Credit Migration and Covered Interest Rate Parity

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Abstract

I provide a theory of liability-driven international capital flows in which firms act as cross-market arbitrageurs in the global credit market. I show that credit markets are segmented along currency fault lines. The relative pricing of credit risks denominated in different currencies are impacted by shocks to investor demand that are slow to revert. Through the choice of the issuing currency, firms act as cross-market arbitrageurs helping to partially integrate these segmented credit markets. This cross-market arbitrage exposes firms to foreign exchange (FX) risk, which they partially hedge. The currency hedging activities in turn generate violations of covered interest rate parity (CIP) as an equilibrium outcome. I document large and sustained violations of long-term CIP and offer explanations of these violations in the context of liability-driven capital flows. Consistent with my theory, CIP deviations function as an indicator for imbalances in the supply and demand of relative funding conditions. Full integration of global credit markets is hindered by capacity constraints of the currency forward market. Segmentation in the credit market at different maturities also provide an equilibrium characterization of the term structure of CIP violations.

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Introduction

In this paper, I show how mis-pricing is linked across the currency and global credit markets. Many violations of the law of one price have been documented in the past, e.g. closed-end funds, twin shares, and stub pricing (see Lamont and Thaler 2003 for survey). These violations are often studied in isolation and attributed to irrational behaviors of investors directly involved. I show, in a novel setting, that law-of-one-price violations in one market (the currency exchange rate market) can arise as an equilibrium outcome of market segmentation in another (the credit market). Segmentations in the global credit market along currency fault lines induce cross-currency debt issuance flows that lead to violations of long-term covered interest rate parity.

Financial frictions that hinder the flow of capital are often masked by a high volume of transactions and the appearance of liquidity. I explore a major component of global capital flows – foreign currency debt issuance initiated by large, public firms. Around a third of the $4.5 trillion corporate debt issuance in 2015 globally was denominated in foreign currency for the issuer[1]. I show how segmented credit markets generated the bulk of these foreign issuance flows. In addition, I examine the creation (and elimination) of deviations from covered interest rate parity (CIP), a no-arbitrage forward-to-spot exchange rate relation[2], as an equilibrium outcome of firms' credit market integration and an indicator of global capital flows.

Credit market segmentation refers to the idea that the pricing of credit risk depends on the currency it is denominated in. Consider AT&T, the BBB-rated and U.S.-based telecommunication giant with limited operations abroad. In November 2014, the firm needed to raise $1 billion in fixed-rate 15-year bonds. It could issue in USD at a yield of 4.8 percent[3], or issue in EUR at a yield of 2.6 percent, but issuing in euro leaves the firm exposed to currency risk, which can be hedged using swap transactions[4]. The 15-year benchmark swap rates were 2.77 percent and 1.31 percent in USD and EUR respectively. Thus, the credit spread, expressed as a yield spread to the swap curve, was 203 bps in USD and 129 bps in EUR. After hedging for foreign exchange (FX) exposure, AT&T loses the difference in underlying interest rate differential of 146 bps but still faces a credit spread

[1] Thompson One SDC Platinum Data

[2] Covered interest rate parity is a no-arbitrage condition that equates forward exchange rate to spot exchange rate adjusting for the interest rate differential: $F_{d/f} = S_{d/f}\frac{1+r_d}{1+r_f}$. Violation of this condition and the measurement of the deviation using cross-currency basis are discussed in detail in section 1.

[3] Conservative estimates based on the prevailing yields of AT&T bonds with similar maturities using Bloomberg data

[4] Specifically, the firm does the following transactions: 1) swaps the euro fixed rate debt into euro floating rate obligations, 2) swaps the euro floater into USD floating rate obligation, 3) swap dollar floater into dollar fixed rate liability. These transactions are described in detail in Section 1.

differential of 74 bps. Subsequently, it issued the debt in euro. The differential pricing of credit risk denominated in different currencies is not just idiosyncratic to specific firms. In the same period, the average spread of BBB corporate bonds was 174 bps in USD and 105 bps in EUR, a difference of 69 bps.

Although cross-currency issuance integrates the credit markets, it also exerts price impact on the hedging currency. Consider again AT&T's issuance of a €800 million ($1 billion) 15-year euro-denominated bond. As AT&T hedges its exchange rate exposure associated with its new issuance[5], it exerts price pressure on the forward EUR-USD exchange rate. In the presence of limited arbitrage, the associated hedging activities generate violations in covered interest rate parity. From September 2014 to March 2015, a net issuance flow of around $60 billion from the U.S. into Europe was accompanied by a widening of the 10 year cross-currency basis (a measurement of long-term CIP deviation) from 5 bps to 30 bps.

