assets during the 2008 Financial crisis period. Foreign private investors reduce their holdings of U.S. corporate bonds and increase their holdings of U.S. Treasury bonds in March 2008, the month when Bear Sterns collapsed due to large mortgage-related losses, and from July 2008 to November 2008, when the Financial crisis was at its worst. The financial crisis represents a typical period when the financial intermediaries suffer a negative shock to their balance sheets, and, consistent with our previous findings on the substitution effect between safe and risky dollar assets, foreign private investors purchase U.S. Treasuries and sell U.S. corporate bonds simultaneously. Foreign official investors, on the other hand, do not exhibit similar behavior.

We then look at the period around the Covid pandemic period. The U.S. and global financial markets took a heavy hit in March 2020, triggered by concerns regarding the pandemic. We find that foreign private investors have a significant outflow from U.S. Treasuries and a negligible inflow to the U.S. Corporate bonds in March 2020. The sharp outflow from the U.S. Treasuries is different from the behaviour of foreign investors during the 2008 GFC. Still, it is consistent with the stylized fact 2 that the U.S. Treasury premium has been declining since the 2008 GFC. During March 2020, U.S. Treasuries are no longer considered as as safe assets for foreign investors. This phenomenon is consistent with several stylized facts documented in the literature. Cesa-Bianchi and Eguren Martin (2021) document a "dash for dollar" phenomenon during the 2020 pandemic, in which investors in need of the U.S. dollar sold their bonds denominated in USD first. Ma, Xiao and Zeng (2020) show that during the 2020 Covid pandemic, mutual funds

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

followed a pecking order by first selling their liquid assets (such as U.S. Treasuries) to meet the sharp redemption pressure. Figure 25b shows the foreign official investor's net flows in dollar assets, which are similar to those for foreign private investors during the Covid period.

We further study the effect of a negative CSD shock on foreign private investors' net purchases of U.S. assets using the structural VAR analysis, and report the IRF in Figure 26. The top panel shows that a negative shock to CSD would result in a contemporaneously drop in foreign private investors' holdings of U.S. corporate bonds, but has an insignificant impact on their U.S. Treasuries holdings. The bottom panel further investigates the effect of an negative shock of CSD on foreign private investors' net bond flow on U.S. assets. The net bond flow is the difference between foreign private investors' net purchases of U.S. corporate bonds and U.S. Treasuries. One standard deviation (18.6) basis point decrease in CSD leads to a contemporaneous drop of around $6.88 billion in foreign investors' net bond flow on U.S. assets.

7 Conclusion

In this paper, we study the determinants of the corporate basis and investigate the effects of different financial shocks, especially shocks to financial intermediaries' balance sheets, on the dynamics of corporate basis, exchange rates and economic activities. We decompose the corporate basis into three components, credit spread differential, convenience yield differential, and the CIP deviation, which reflect, respectively, the risky asset demand, the safe asset demand, and the FX hedging cost. Our decomposition reveals three stylized facts of the corporate basis: a strong substitution effect between safe and risky assets, a declining US Treasury premium since the 2008 financial crisis, and a negative correlation between CIP deviation and credit spread differential. Using shocks to financial intermediaries' balance sheet constraints as the instrument variable, we find that a negative shock to credit spread differential results in a substitution between safe and risky assets, an appreciation of the USD, negative returns in the equity and commodity market, and deterioration in both U.S. and non-U.S. economy activities. Lastly, we provide holdings-level evidences consistent with the substitution effect between foreign investors' demand on dollar safe and risky assets.

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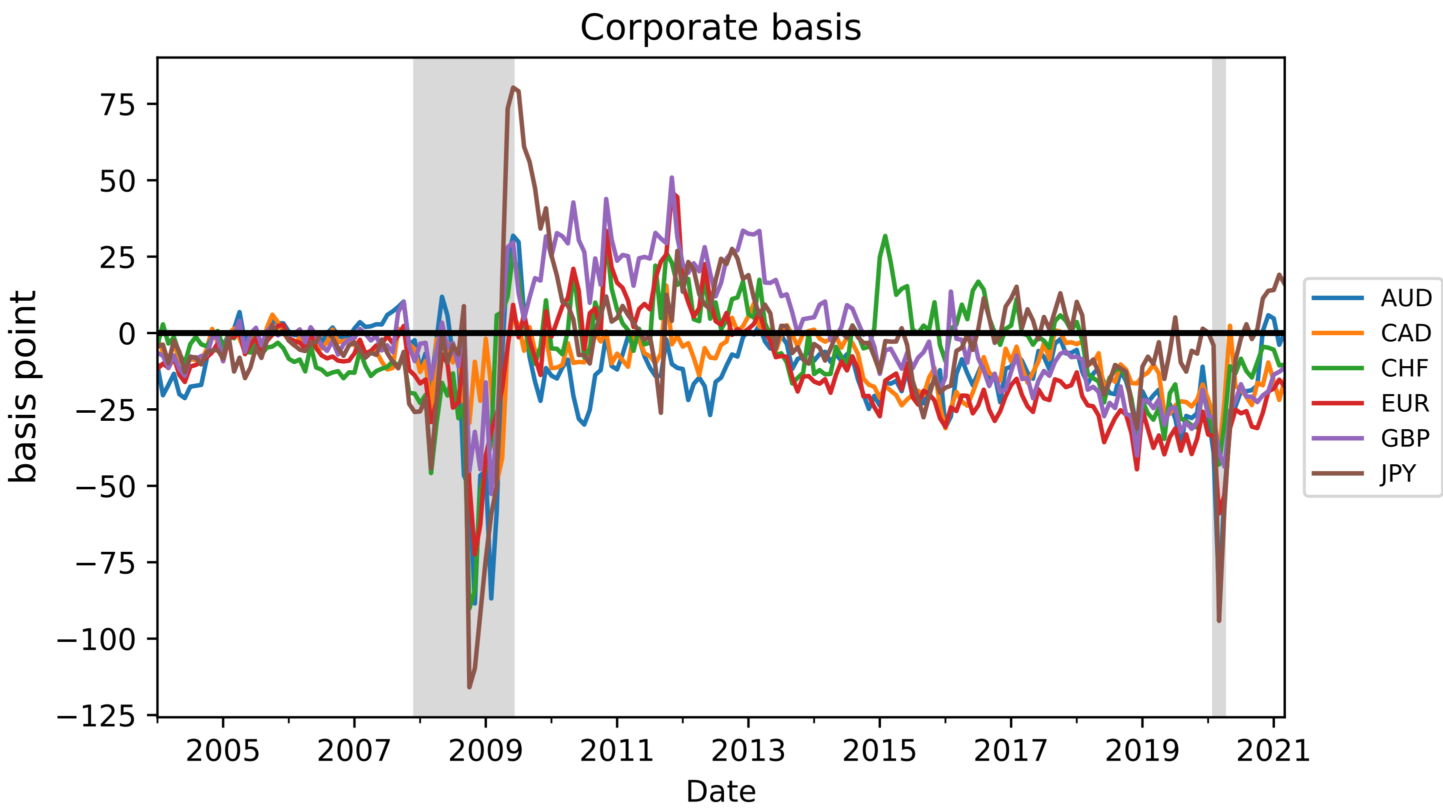
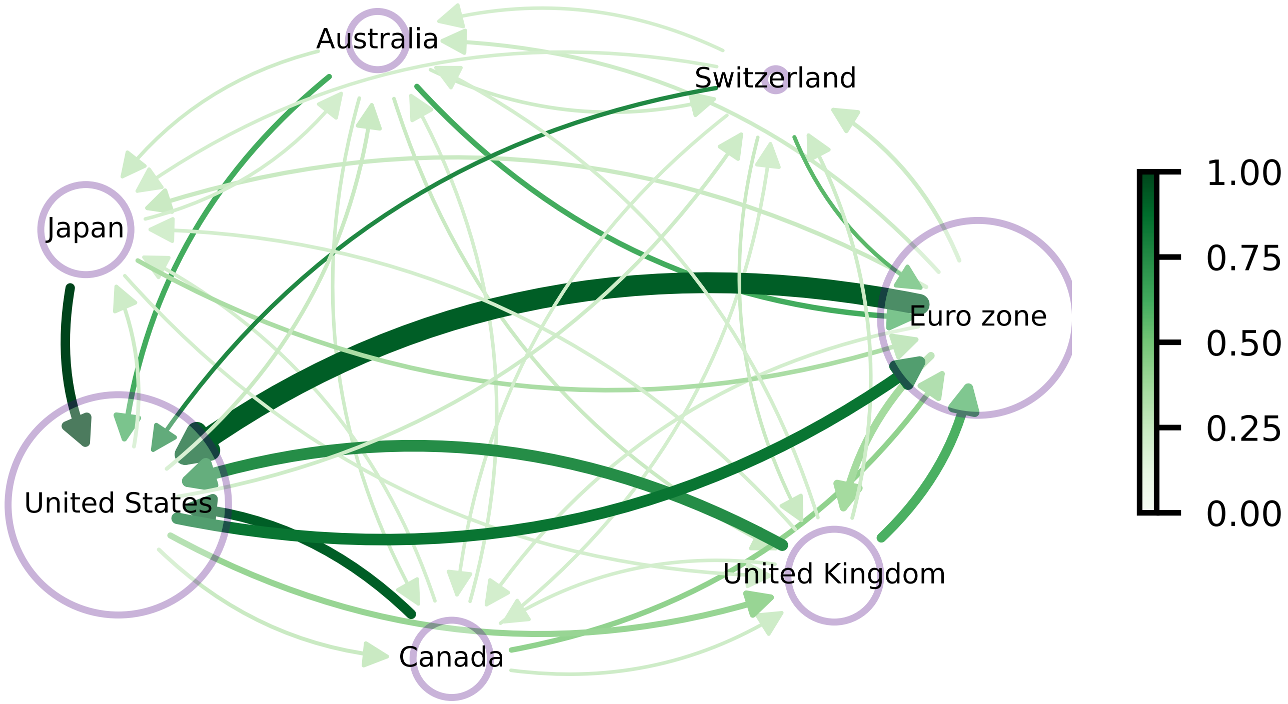
Figure 1: The Corporate Basis



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

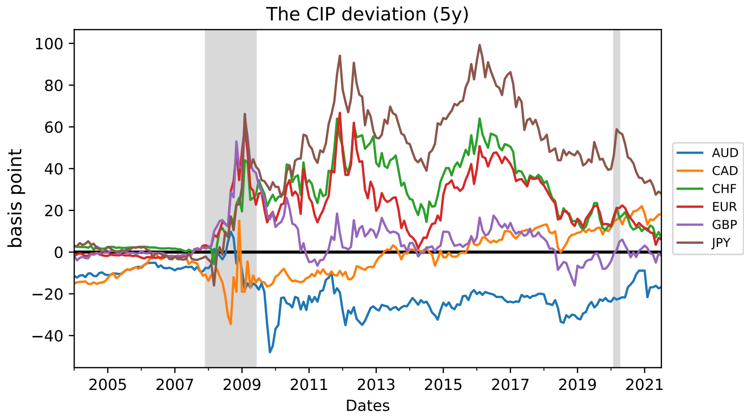
Figure 2: Cross-border Bond Issuance



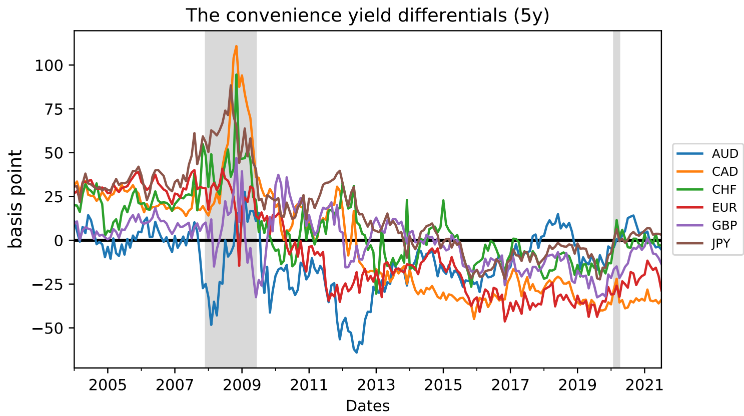
This figure presents the cross-border issuance of corporate bonds with currency denominations in AUD, CAD, CHF, EUR, GBP, JPY, and USD, based on the bond outstanding data in March 2021. Purple circles depicts the total notional principal of outstanding bonds issued by the domestic firms. Green arrows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