In this paper, I examine the linkage between currency basis and corporate credit markets in an equilibrium model that incorporates credit risk and CIP deviations. In this model, two sets of investors are specialized in the investment of corporate bonds in their respective home currencies. Investors are averse to default risk, resulting in downward sloping demand curves in their home credit markets. Exogenous demand shocks, such as Quantitative Easing, to the credit market in one currency cannot be easily transmitted across currency boundaries by these investors. Therefore, the aggregate corporate credit risks of bonds with similar credit ratings are priced differentially when denominated in different currencies. Corporations have the ability to issue in either currency. Issuing in the foreign currency generates FX exposure for the firms. The firms can choose to reduce their FX exposure by hedging. However, FX-hedging is costly, both in terms of loss in risk-free rate differential and CIP deviations that are created by the hedges. Currency swap arbitrageurs attempt to eliminate the deviations to CIP, but they are unable to do so fully due to limited arbitrage capital. That is to say that the FX forward market also has a downward sloping demand curve, and to integrate the two downward sloping demand curves in the bond markets, the firms have to walk down the downward sloping demand curve in the FX forward market. The firms choose the optimal fraction of foreign issuance and hedging ratio to minimize financing cost.

Using this model, I show how the the currency basis market, the market for trading CIP

[5] AT&T, stated in its 2014 10K filing: "We have entered into multiple cross-currency swaps to hedge our exposure to [...] foreign currency risk generated from the issuance of our Euro, British pound sterling, Canadian dollar and Swiss Franc denominated debt." Many similar examples of FX hedged cross-currency issuance by other firms can be found in voluntary disclosures to investors.

deviations, is linked to the global credit market and to debt issuance flows across currencies. Firms engage in the integration of credit risk across currency boundaries by denominating debt in currencies with lower financing cost. However, firms cannot completely integrate credit markets across currency boundaries because of price pressures that they exert on the currency basis market. Large volume of debt issuance is forced though a relatively thin pipe used for the hedging of long-term exchange rate movements. Dysfunctional plumbing in marketplace creates a barrier that prevents the full integration of segmented credit markets. CIP deviations arise as a result of large issuance-related hedging of FX risks and limited arbitrageur capital. I show that higher arbitrageur wealth reduces the impact of cross-currency issuance and the magnitude of the deviations.

I then explore these ideas empirically. First, I show that firms engage in the integration of credit risks across currencies through synthetic local debt issuance (a combination of foreign currency debt issuance and hedging transactions using derivatives). I show that the aggregate credit spread differential between funding currencies can be used to forecast future issuance flows between countries. A 100 basis point reduction in the relative credit spread for single-A-rated corporate bonds denominated in the euro versus the dollar induces an additional US$6.5 billion per month of debt issuance into the lower cost currency. Given that the credit spread differential is volatile, firms act as natural arbitrageurs that attempt to equilibrate credit spreads in different currencies.

Second, I show that FX hedged foreign currency issuance dominates over unhedged issuance for large public firms. Differentiating these two channels is important as it separates capital flows that are indicative of risky carry trade behaviors by firms and those that reflect globalization of funding sources. Currency carry trades, often indicated by interest rate differentials, have been suggested as a determinant of foreign currency debt issuance by a set of previous studies[6]. Bruno and Shin (2015) attributed currency carry trade motive as an important factor behind the recent increase in dollar-denominated issuance by foreign firms. When firms engage in currency carry trades, their FX exposures associated with foreign debt issuance are unhedged. Cross-currency issuance flows should be equally sensitive to risk-free rate differentials as they are to credit spread differentials. However, I find that issuance flows are more than twice as sensitive to credit spread differentials between countries as they are to underlying interest rate differentials. This finding suggests that the bulk of the cross-currency issuance flows between developed markets are made up of FX hedged issuance that are immune from crashes in the carry trade. Firms effectively issue

[6] Allayannis et al (2003), Kim and Stulz (1988), Miller and Puthenpurackal (2002)

synthetic local currency debt by hedging the exchange rate movements, consistent with my proposed mechanism of credit market integration through liability-driven international capital flows.

Third, I show that distortions to the forward-to-spot exchange rate relation, the covered interest rate parity condition, is indicative of cross-currency funding flows and supply and demand imbalances. Using regressions with monthly and daily observations, I identify issuance-related currency hedging demand as a direct contributor to deviations from CIP. Foreign currency debt issuance bridges the relation between credit market and CIP violation, two seemingly disconnected concepts. In addition, I show that issuance-related hedging demand has a larger impact on CIP deviations when broker-dealer leverage is low. This signals that arbitrageur capital, reflected through broker-dealer balance sheet, is also important in determining the size of CIP violations.

I further document sustained and extensive violations of long-term CIP using cross-currency basis. Figure 1 shows the 10-year CIP deviation in four funding currencies – EUR, GBP, JPY, and AUD – relative to the dollar. The magnitude and the time variations of these deviations are large and persistent especially after the financial crisis. While part of the CIP deviation during the financial crisis reflects shortage of dollar liquidity, as indicated by sharp declines in currency basis in 2008-2009, large deviations continue to persist through 2016. Furthermore, the direction and magnitudes of the deviations differ across currencies and reflect overall supply and demand for fundings. EUR, GBP, and JPY generally have had negative cross-currency basis, signaling the relative shortage of the dollar for long-term borrowing, while the positive AUD basis reveals the relative abundance of USD. In Section 1, I detail how CIP deviations are related to net savings as shown in Figure 2.

Distortions in the credit and currency forward market can elicit heterogeneous responses of issuers. Since CIP distortion is a spread (either as a cost or discount) common to all firms considering FX-hedged foreign currency debt issuance in the associated currency, differential shocks to credit markets of varying ratings can result in simultaneous issuance flow in opposite directions by firms with different credit ratings. For instance, a triple-A rated U.S. firm seeking lower debt servicing cost can issue in Yen while a high-yield Japanese firm might find cheaper funding in dollar. The two firms would exert opposite price pressure on the dollar-yen currency basis. Furthermore, preferred habitat of cross-currency issuers and investors in different maturity buckets induces the use of currency basis swaps of varying maturities, thus determining the term-structure of arbitrage deviations. Intermediaries with limited capital most readily correct arbitrage deviations through the smoothing of the currency basis *term structure*, while leaving the more capital-intensive correction of currency basis *levels* to firms and investors. These intricate dynamics are currently being explored in a model and further empirical analysis.

What prevents the elimination of this arbitrage deviation in CIP? Noise trader risks and performance based arbitrage pose limits to the amount of arbitrage activities (De Long et al. [1990], Shleifer and Vishny [1997]). The noise traders in this context are not behavioral agents expressing sentiment shocks; rather, they are foreign currency debt issuers rationally engaging in transactions that push price beyond fundamental values. While in the process of *transmitting* an exogenous shock in the local credit market to credit markets denominated in other currencies, the issuers inadvertently *transform* the credit shock to deviations from CIP. The worsening of the CIP violations after the global financial crisis relates closely to the reduction of capital available for arbitrage as intermediary balance-sheet constraints are tightened. Thus, no-arbitrage deviation is jointly determined by a combination of supply and demand flows as well as intermediary capital constraints, as has been stressed by Garleanu and Pedersen (2011), He and Krishnamurthy (2013), Gabaix and Maggiori (2015) among others.

Where do the exogenous shocks in the credit market come from? Various behavioral and institutional frictions can differentially influence credit spreads denominated in different currencies. Large supply and demand shocks, such as those from central bank Quantitative Easing programs, are slow to transmit across markets and often require market generalists, such as firms, that gradually reallocate capital (or issue debt) across markets (Greenwood, Hanson, and Liao [2015]). In the context of the previous example, ECB announcements in September 2014[7] and the anticipation of an ensuing full-blown ECB QE program throughout the fall of 2014 contributed to a narrowing of the euro credit spread relative to the dollar credit spread. EUR-denominated BBB credit spread narrowed by more than 70 bps relative to the dollar credit spread from September 2014 to January 2015. Following an event study methodology from Mamaysky (2014) that examines event windows up to three weeks, I show that the Federal Reserve Quantitative Easing program had contributed to the compression of U.S. credit spreads relative to other countries. I am currently carrying out similar exercises using announcements of QE in Europe and Japan as exogenous shocks.