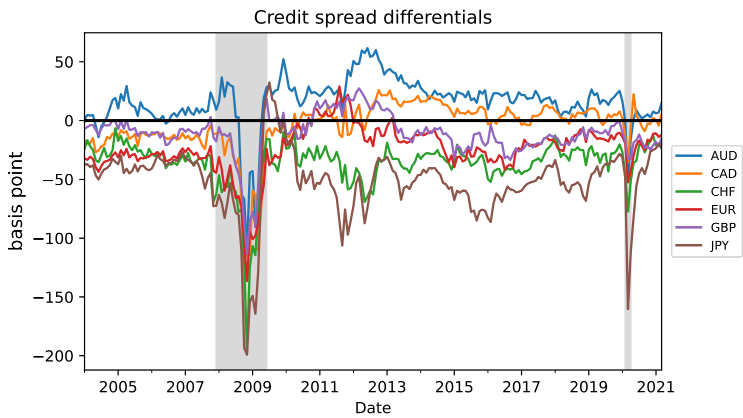
(a) CIP Deviations



(b) Convenience Yields Differentials

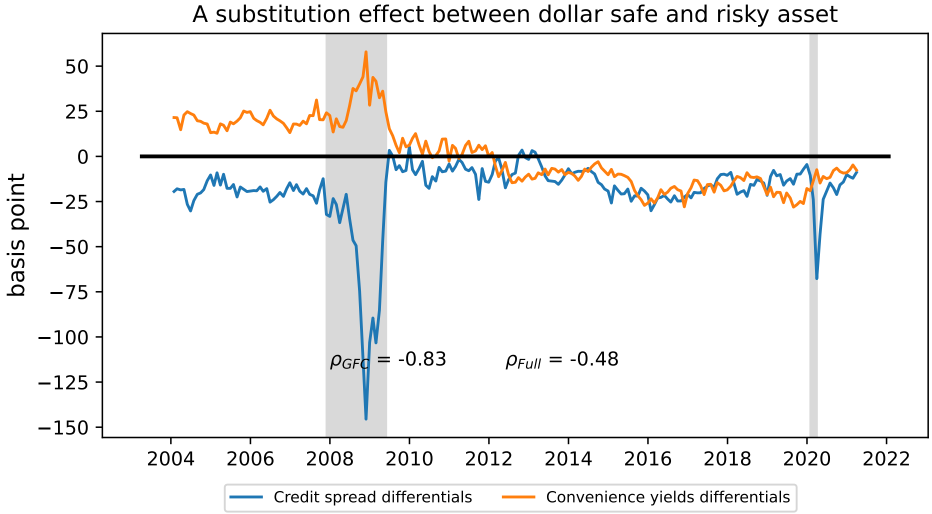


(c) Credit Spread Differentials



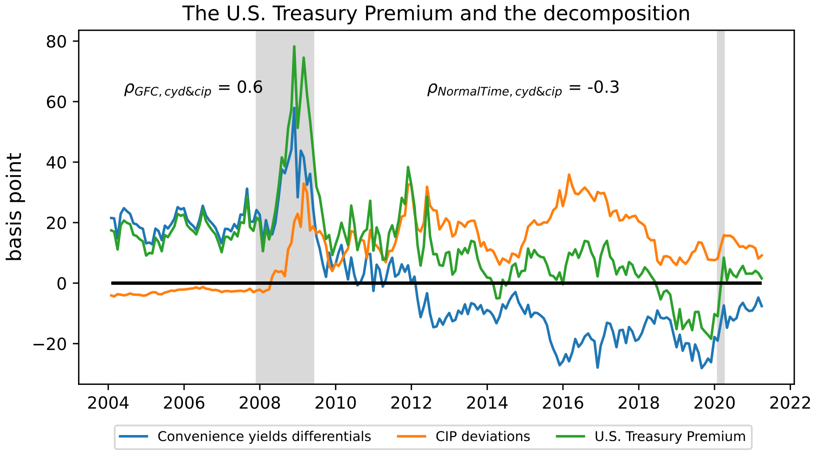
This figure presents the CSD, CYD (5-year maturity) and CIP (5-year maturity) which are estimated based on Eqs. (4) and (3). The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 4: Fact 1: A Substitution Effect Between safe dollar and Risky Asset (Mean)



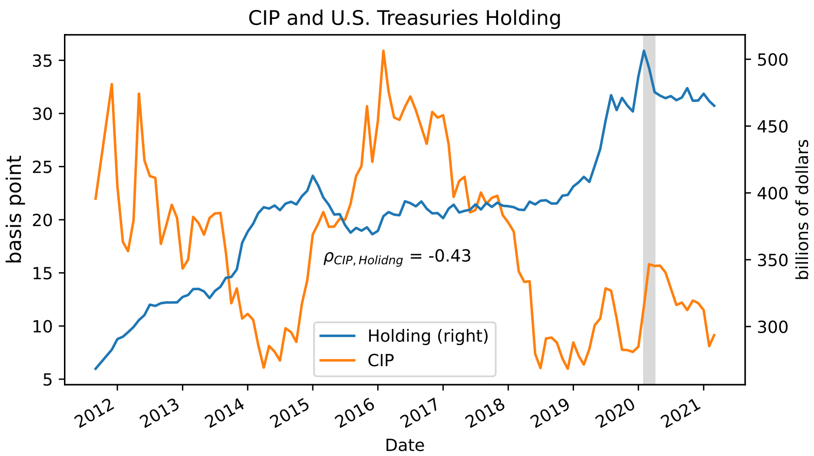
This figure presents the mean value of CSD and CYD from January 2004 to March 2021 with a negative correlation during the GFC (-0.83) and full time (-0.48). Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 5: Facts 2: A Diminishing of U.S. Treasury Premium (Mean)



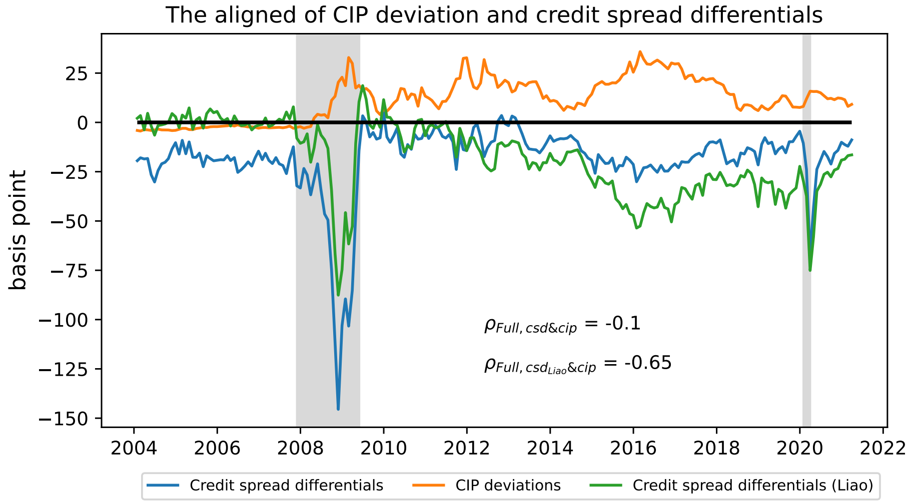
The figure presents the mean value of the CSD, CIP and U.S. Treasury premium (CSD + CIP). The correlation between CYD and CIP is 0.6 during the GFC but is -0.3 after the GFC before the Covid-19. All variables are with 5-year maturity. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 6: CIP and Foreign Residents' Holding on U.S. Treasuries (Mean)



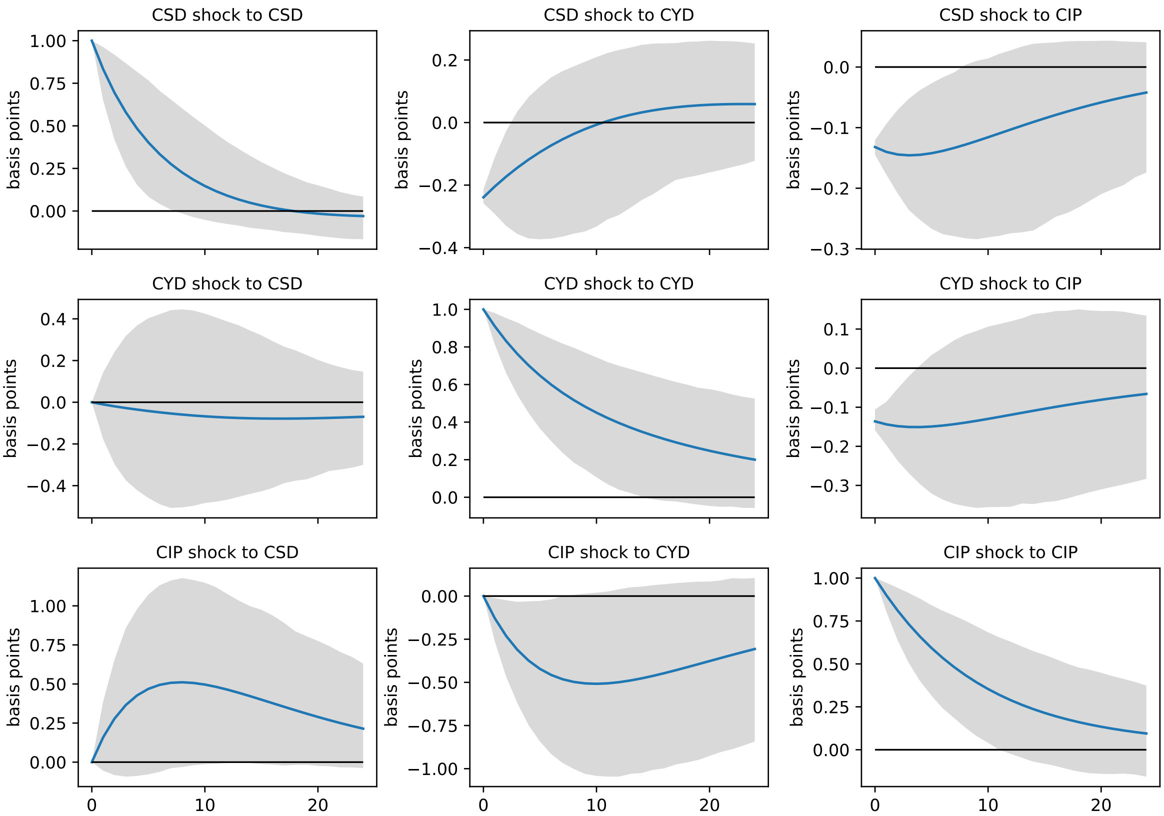
The figure presents the mean value of CIP and foreign residents' holding on U.S. Treasuries. For holding data, I use the countries that correspond to the currencies (AUD, CAD, CHF, EUR, GBP and JPY). The full sample correlation between CIP and holding is -0.43. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 7: F3: The Aligned of CIP and CSD (Mean)



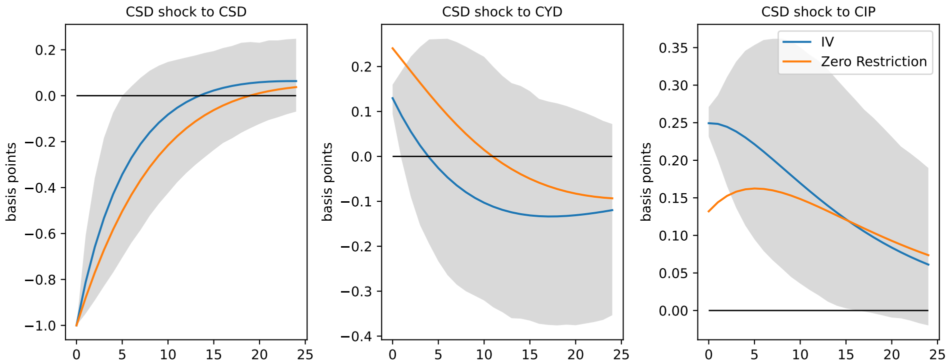
This figure presents the mean value of CSD, CIP and CSD_{Liao} (as CSD + CIP) from January 2004 to March 2021. The CIP has a highly negative correlation with CSD_{Liao} (-0.65) but a weaker correlation with CSD (-0.1). Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