My paper is related to previous work on corporate debt issuance currency choice. McBrady and Schill (2007) finds opportunistic motive for foreign currency denominated borrowing by sovereigns, supranationals and agencies issuers. Cohen (2005) finds more issuance of international bonds in

[7]ECB announced asset-backed securities purchase and refi rate cut to 0.05% in September 2014 and hinted at large forthcoming QE programs.

stronger currencies than weak ones and greater issuance in higher-yielding currencies. Munro and Wooldridge (2010) discusses various considerations and motives in swap-covered debt issuance in a sample of Asian issuers. This string of literature does not make conjectures regarding the amount of FX-hedged issuance, the impact of issuance on the FX forward market, and the firms' role in integrating credit markets. My paper is also related to papers showing that corporations behave like arbitrageurs in their financing activities (Baker and Wurgler [2000] and Baker, Foley, and Wurgler [2009], Greenwood, Hanson, and Stein [2010], and Ma [2015]). Greenwood, Hanson, and Liao (2015) explores asset price dynamics when large supply shocks are transmitted across markets by slow-moving market generalists such as firms. Price pressures from large supply and demand shocks have also been studied in other contexts.

A small set of literature has examined short-term CIP violations during the financial crisis (Baba, Packer, and Nagano [2008], Coffey, Hrung, and Sarkar [2009] Griffoli and Ranaldo [2011], and Levich [2012]). Fletcher and Taylor (1996) documents long-term CIP violations of the early 1990s and concludes that these violations have diminished or disappeared over time. While these papers discuss limits to arbitrage that prevent the elimination of CIP violations, their examinations of the root cause of deviation in both crisis and non-crisis periods are limited.

This paper most closely relates to Ivashina, Scharfstein, and Stein (2015), which examines the dollar funding and lending behaviors of European banks and explores how relative funding costs in euro and dollar could generate CIP violations that affect lending. The empirical analysis of their study focuses on the European Sovereign Debt Crisis episode in 2011-2012 when European banks partially substituted their short-term U.S. funding with synthetic borrowing from their European deposit base and cut dollar lending. My paper differs in its focus on corporate debt issuance flow, the analysis of long-term CIP violations through the lens of currency basis, discussion on the term structure of the no-arbitrage deviation, and empirical evidence across five major global funding currencies in both crisis and non-crisis sample periods. In a concurrent project, Du, Tepper, and Verdelhan (2016) documents the persistent deviations from covered interest rate parity after the Global Financial Crisis and proposes explanations based on costly financial intermediation and global imbalances. My paper explains CIP violations in the same vein but also identifies segmentations in the global debt market as a causal source and delineates the channel through which firms as arbitrageurs can transform law-of-one-price violations in the bond market into violations in the currency market.

1 Global Funding Imbalance and the Market for Trading CIP Deviations

In this section, I discuss the mechanism and market structure of cross-currency basis swap, the issuance and construct of synthetic local bonds, and the connection between CIP deviations and global funding imbalances.

1.1 Cross-currency basis swap and CIP deviations

Corporations utilize currency swaps to convert debt proceeds from foreign debt issuances into their domestic currencies while also guaranteeing the exchange rate at which they repay the coupons and principals. Similarly, investors utilize currency swaps to invest in foreign bonds while hedging against exchange rate movements. In this subsection, I show how the price impact of these parties can be read off from the cross-currency basis, which measures deviations from CIP. Cross-currency basis swap (XCBS) allows each party in a bilateral contract to simultaneously lend and borrow at the floating short-term rates in two different currencies for a defined period of time. Figure 3 illustrates the cash flow of a cross-currency basis swap that allows the lending of EUR in exchange for the borrowing of USD. At the initiation, the principal amount denoted in two different currencies are exchanged at the spot exchange rate. In the interim, the two parties exchange interest payments based on the reference floating short-term funding rates[8]. At the maturity date, principals are repaid at the initiating exchange rate. Equivalently, one can think of a XCBS as a total return swap with the asset being a foreign money market fund. The swap can be replicated by two Floating Rate Notes. For instance, a lend EUR/borrow USD (receive *Euribor*, pay \$*Libor*) position through XCBS is equivalent to selling a euro floater lending in EUR) and buying a dollar floater (borrowing in USD). Theoretically, these two floating rate notes should each trade at par since they are accruing the benchmark floating interest rate coupons. The package combined should also have zero fundamental value. However, excess demand for loans in one currency versus another exerts pressure on the floating interest rates. A fixed spread, known as the currency basis, is applied to the non-dollar short-term reference rate to equilibrate the supply and demand for loans in each currency. With a large amount of USD borrowing and EUR lending, lenders of EUR would take

[8] The market convention is to use 3-month Libor or equivalent reference rates for each currency. Overnight rates based on actual transactions, such as the Eonia and Fed Fund Effective Rate are also occasionally used, but liquidity in these alternate benchmark swaps are poor. Appendix Figure B.1 shows similarity for cross-currency basis levels under bank-reported reference rates and overnight transaction based rates.

a discount on the short-term rate that they receive. The currency basis would become negative until an equilibrium is reached when market participants agree to exchange $Euribor + basis$ against $\$Libor$ in the simultaneous EUR lending/USD borrowing swap. The specialness of the dollar as a funding currency typically generates a negative basis for most currencies. In contrast, with large amount of foreign currency borrowing and USD lending demand, the currency basis would become positive, as it is the case with AUD, NZD, HKD in recent periods.