Figure 8: IRF of SAVR Model (Mean)



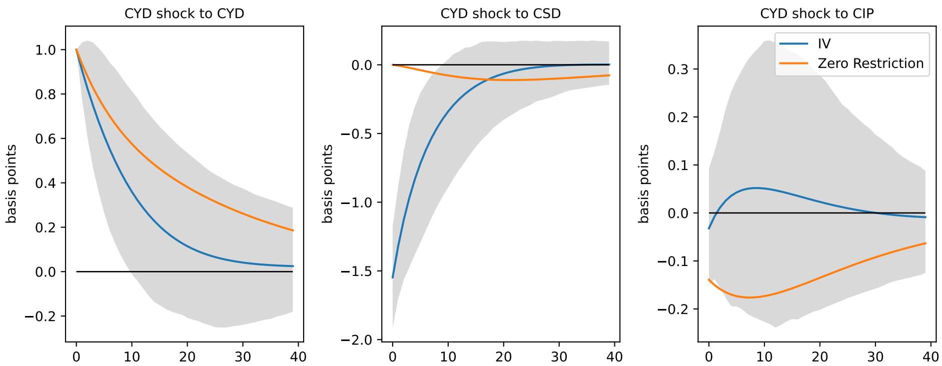
This figure presents the impulse response function (IRF) of one unit corresponding shock to each variable. The plots are based on 1,000 wild bootstraps. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with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

Figure 9: IRF of the CSD Shock (Mean)



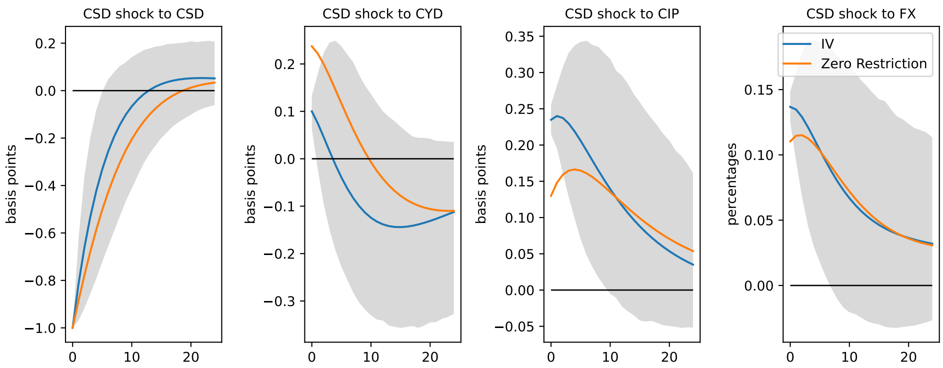
This figure presents the impulse response function (IRF) of one unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands.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

Figure 10: IRF of the CYD Shock (Mean)



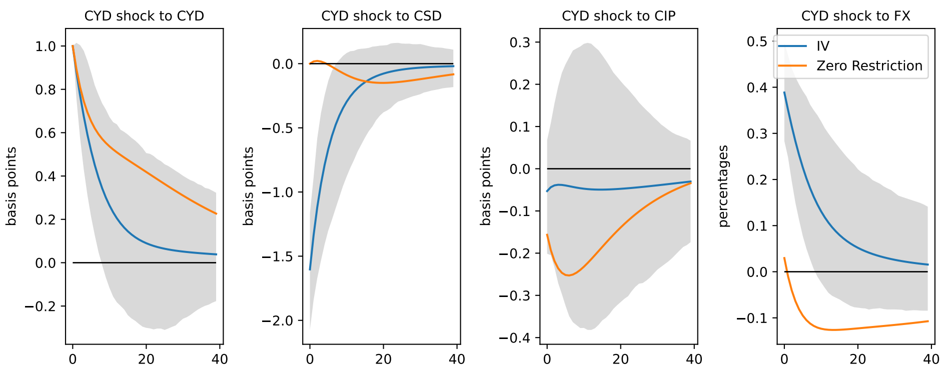
This figure presents the impulse response function (IRF) of one unit CYD shock to each variable. The plots are based on 1,000 wild bootstraps with the monetary policy shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January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

Figure 11: IRF of the CSD Shock with the FX Market (Mean)



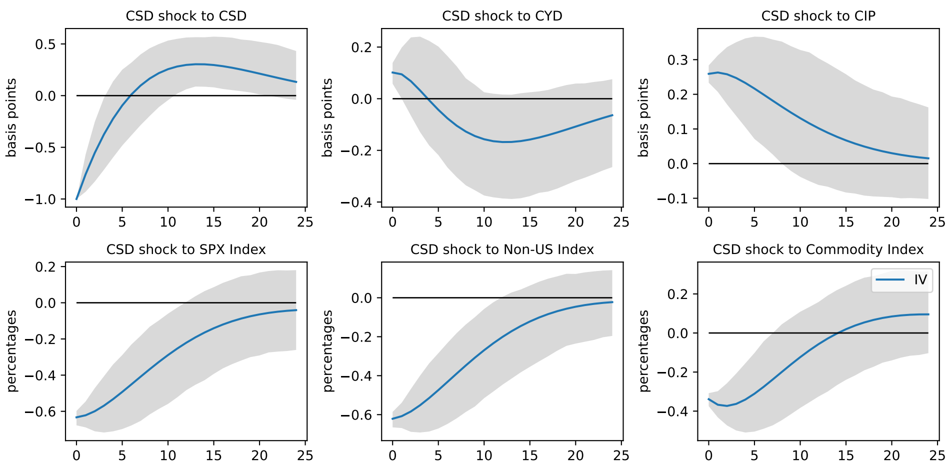
This figure presents the impulse response function (IRF) of one unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands.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

Figure 12: IRF of the CYD Shock with the FX Market (Mean)



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

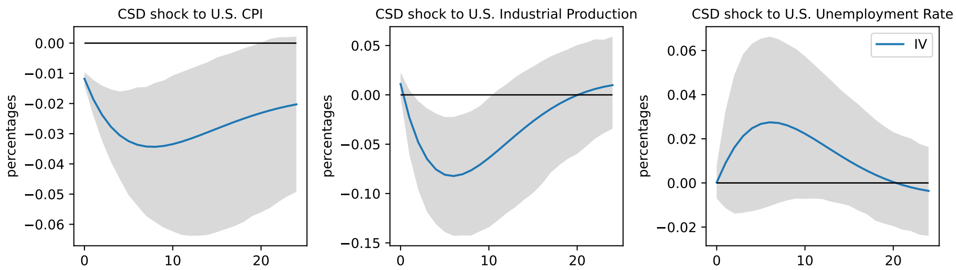
Figure 13: IRF of the CSD Shock with the Other Assets Classes (Mean)



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

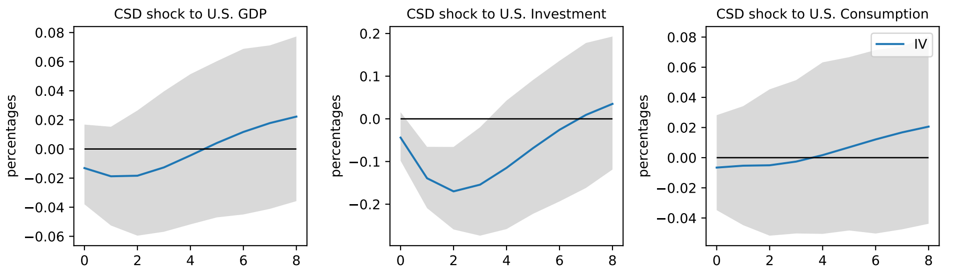
Figure 14: IRF of the CSD Shock with the U.S. Macroeconomic Activity (Mean)

(a) Monthly Variables



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

(b) Quarterly Variables

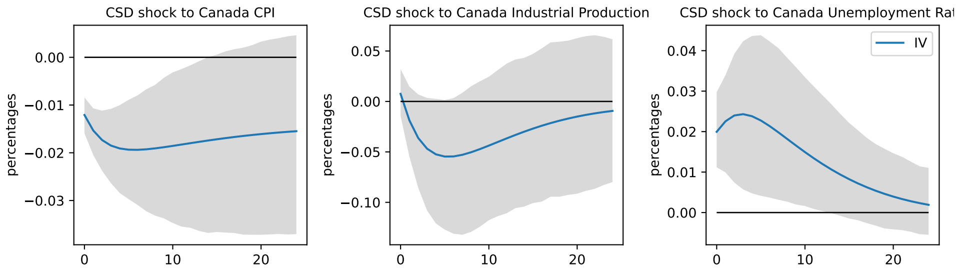


First stage regression: Coefficient: 49.89; F-statistics: 36.79; R^2: 0.36.

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

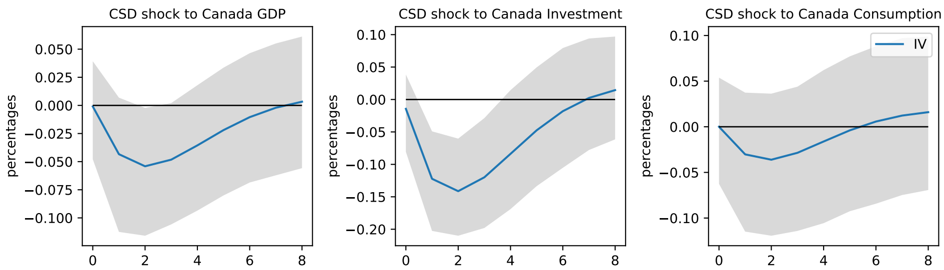
Figure 15: IRF of the CSD Shock with the Canada Macroeconomic Activity (CAD)

(a) Monthly Variables



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

(b) Quarterly Variables

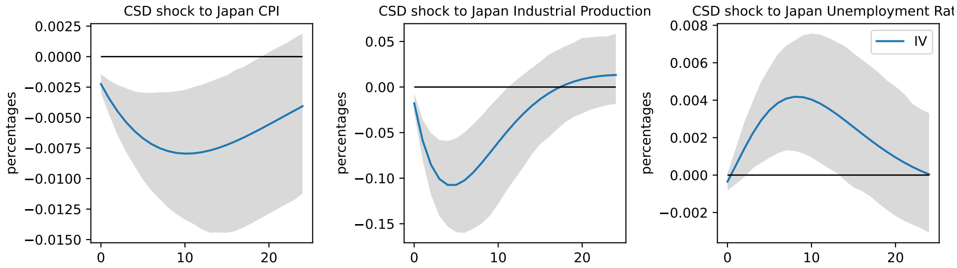


First stage regression: Coefficient: 43.29; F-statistics: 26; R^2: 0.28.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the CAD data of CSD, CYD, CIP, 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.

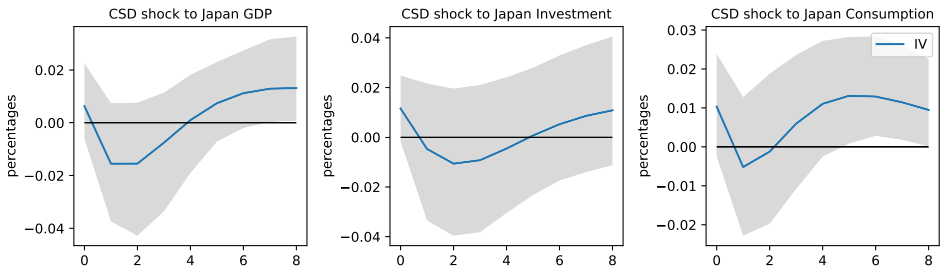
Figure 16: IRF of the CSD Shock with the Japan Macroeconomic Activity (JPY)

(a) Monthly Variables



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

(b) Quarterly Variables

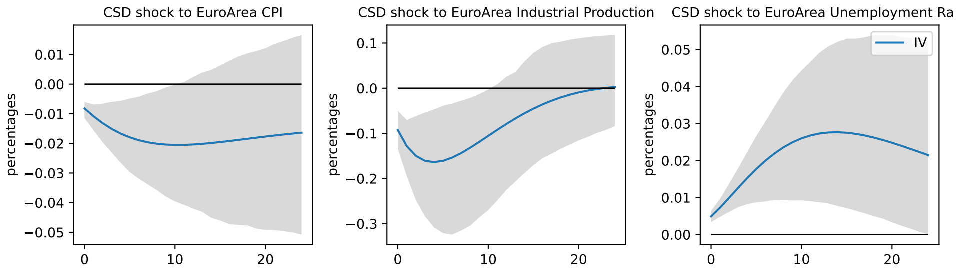


First stage regression: Coefficient: 98.9; F-statistics: 58.96; R^2: 0.47.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the JPY data of CSD, CYD, CIP, 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.

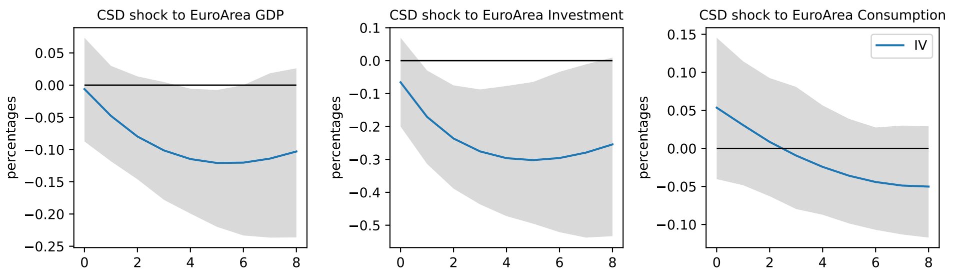
Figure 17: IRF of the CSD Shock with the Euro Area Macroeconomic Activity (EUR)

(a) Monthly Variables



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

(b) Quarterly Variables

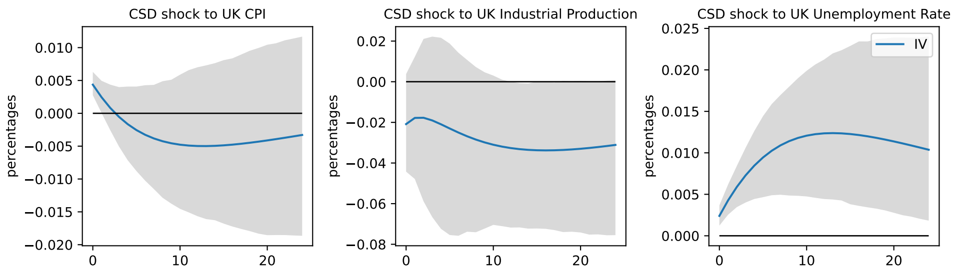


First stage regression: Coefficient: 26.43; F-statistics: 11.30; R^2: 0.15.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the EUR data of CSD, CYD, CIP, 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.

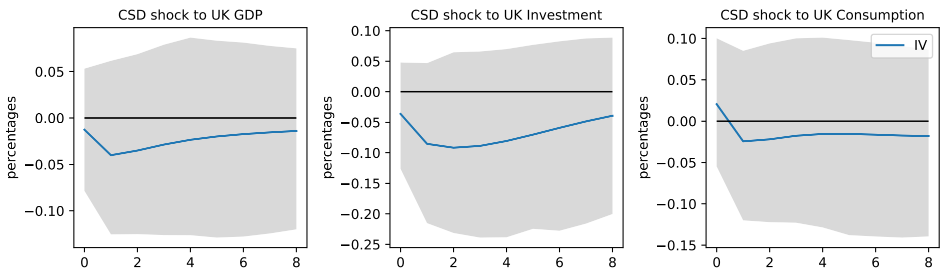
Figure 18: IRF of the CSD Shock with the UK Macroeconomic Activity (GBP)

(a) Monthly Variables



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

(b) Quarterly Variables

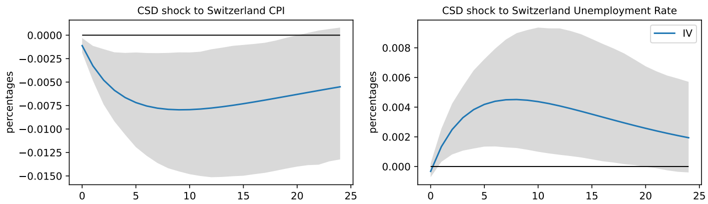


First stage regression: Coefficient: 37.45; F-statistics: 13.78; R^2: 0.18.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the GBP data of CSD, CYD, CIP, 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.

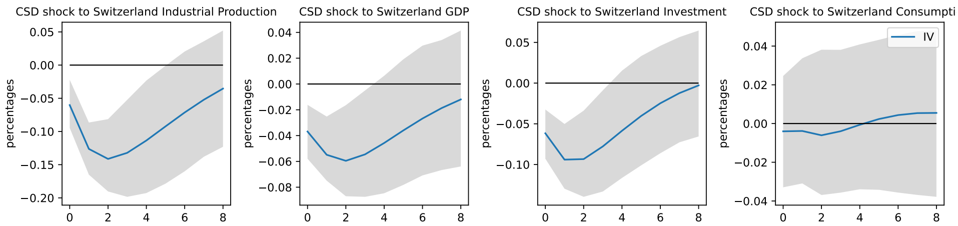
Figure 19: IRF of the CSD Shock with the Switzerland Macroeconomic Activity (CHF)

(a) Monthly Variables



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

(b) Quarterly Variables

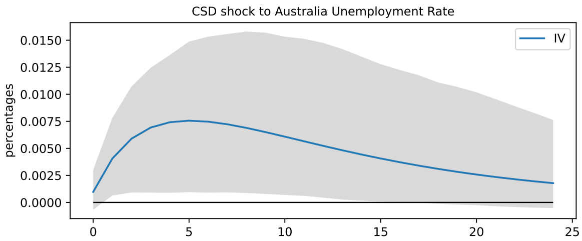


First stage regression: Coefficient: 53.08; F-statistics: 27.6; R^2: 0.29.

This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the CHF data of CSD, CYD, CIP, 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.

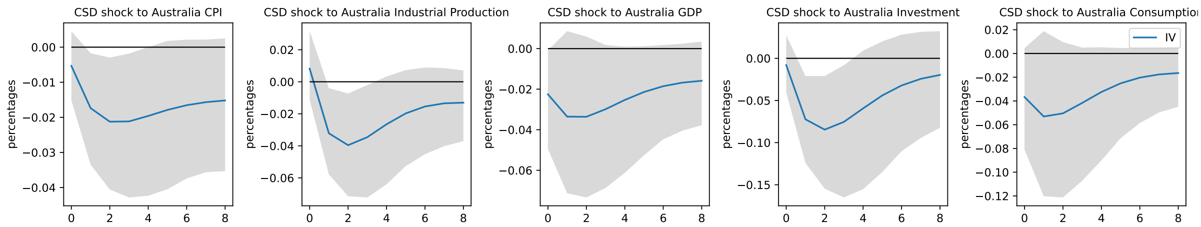
Figure 20: IRF of the CSD Shock with the Australia Macroeconomic Activity (AUD)

(a) Monthly Variables



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

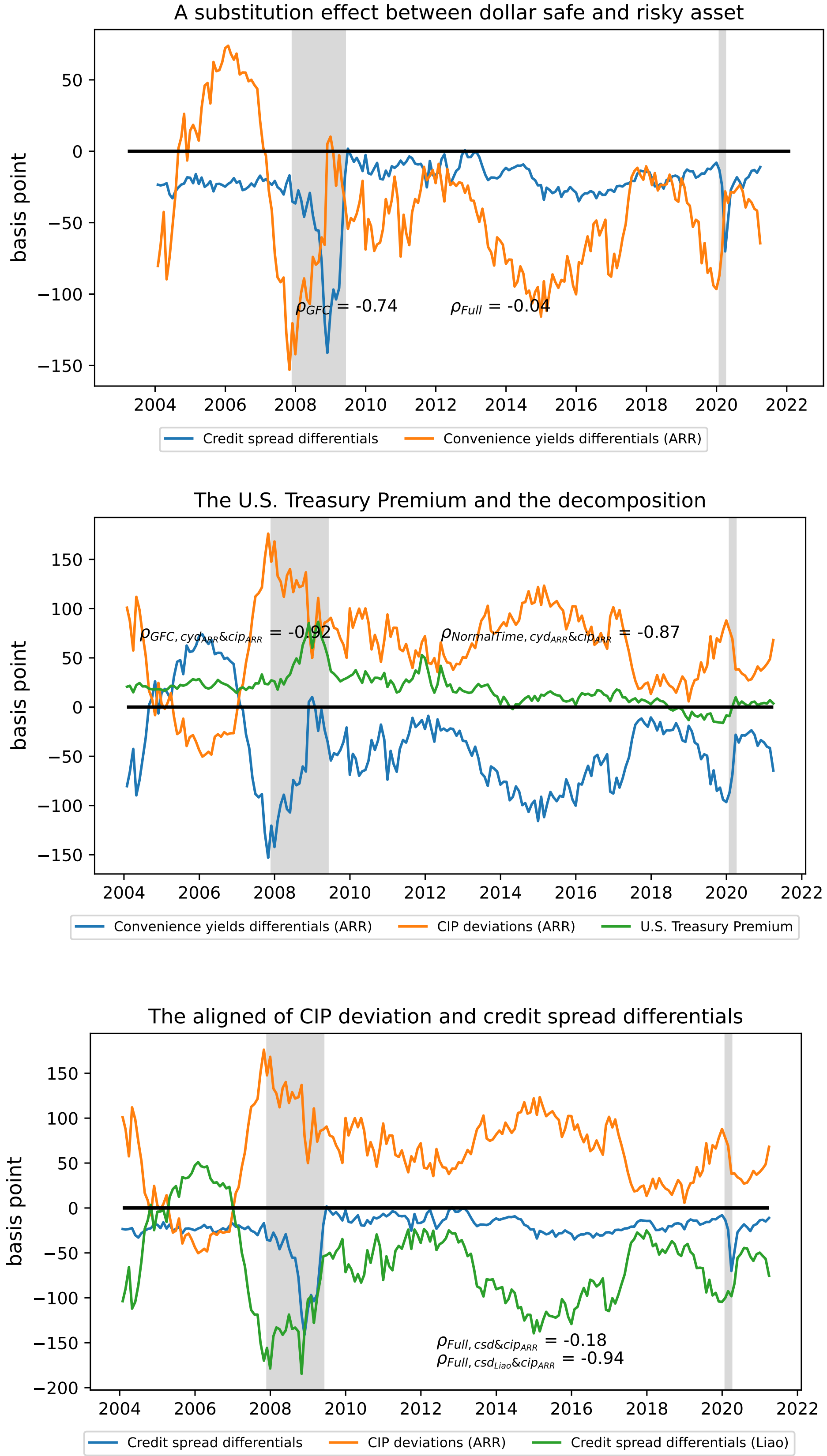
(b) Quarterly Variables



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

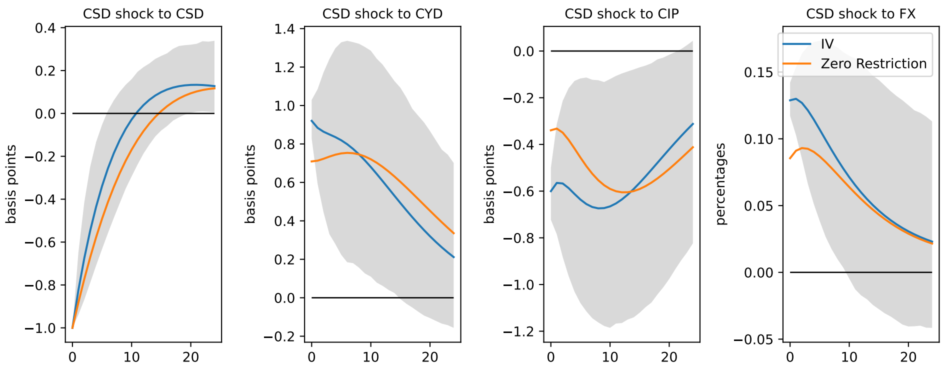
This figure presents the impulse response function (IRF) of one (negative) unit CSD shock to each variable. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021 with the AUD data of CSD, CYD, CIP, 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.