Cross-currency basis is tightly linked to CIP deviations. I show the equivalence between the two instruments first through an example followed by a precise definition. Suppose a U.S. firm with no operations in the Eurozone issues in Euro and wants to convert the issuance proceed to dollar and hedge its exposure to Euro. It can do one of the following. With forward contract, the firm buys dollar/sells euro in the spot market while simultaneously enters into a forward to buy euro/sell dollar at the maturity date. Alternatively with a cross-currency swap, the firm lends the euro debt proceeds to a bank. At the same time the firm borrows dollar from the bank to fund its U.S. operation. These two methods of converting the euro proceed to dollars are equivalent in terms of cash flows for a short-term bond with a single coupon payment. For a longer maturity bond with many interim coupon payments, the issuer can either opt to enter either a single XCBS transaction or an array of forwards contracts for payments of coupons and the principal.

In the appendix, I show that the T-period forward currency price is related to cross-currency basis, denoted as B, by the following expression,

$$F_T = S\frac{(1+Z)^T}{(1+Z^*)^T}\left(1 + B\sum_{t=1}^{T}\left(1+Z^*_{0,t}\right)^{-t}\right)^{-1} \tag{1}$$

where F and S are the forward and spot exchange rates expressed in domestic currency per foreign currency, Z and Z^* denote zero coupon yields in the domestic and foreign currency respectively. That is, the forward exchange rate is equal to the frictionless forward adjusted for the present value of the stream of coupon payments equal to the currency basis.

Covered interest rate parity implies $B = 0$, which reduces Equation 1 to the familiar frictionless forward-to-spot relation

$$F = S\frac{(1+Z)^T}{(1+Z^*)^T}.$$

When this condition holds, interest rate differential constitutes the primary cost of hedging using forward contracts. When combined with limited amount of arbitrageur capital devoted to replicating the forward, large demand for the forward (or equivalently for the XCBS) creates a wedge in this frictionless relation. It is natural to think of the currency basis as deviations from CIP since the basis is the wedge in the forward-to-spot relation and has a theoretical value of zero[9]. In the analysis that follows, I define CIP violations directly as the cross-currency basis.

While forwards are more liquid for short maturities, basis swaps are more liquid for longer maturities and are used for the pricing of long-dated forwards. It is natural that cross-currency basis swaps take on the cash-flow structure with intermediate coupon payments. This instrument is essentially designed for the FX hedging in foreign currency debt. For this reason, debt issuance is a dominant driver of the long-dated currency basis.

1.2 Synthetic local bonds and firms as credit market arbitrageurs

When firms issue in a foreign currency and hedge their exchange rate risk, they are essentially issuing synthetic local bonds. In this subsection, I discuss how synthetic local bond issuances allow firms to act as arbitrageurs of relative credit spreads but not interest rate differentials between currencies. In Figure 4, I present a schematic showing the decomposition of corporate bond yields into three main components - the short-term funding rate, the term spread, and the credit spread. The figure also shows the yield decomposition of a fixed-rate synthetic dollar bond. A firm can convert a fixed-rate bond issuance denominated in EUR to a synthetic fixed-rate dollar bond by entering into a XCBS and two single-currency fixed-to-floating swaps. The XCBS hedges the exposures in exchange rate and short-term funding rates, and the vanilla interest rate swaps further locks in the term spreads. The combined package is a synthetic fixed-rate dollar bond that differs from a regular dollar bond only by the credit spread differential. Differences in short-term funding rates and term spreads between the two currencies become irrelevant to the issuer.

Synthetic local bonds allow firms to issue in different currencies and cater to investors of

[9] Alternatively, we can define deviations to CIP as a spread to the foreign zero-rate, denoted μ, in the following expression

$$F = S\frac{(1+Z)^T}{(1+Z^*-\mu)^T}.$$

We can relate μ with B by the following approximation shown in the appendix:

$$\mu \approx -B\left[\sum_{t=1}^{T}\left(1+Z^*_{0,t}\right)^{-t}\right]\frac{1+Z^*}{T}. \tag{2}$$

Traditionally, CIP deviations are defined using government bond rates as the underlying risk-free rates. However, these government bond "risk-free rates" are not the actual rates used in calculating forwards. In reality, forwards are calculated using funding rates for large financial institutions such as Libor or more recently Overnight Index Swap rates.

different bond markets. A natural question is why are the investor base segmented? While many institutional investors such as pension funds, life insurance companies and endowments have diversified exposure to bonds in different currencies, they often have clear mandates on their benchmarks and currency exposure. The rigidity of their mandates allow for little discretion in their portfolio allocation choice. They are also often limited in their usage of derivatives due to the lack of expertise and regulatory restrictions. Mutual funds and hedge funds in fixed income also typically follow benchmarks. Some macro funds do engage in the active investment of foreign credit markets. However, they are relatively small in size and lack the amount of capital necessary to fully offset large demand shocks such as those related to quantitative easing. In short, dedicated cross-market arbitrageurs simply do not have enough capital or risk tolerance to digest large demand shocks and fully integrate the credit markets.

Arbitrageurs that can readily integrate cross-market asset prices need to have the ability to bear noise-trader risk, withstand large mark-to-market losses and endure long investment horizons. Firms are natural to take on this role. By issuing debt in different currencies, firms can affect the supply of credit in order to equilibrate the pricing of credit risks across currencies. The standard deviation of monthly issuance flow between the Eurozone and the U.S. is in excess of $6 billion. This is equivalent to the creation of a sizable hedge fund fully dedicated to exploiting the relative pricing of corporate credit risks between the two regions every month.

1.3 Cross-currency basis as a barometer for global funding imbalances and capital flows

Thinking of CIP violations in terms of cross-currency basis not only allows the empirical measure to be easily defined but also imparts a different perspective. Instead of viewing CIP deviations as a minor friction in the FX forward market, we can interpret it as a barometer of global funding imbalances and liability-driven capital flows. This line of thinking motivates exploration of both the time and cross-sectional variations in CIP deviations.

Substantial deviations of long-term CIP have persisted after the global financial crisis. Figure 5 presents the time series of short-term (3 month) and long-term (10 year) currency basis for the EUR/USD pair. Short-term basis became sharply negative during the financial crisis around 2008-2009 and the Euro sovereign debt crisis in 2011. Ivashina, Scharfstein, and Stein (2015) attributes the short-term CIP violation in 2011 to European banks swapping their euro retail deposits to make up for loss in wholesale dollar funding. Others have documented the violation in short-term CIP during the financial crisis (see for example, Coffey, Hrung and Sarkar, 2009 and Akram, Dagfinn and Sarno, 2008). I focus on the violation of long-term CIP in this paper. While long-term currency basis is connected to the short-term basis, the hedging of foreign currency debt by issuers and investors is an independent driver of long-term currency basis. Figure 6 presents the term structure of the Euribor-Libor basis swap in April 2015. U.S. issuers swapping Euro debt proceeds into dollars exert price pressure of receiving $Euribor + basis$ versus paying $\$Libor$ (lending EUR/borrowing USD), pushing the currency basis more negative. Vice versa for European dollar debt issuers.

Cross-sectionally, I show in Figure 2 that CIP violations in G10 currencies are closely linked to the associated country's current account. Since current account measures the difference between national saving and domestic investment, countries that have relatively more net saving tends to have foreign investment and banking operations abroad. These investment and banking operations require funding in the dollar, the dominant global currency. The swapping of savings from local currency to the dollar generates a negative currency basis, or a deviation in CIP indicating relative dollar scarcity. This is particularly evident at the short tenors of the cross-currency basis curve in which global banks fund dollar-based operation with local currency deposits. At the longer horizons, direct borrowings by firms through synthetic issuances exert pressure on long-dated currency basis.

The outliers of CIP violations shown in Figure 2 epitomize a broader phenomenon. Japan has the most negative currency basis and a large net saving in the economy. Japanese banks with foreign operations have large dollar funding needs, and they need to swap Yen savings into dollars for lending abroad. At the longer maturities, low Yen credit spread incentivizes the issuance of Samurai and Euroyen bonds by foreign firms. The hedging of these foreign issuance also requires swapping Yen into dollar. The result is large negative currency basis in both the short-end and long-end of the maturity curve. In contrast, Australia has the exact opposite dynamics. Relatively low domestic saving means that Australian banks rely on wholesales dollar funding from abroad to fuel domestic lending, and thus they need to swap these dollar funding to Aussie with short-term XCBS. With a large amount of long-term infrastructure investment and a small domestic corporate bond market, Aussie firms issue debt abroad and swap the proceed back to AUD. Both the banking and issuance channels apply positive pressure on the Aussie-dollar currency basis curve.