Figure 21: Stylized Facts using Alternative Risk-Free Rates (ARR) (Mean)

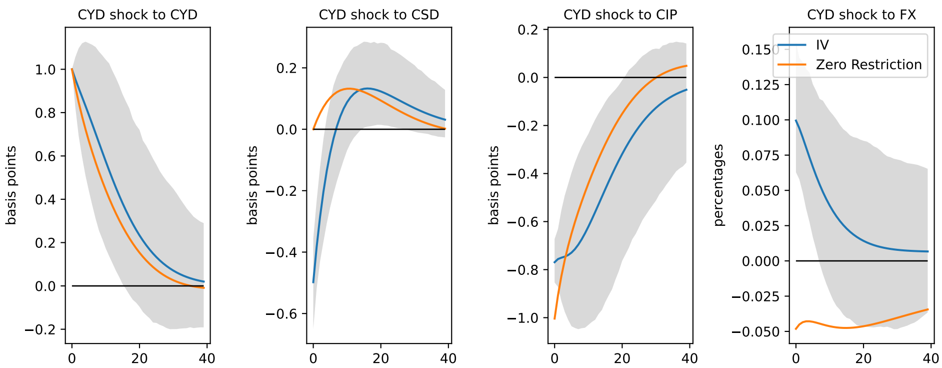


The figure redraws the three stylized facts figures with the CYD_{ARR} and CIP_{ARR}. The sample is from January 2004 to March 2021 with the currency of CAD, EUR, GBP and JPY. The shadow areas indicate the recession period of the GFC and Covid-19 based on NBER business cycle dates, respectively.

Figure 22: SVAR Model Analysis using Alternative Risk-Free Rates (ARR) (Mean)



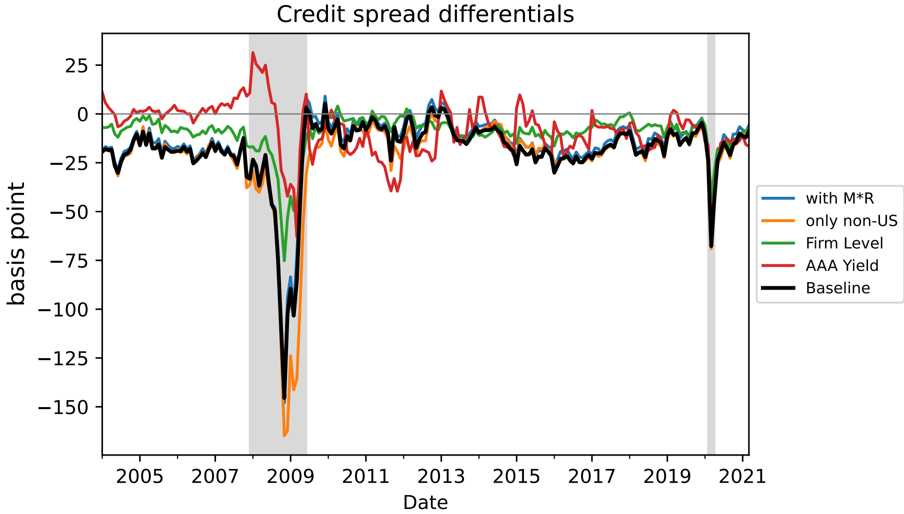
First stage regression: Coefficient: 67.53; F-statistics: 92.50 ; R^2: 0.32.



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

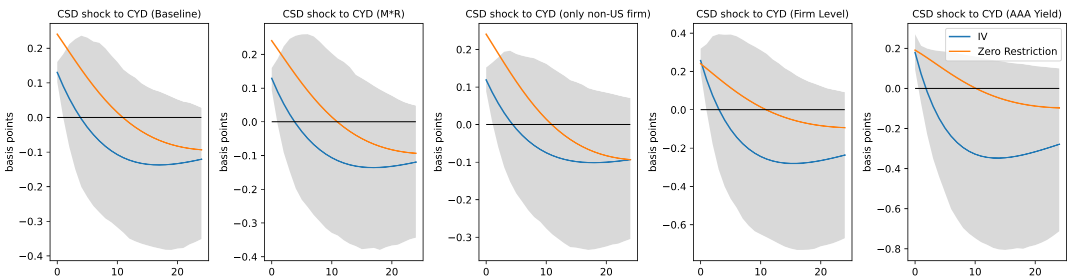
The figure redraws the SVAR model analysis with the ARR. The IVs are the financial intermediaries' balance sheet constraints shock and monetary policy shock for CSD shock and CYD shock, respectively. The sample is from January 2004 to March 2021 with the currency of CAD, EUR, GBP and JPY.

Figure 23: Alternative Measurement of CSD



The figure compares the baseline CSD with four alternative measures. The baseline CSD is the black line. The label "with M*R" line shows the alternative CSD, which adds the interaction terms between maturity buckets and rating buckets into cross-section regression. The label "only non-US" line shows the alternative CSD, which only uses the non-US firms' sample. The label "Firm Level" line shows the CSD, which takes the mean value of firm-level CSD. The label "AAA yield" line shows the CSD, which calculates the corporate bond credit spread as the bond yield net of the AAA bond yield. The sample period ranges from January 2004 to March 2021. Shaded bars denote months designated as recessions by the National Bureau of Economic Research.

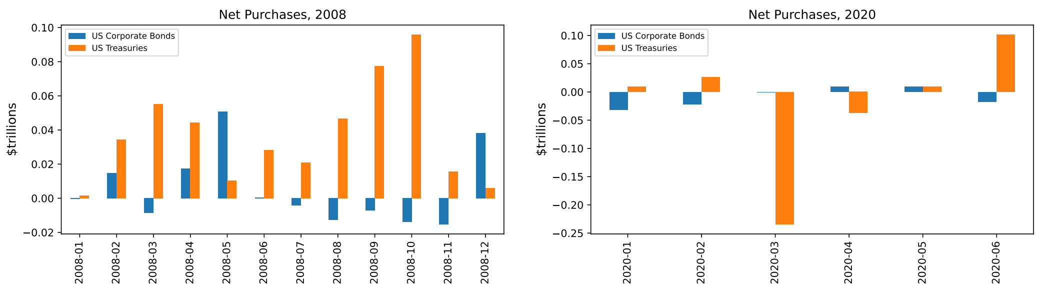
Figure 24: SVAR Model Analysis with Alternative Measurement of CSD (Mean)



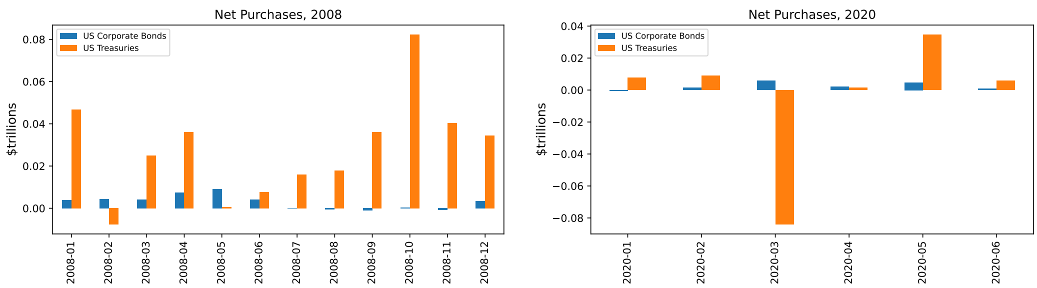
The figure compares the substitution effect between CSD and CYD when using the baseline and alternative CSD. Each sub-figure shows the impulse response functions (IRF) of one (negative) unit CSD shock to CYD. The plots are based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The monthly sample is from January 2004 to March 2021.

Figure 25: Foreign Investors' Net Purchases of U.S. Assets

(a) Foreign Private Investors



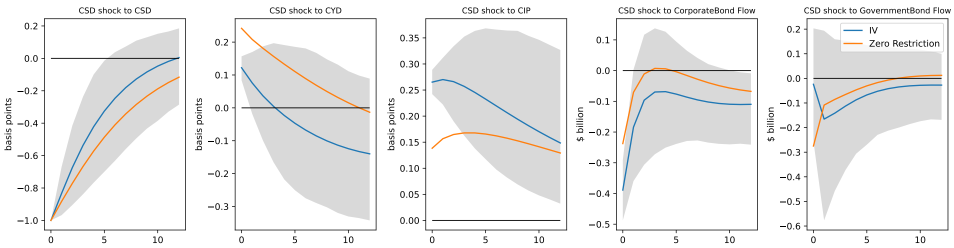
(b) Foreign Official Investors



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

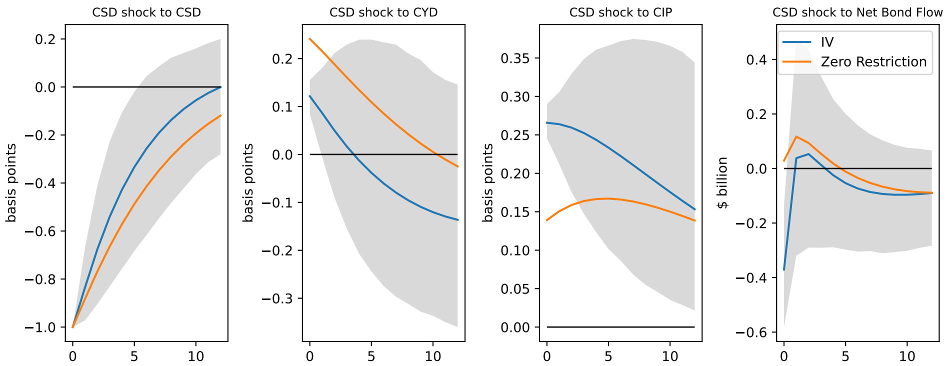
Figure 26: SVAR Model Analysis with the Foreign Private Investors' Net Purchases of U.S. Bonds (Mean)

(a) Effect on U.S. Corporate Bond and U.S. Treasuries



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

(b) Effect on Net U.S. Bond Flow



First stage regression: Coefficient: 67.99; F-statistics: 89.03; 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 financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021, with the mean value of CSD, CYD, and CIP, as well as foreign private investors' net purchases of U.S. corporate bonds and U.S. Treasuries. The net bond flow is the difference between private investors' net purchases of U.S. corporate bonds and U.S. Treasuries.