The term structure dynamics can be modeled similarly to the preferred-habitat model of Vayanos and Vila (2009) and Greenwood and Vayanos (2014). Market participants utilize XCBS, or alternatively FX forwards, of varying maturities depending on their needs. These preferred-habitat users exerts price pressures in different maturities of the currency basis curve. Localized dislocations are then transmitted to other maturities of the basis curve by arbitrageurs. Main users of XCBS and related FX derivatives are listed as follows:

- **Debt issuers** typically hedge the currency and rate risk by matching the swap to the maturity of their debt issuance. Therefore, they constitute a major driver of deviations from long-term CIP.

- **Banks** Prior to the global financial crisis, banks provided most of the arbitrage to enforce CIP by lending their balance sheets. Since the crisis, non-U.S. banks, in need of short-term dollar funding, became active borrowers of dollar/lender of other currencies (receivers of basis). The swapping of deposits and wholesale fundings are typically concentrated in the short-end of the curve.

- **Global bond investors** Investors often hedge FX risk using short-dated forwards. Most benchmark indices calculate total returns on foreign sovereign and corporate bonds either as unhedged returns or hedged returns using 1-month rolling FX forwards[10]. Longer horizon FX hedging are sometimes used but generates tracking errors from the benchmark indices.

- **Structured note issuers** also utilize XCBS in the hedging of ultra long-dated structured notes[11].

- **Hedge funds** typically hold forward starting XCBS positions as a carry strategy. They help to integrate demands across the maturity curve but provide less mitigation of the outright level of currency basis.

Can these deviations be explained by credit risk of counterparties? While individual counterparties might incur additional Credit Valuation Adjustment depending on their collateral agreement, the basis swap levels used in the analysis are independent of the users and represent quotes among broker-dealers that have cash-collateral with daily mark-to-market. Currency swaps are generally collateralized in the same way as single-currency fixed-for-floating interest rate swaps. While practices may differ across counterparties [12], corporations generally have adopted security collaterals after the global financial crisis while inter-dealer trades are cash collateralized.

[10]Bank of America Merrill Lynch, Barclays, and Citi each state in their index methodology that 1 month rolling forwards are used in the calculation of total returns for currency hedged indices.

[11]The hedging of Power Reverse Dual Currency Notes by issuers had been an important driver of currency basis in AUD, JPY and other Asian currencies for brief periods of time.

[12]Each counter party specify collateral rules bilaterally with broker-dealers based on their Credit Support Annex in their ISDA agreement.

2 Theoretical framework

To facilitate discussions of the empirical results, I develop a simple framework to lay out motives for FX-hedged foreign debt issuance and discuss the channel through which foreign currency issuance interacts with credit spreads and deviations to covered interest rate parity.

Firms issue debt denominated in a foreign currency for a number of operational and financial reasons. If a firm has substantial asset exposure or income in a foreign currency, debt issuance in the same currency allows the firms to reduce the currency mismatch between the asset and liability sides of its balance-sheet. In this case, the issuer is naturally hedged against exchange rate fluctuations. Absent any natural hedges, the issuer can choose to either leave its foreign liability hedged or unhedged to exchange rate movements. Currency unhedged issuance often constitute an implicit carry trade or an expression of view on future exchange rate movement by the issuer. In this case, firms would issue in currencies that have lower interest rates. They either neglect or knowingly bet against the currency appreciation as implied by the interest rate differential. Issuers might also hold explicit views on the directionality of exchange rate movement and issue in currencies that they expect to depreciate. These alternate motives have been considered by other papers, such as Bruno and Shin (2015). While I will not explore the alternative motives in detail, I will draw comparisons on the relative magnitude of hedged versus unhedged issuance through my analysis.

I explore the rationale for FX hedged foreign currency issuance and the connection between credit market and CIP deviations through a simple static model. First, I layout a model of segmented credit markets without firms as cross-market arbitrageurs. Second, I add firms that are able to issue across currencies. Their cross-market issuance impacts the credit spread as well as the currency basis.

2.1 Credit markets without cross-currency issuers

In this static model, there are two credit markets: the euro denominated corporate bond market and the dollar denominated corporate bond market, and three types of actors in each market: active local investors, firms with local currency debt issuance, and preferred-habitat investors. The preferred-habitat investors represent pension funds, insurance companies and endowments that allocate according to benchmarks and inelastically demand a quantity δ_U of corporate bonds in USD and δ_E of corporate bonds in EUR. These quantities are taken to be exogenous to the model and can represent demand shocks that originates from Quantitative Easing. At the same time, local firms issue a fixed quantity D_U of bonds in dollar and a quantity D_E of bonds in euro.