Table 1: Corporate Bond Information - Currency Level

	No.	**Notl. $bil**	**No. Firms**		**No.**	**Notl. $bil**	**No. Firms**
All				**USD**			
Total	7189.6	5399.8	1438.0	Total	2,890.9	2,581.9	828.5
Rating				**Rating**			
AAA&AA	2174.6	1849.9	278.4	AAA&AA	662.0	771.4	148.6
A	2843.7	1967.1	514.5	A	1,058.6	906.2	273.8
BBB	1743.8	1279.4	488.6	BBB	884.9	701.8	278.2
HY (BB and below)	427.6	303.5	187.7	HY (BB and below)	285.4	202.5	140.4
Maturity				**Maturity**			
1-3 yrs	1809.5	1457.2	730.5	1-3 yrs	754.6	713.5	391.1
3-7 yrs	2819.3	2234.9	975.1	3-7 yrs	1096.8	998.3	538.0
7-10 yrs	1229.4	909.4	584.4	7-10 yrs	513.6	455.0	325.2
10+ yrs	1331.4	798.4	448.3	10+ yrs	526.0	415.1	229.2
% by Foreign Firms				**% by Foreign Firms**	39.2%	42.6%	50.8%
AUD				**CAD**			
Total	251.6	78.4	93.8	Total	280.6	115.1	94.8
Rating				**Rating**			
AAA&AA	166.6	58.5	45.8	AAA&AA	81.3	36.7	30.8
A	59.6	14.1	32.3	A	98.2	41.8	33.0
BBB	24.3	5.6	15.3	BBB	96.8	35.3	28.6
HY (BB and below)	1.2	0.2	0.9	HY (BB and below)	4.4	1.3	2.9
Maturity				**Maturity**			
1-3 yrs	90.1	25.5	53.7	1-3 yrs	74.0	33.8	45.7
3-7 yrs	110.9	36.6	60.2	3-7 yrs	102.1	50.4	58.3
7-10 yrs	39.5	11.7	26.7	7-10 yrs	34.3	13.0	25.2
10+ yrs	11.0	4.6	7.7	10+ yrs	70.3	17.8	29.1
% by Foreign Firms	57.4%	47.8%	58.4%	**% by Foreign Firms**	16.1%	14.0%	27.8%
CHF				**EUR**			515.4
Total	294.4	69.3	131.1	Total	1,702.7	1,915.0	118.3
Rating				**Rating**			
AAA&AA	156.7	35.0	54.8	AAA&AA	507.1	732.4	193.6
A	96.4	23.5	49.0	A	657.4	687.6	159.5
BBB	37.2	9.6	24.9	BBB	445.9	416.1	51.7
HY (BB and below)	4.2	1.2	3.0	HY (BB and below)	92.3	78.9	12.2
Maturity				**Maturity**			
1-3 yrs	85.9	21.5	66.8	1-3 yrs	438.5	526.3	259.3
3-7 yrs	139.3	33.3	85.5	3-7 yrs	784.6	908.2	361.8
7-10 yrs	42.2	9.6	31.7	7-10 yrs	290.8	320.2	175.2
10+ yrs	27.1	4.9	17.7	10+ yrs	188.9	160.3	103.9
% by Foreign Firms	88.6%	82.9%	89.0%	**% by Foreign Firms**	32.4%	30.4%	43.7%
GBP				**JPY**			
Total	479.0	295.9	246.2	Total	1,290.3	344.2	135.2
Rating				**Rating**			
AAA&AA	174.4	92.0	71.6	AAA&AA	426.5	123.9	41.1
A	162.0	114.1	85.4	A	711.5	179.8	67.2
BBB	128.5	82.0	82.4	BBB	126.3	29.0	23.9
HY (BB and below)	14.1	7.8	10.1	HY (BB and below)	26.1	11.5	4.8
Maturity				**Maturity**			
1-3 yrs	91.6	50.4	71.0	1-3 yrs	275.0	86.0	85.5
3-7 yrs	136.2	78.4	103.3	3-7 yrs	449.4	129.5	99.7
7-10 yrs	62.2	40.5	55.7	7-10 yrs	246.9	59.4	64.6
10+ yrs	189.0	126.5	115.5	10+ yrs	319.1	69.3	35.4
% by Foreign Firms	59.3%	59.1%	55.9%	**% by Foreign Firms**	9.0%	10.9%	37.5%

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

Table 2: Variance Decomposition of Corporate Basis Movement

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

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

Table 3: Summary Statistics of CIP, CYD and CSD

		Full Sample	**Jan 04 to Nov 07**	**Dec 07 to May 09**	**Jun 09 to Mar 21**
			CIP		
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]
CHF	Mean	24.51***	1.95***	15.50***	33.12***
	SEs	[1.26]	[0.09]	[3.26]	[1.2]
EUR	Mean	19.82***	-1.49***	24.30***	26.31***
	SEs	[1.14]	[0.17]	[4.34]	[1.05]
GBP	Mean	5.89***	-0.75***	26.40***	5.49***
	SEs	[0.79]	[0.18]	[4.65]	[0.72]
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]
CHF	Mean	6.56***	21.83***	43.47***	-3.17***
	SEs	[1.35]	[1.28]	[3.65]	[1.02]
EUR	Mean	-5.55***	30.67***	25.60***	-21.49***
	SEs	[1.87]	[0.61]	[2.84]	[1.22]
GBP	Mean	-0.74	7.58***	8.65**	-4.69***
	SEs	[1.03]	[0.61]	[4.2]	[1.27]
JPY	Mean	15.81***	35.08***	61.13***	3.69***
	SEs	[1.63]	[1.14]	[2.65]	[1.28]
Average	Mean	0.55	19.88***	31.16***	-9.73***
	SEs	[1.25]	[0.55]	[2.83]	[0.83]
			CSD		
AUD	Mean	16.03***	7.64***	-15.61	22.82***
	SEs	[1.51]	[1.16]	[10.97]	[1.23]
CAD	Mean	-4.42***	-14.51***	-51.59***	4.90***
	SEs	[1.49]	[0.68]	[8.75]	[0.81]
CHF	Mean	-36.45***	-29.18***	-78.40***	-33.55***
	SEs	[1.42]	[1.38]	[9.63]	[0.96]
EUR	Mean	-24.20***	-30.81***	-70.35***	-16.16***
	SEs	[1.46]	[0.67]	[6.59]	[1.15]
GBP	Mean	-11.43***	-8.47***	-42.63***	-8.45***
	SEs	[1.28]	[0.75]	[8.39]	[1.19]
JPY	Mean	-52.20***	-39.53***	-99.23***	-50.42***
	SEs	[2.07]	[1.13]	[12.9]	[2.01]
Average	Mean	-18.78***	-19.14***	-59.64***	-13.48***
	SEs	[1.29]	[0.67]	[8.99]	[0.75]
N		207	47	18	142

The table reports the mean (Mean), White heteroscedasticity-robust standard errors (SEs) and number of observations (N) of CSD, CYD (5-year maturity) and CIP (5-year maturity), which are estimated based on the equation 4 and equation 3. The full sample is monthly from January 2004 to March 2021. The sub-periods are Pre-GFC (Jan 2004 to November 2007), GFC (December 2007 to May 2009) and post-GFC (June 2009 to March 2021). *** p<0.01, ** p<0.05, * p<0.1.

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

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

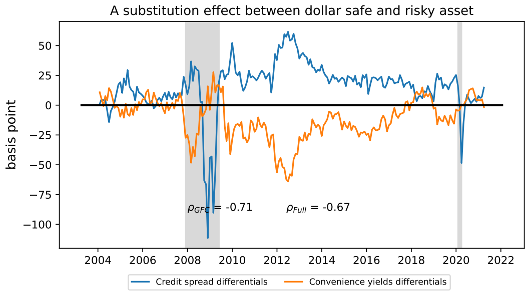
The table reports the regression results in which the dependent variable is the monthly change in the log of the spot USD exchange rate against a basket. The independent variables include the corporate basis (Ψ), U.S. Treasury premium, CSD, CYD and CIP in Mean, and we use the simple change as the innovation.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

Appendix

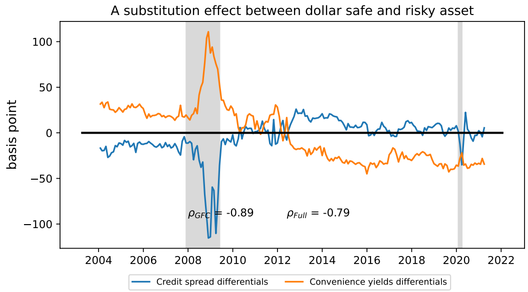
A Stylized Facts

Figure A.1: A substitution effect between dollar safe and risky asset

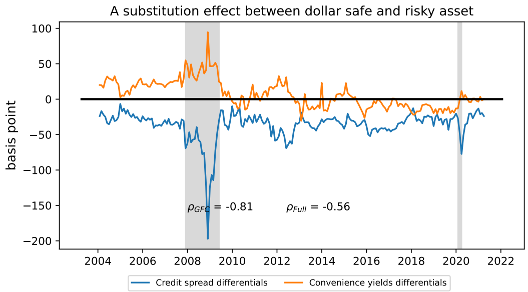
(a) AUD



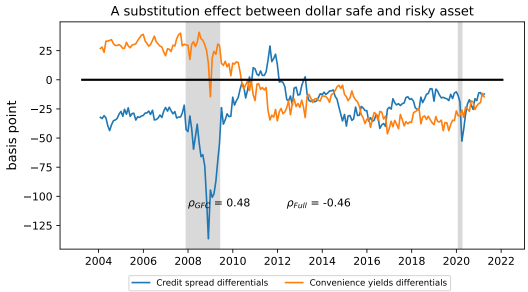
(b) CAD



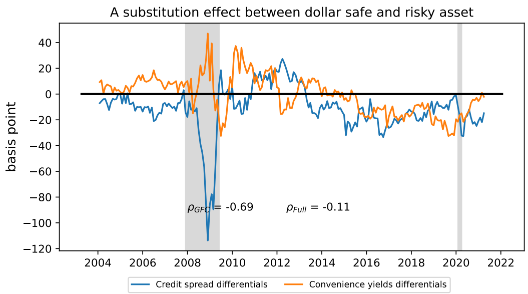
(c) CHF



(d) EUR



(e) GBP



(f) JPY

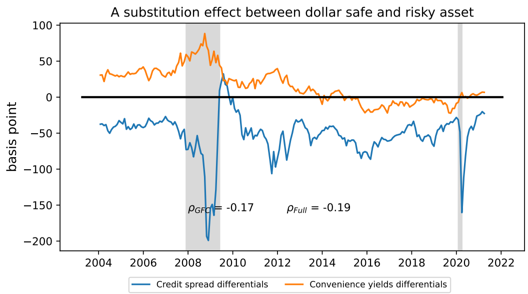
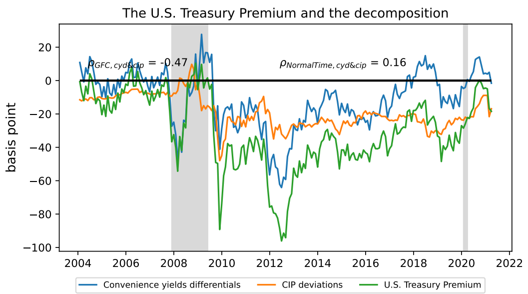
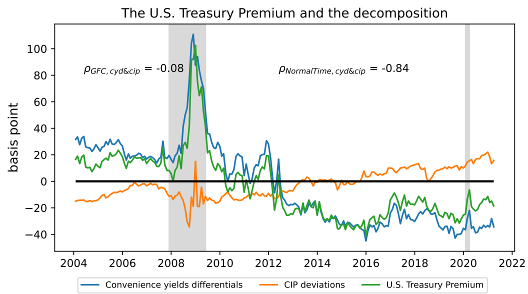


Figure A.2: A diminishing of U.S. treasury premium

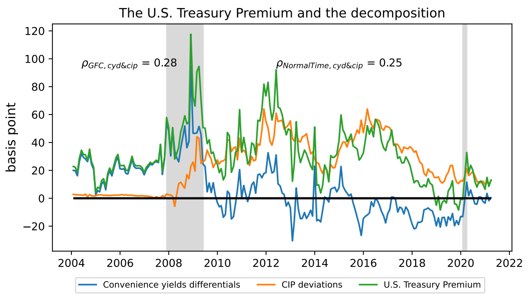
(a) AUD



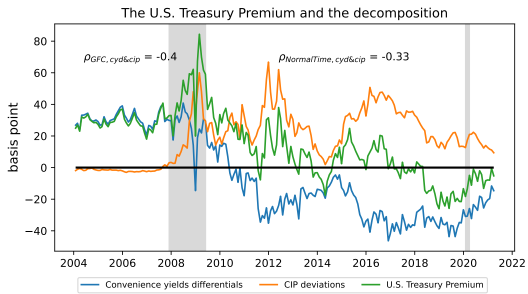
(b) CAD



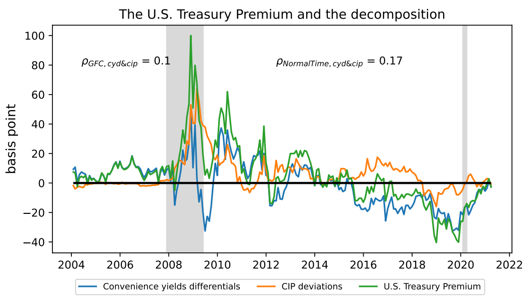
(c) CHF



(d) EUR



(e) GBP



(f) JPY

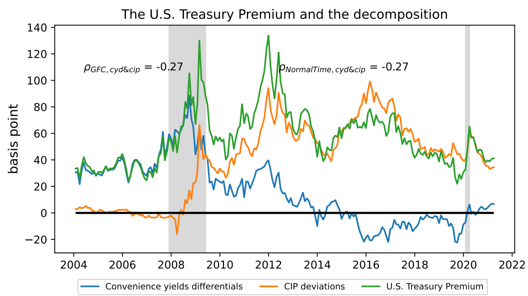
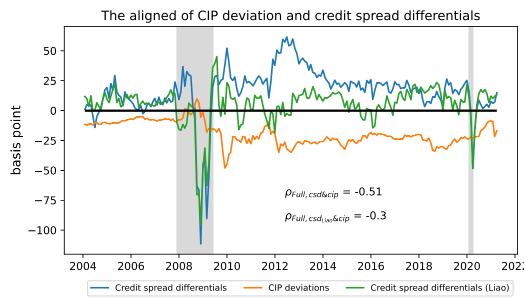
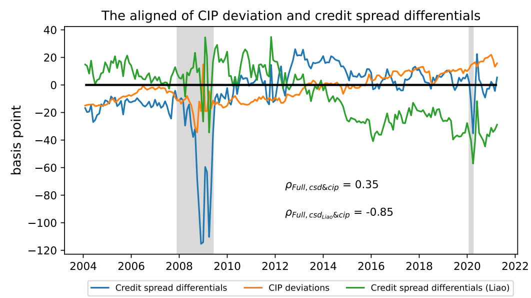


Figure A.3: The aligned of CIP deviation and credit spread differentials

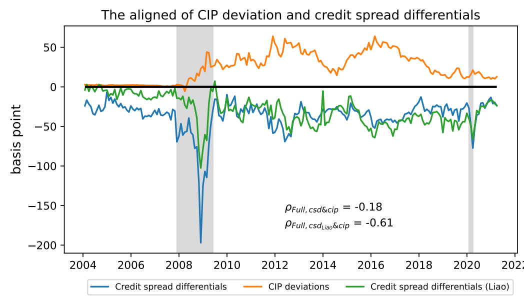
(a) AUD



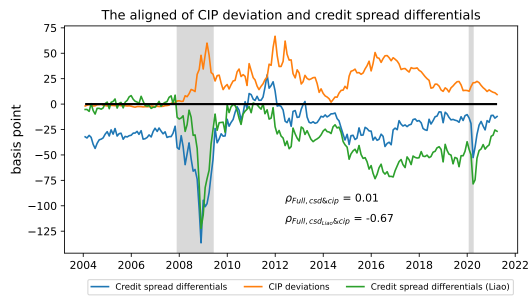
(b) CAD



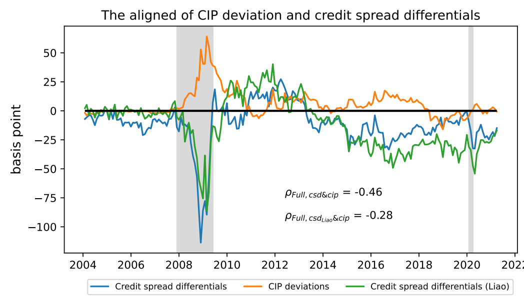
(c) CHF



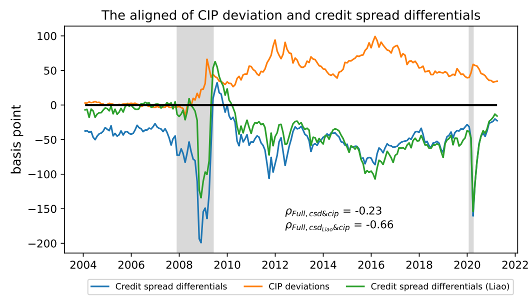
(d) EUR



(e) GBP



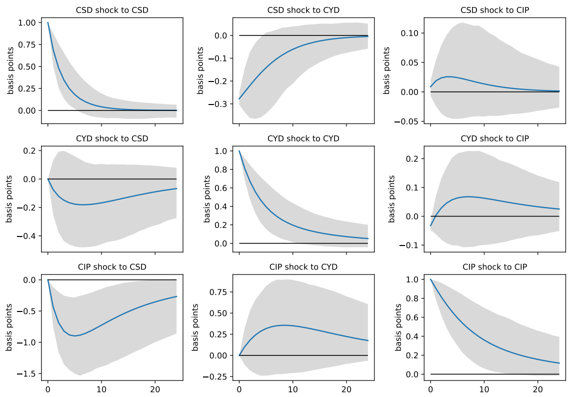
(f) JPY



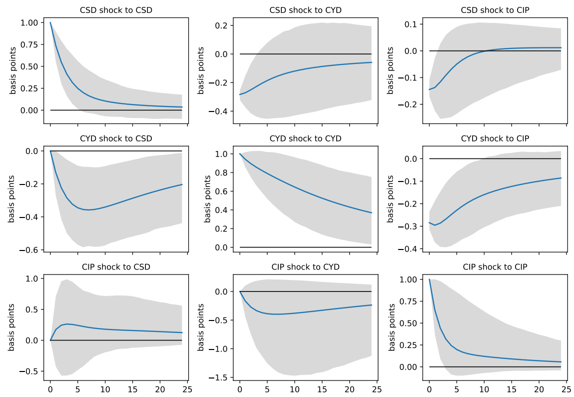
B SVAR with Zero Contemporaneous Restrictions

Figure B.1: IRF of SAVR Model

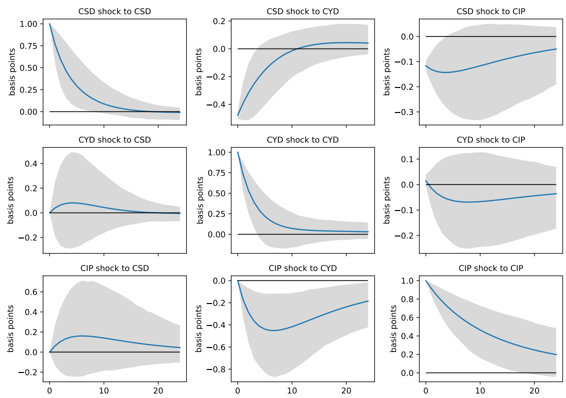
(a) AUD



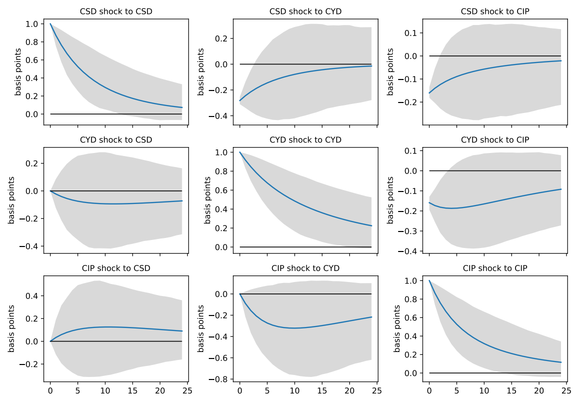
(b) CAD



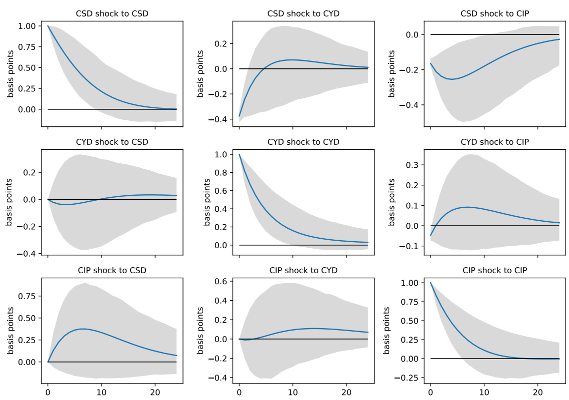
(c) CHF



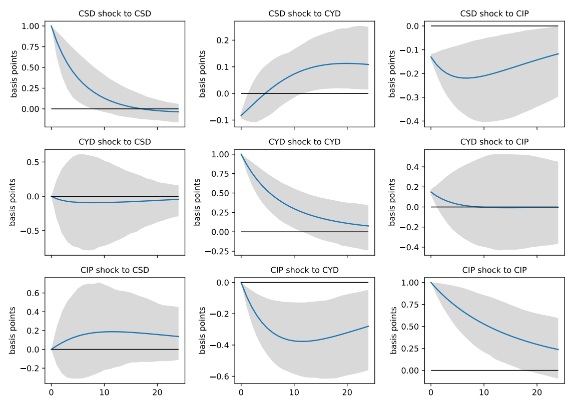
(d) EUR



(e) GBP



(f) JPY

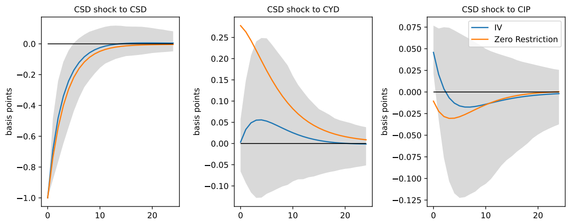


This figure presents the impulse responses functions (IRF) based on 1,000 wild bootstraps. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The sample is from January 2004 to March 2021.

C SVAR with the Financial Intermediaries' Balance Sheet Constraints shock IV

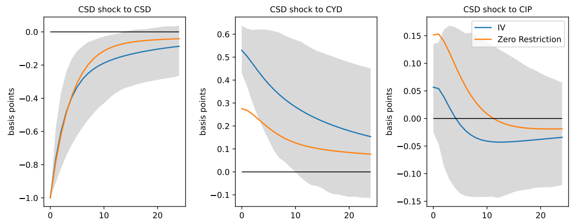
Figure C.1: IRF of SAVR Model with the CSD Shock

(a) AUD



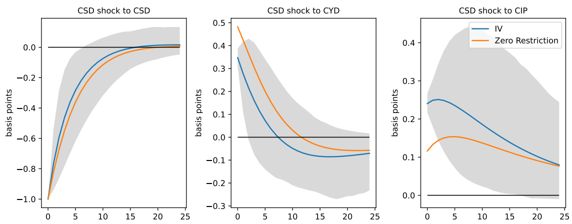
First stage regression: Coefficient: 68; F-statistics: 42; R^2: 0.17.

(b) CAD



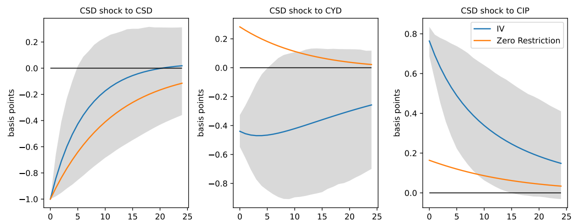
First stage regression: Coefficient: 48; F-statistics: 28; R^2: 0.12.

(c) CHF



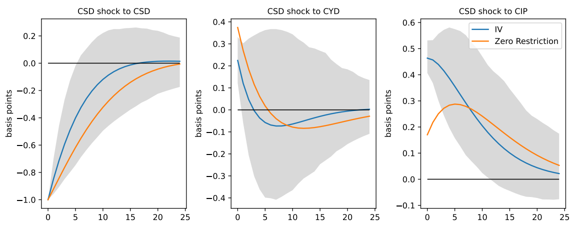
First stage regression: Coefficient: 95; F-statistics: 87; R^2: 0.30.

(d) EUR



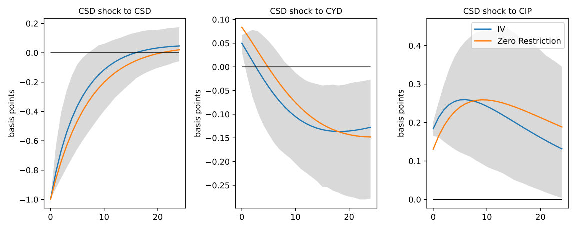
First stage regression: Coefficient: 39; F-statistics: 24; R^2: 0.11.

(e) GBP



First stage regression: Coefficient: 44; F-statistics: 35; R^2: 0.15.

(f) JPY



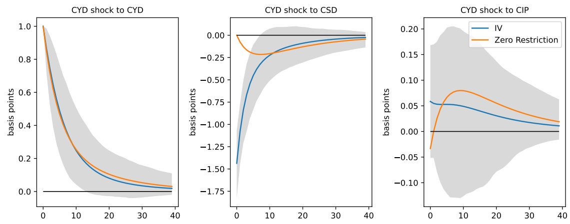
First stage regression: Coefficient: 149; F-statistics: 162; R^2: 0.44.

This figure presents the impulse responses functions (IRF) based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021.

D SVAR with the Monetary Policy Shock IV

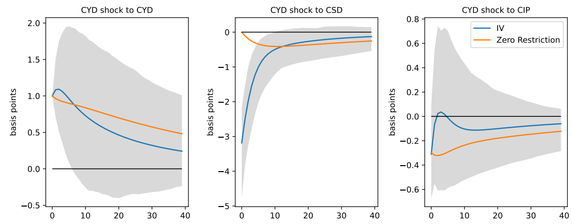
Figure D.1: IRF of SAVR Model with the CYD Shock

(a) AUD



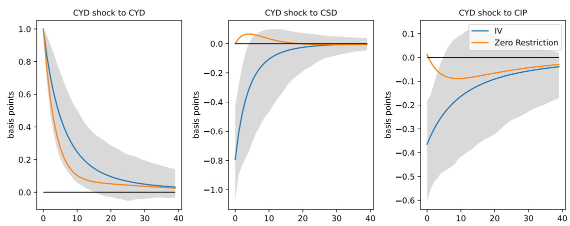
First stage regression: Coefficient: 41.3; F-statistics: 2.6; R^2: 0.013.

(b) CAD



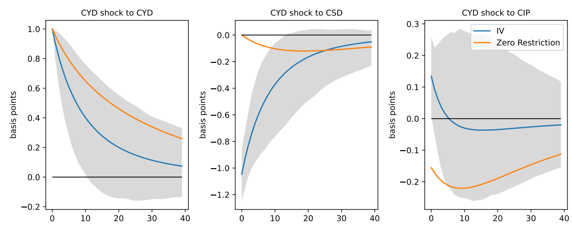
First stage regression: Coefficient: 17.5; F-statistics: 0.7; R^2: 0.003.

(c) CHF



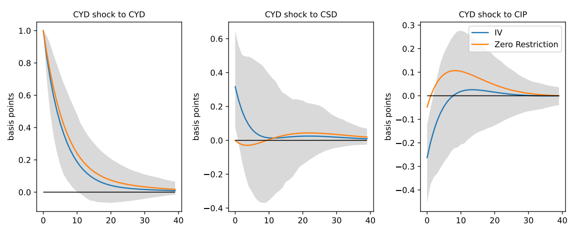
First stage regression: Coefficient: 38.8; F-statistics: 1.5; R^2: 0.007.

(d) EUR



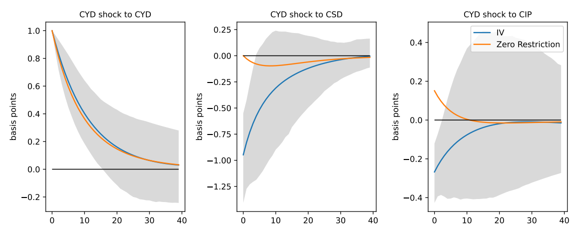
First stage regression: Coefficient: 50.7; F-statistics: 5.8; R^2: 0.007.

(e) GBP



First stage regression: Coefficient: -41.0; F-statistics: 2.6; R^2: 0.013.

(f) JPY



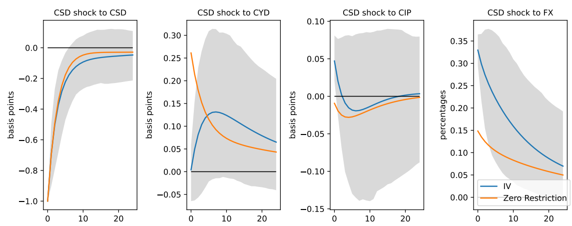
First stage regression: Coefficient: 49.9; F-statistics: 7.4; R^2: 0.035.

This figure presents the impulse responses functions (IRF) based on 1,000 wild bootstraps with the monetary policy shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021.

E The FX Market

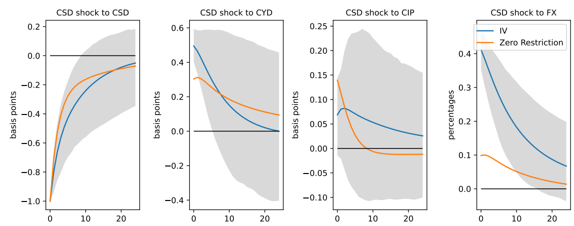
Figure E.1: IRF of SAVR Model with the CSD Shock and FX

(a) AUD



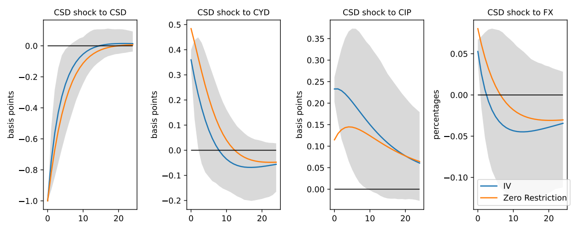
First stage regression: Coefficient: 68; F-statistics: 43; R^2: 0.18.

(b) CAD



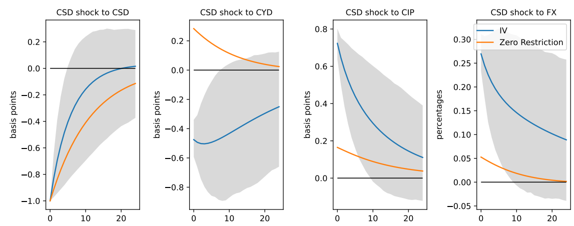
First stage regression: Coefficient: 51; F-statistics: 33; R^2: 0.14.

(c) CHF



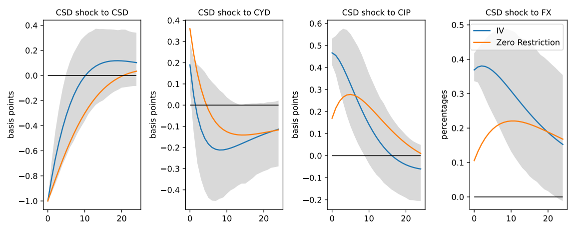
First stage regression: Coefficient: 94; F-statistics: 85; R^2: 0.30.

(d) EUR



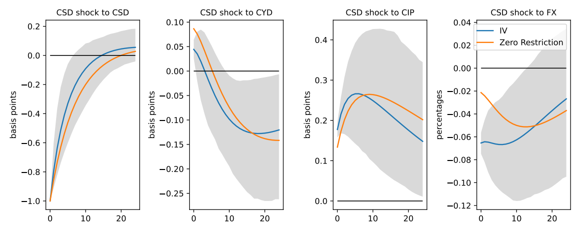
First stage regression: Coefficient: 39; F-statistics: 24; R^2: 0.11.

(e) GBP



First stage regression: Coefficient: 43; F-statistics: 35; R^2: 0.14.

(f) JPY

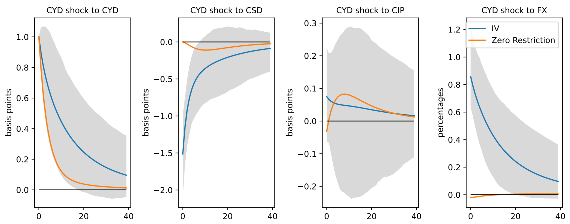


First stage regression: Coefficient: 150; F-statistics: 166; R^2: 0.45.

This figure presents the impulse responses functions (IRF) based on 1,000 wild bootstraps with the financial intermediaries' balance sheet constraints shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021.

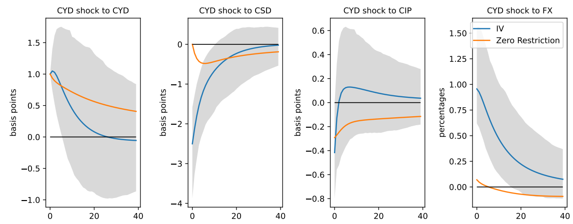
Figure E.2: IRF of SAVR Model with the CYD Shock and FX

(a) AUD



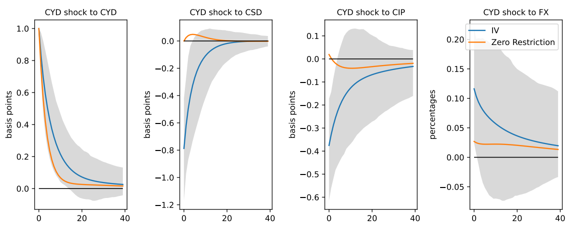
First stage regression: Coefficient: 35.2; F-statistics: 2.0; R^2: 0.010.

(b) CAD



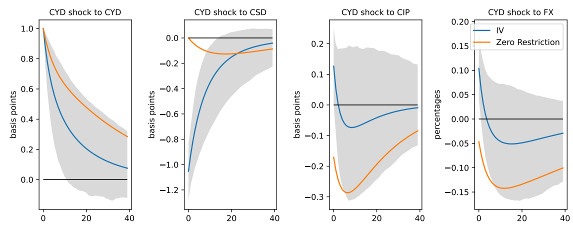
First stage regression: Coefficient: 19.2; F-statistics: 0.84; R^2: 0.000.

(c) CHF



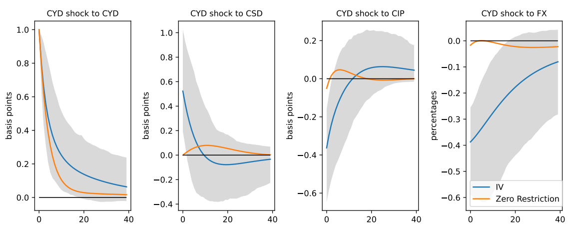
First stage regression: Coefficient: 39.0; F-statistics: 1.52; R^2: 0.010.

(d) EUR



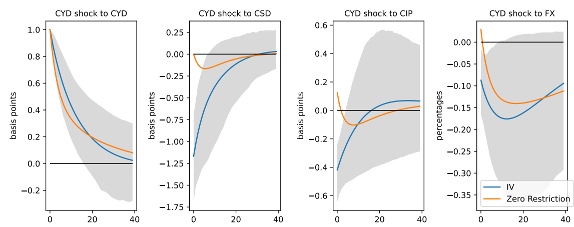
First stage regression: Coefficient: 50.5; F-statistics: 5.76; R^2: 0.030.

(e) GBP



First stage regression: Coefficient: -31.7; F-statistics: 1.65; R^2: 0.010.

(f) JPY



First stage regression: Coefficient: 44.6; F-statistics: 6.07; R^2: 0.030.

This figure presents the impulse responses functions (IRF) based on 1,000 wild bootstraps with the monetary policy shock IV. The solid lines are the mean value of IRF, and the shaded areas are 95% confidence bands. The monthly sample is from January 2004 to March 2021.