I impose the assumption that the active investors are restricted to investments in their home currency. U.S. active investors specialize in the investment of corporate bonds denominated in dollars. They borrow at the domestic short rate, r_U, and purchase bonds that have a coupon of C_U. With fixed probability π, the bonds default and lose L in value. U.S. investors have a mean-variance preference with risk tolerance τ and choose investment amount X_U to solve the following

$$\max_{X_U} \left[X_U \left((1-\pi) C_U - \pi L - r_U \right) - \frac{1}{2\tau} X_U^2 V_P \right] \tag{3}$$

which has the solution

$$X_U = \tau \frac{(1-\pi) C_U - \pi L - r_U}{V_P}. \tag{4}$$

V_P is the payoff variance mainly determined by default probability and loss given default.

Similarly, the European credit investors are constrained to invest in euro denominated bonds. For simplicity, assume that the default probability and loss given default are the same for bonds in both markets. Market clearing conditions are

$$X_U + \delta_U = D_U \tag{5}$$

$$X_E + \delta_E = D_E. \tag{6}$$

Applying first-order Taylor approximation around $\pi = 0$ and combining with market clearing conditions, the financing costs for local issuers can be expressed as

$$C_U \approx \pi L + r_U + \frac{V}{\tau} (D_U - \delta_U) \tag{7}$$

$$C_E \approx \pi L + r_E + \frac{V}{\tau} (D_E - \delta_E). \tag{8}$$

Thus, the two markets are completely separated.

2.2 Credit markets with cross-currency issuer

Now, we introduce an additional actor, a representative U.S.-based firm that has access to both debt markets. This firm has only domestic operations and no foreign cash flows. It needs to issue a total debt amount D and choose a fraction f of the debt to be issued in euro at a cost of C_E. The reminder $1-f$ of the debt is issued in dollar at a cost of C_U. A schematic of the model is provided in Figure 8.

I define δ_U and δ_E as the residual credit demand from preferred-habitat investors net of issuance by other firms. The market clearing conditions in the dollar and euro credit market become

$$X_U + \delta_U = (1-f)\,D \tag{9}$$

$$X_E + \delta_E = fD. \tag{10}$$

Again, δ_D and δ_E are exogenous shifts in demands.

The financing costs for the cross-currency issuer in EUR and USD can be written as

$$C_E \approx (\pi L + r_E) + \frac{V}{\tau}\,(fD - \delta_E) \tag{11}$$

$$C_U \approx (\pi L + r_U) + \frac{V}{\tau}\,((1-f)\,D - \delta_U)\,. \tag{12}$$

We can decompose the difference between the two financing costs above into a credit spread difference, denoted d, and a risk-free rate difference, denoted ρ.

$$C_E - C_U = \underbrace{\frac{V_P}{\tau}\,((2f-1)\,D + \delta_U - \delta_E)}_{d} + \underbrace{(r_E - r_U)}_{\rho}\,. \tag{13}$$

The relative credit spread, d, is a function of the foreign issuance fraction, f, and local residual demands, $\delta_U - \delta_E$. Large scale asset purchases by central banks can have a displacement effect and result in an increased demand for corporate debt in the local market. Sentiment shocks can also encourage investors to purchase corporate bonds without changes in the fundamentals. These shocks are taken as exogenous variations in δ_U and δ_E.

The cross-currency issuer has limited ability to influence the relative credit spread. If it chooses all of its debt to be issued in EUR instead of USD, i.e. $f = 1$, then the relative credit spread denominated in EUR would widen as a result of additional debt supply. The issuer's impact is limited, however, by the size of its total debt issuance D relative to the overall size of debt markets and the risk bearing capacity of investors.

2.3 The Firm's Optimization Problem

The cross-currency issuer chooses foreign debt fraction f and hedging ratio $h \in [0,1]$ for a total amount of hedged foreign issuance fhD. CIP deviation, denoted as Δ, contributes to the cost of hedging beyond the risk-free rate differential. The cross-currency issuer has a mean-variance preference and solves

$$\min_{f,h} D\left[f\left(C_E + h\left(\Delta - \rho\right)\right) + \left(1-f\right)C_U + \frac{\phi}{2}\left(f-k\right)^2 + \frac{1}{2\theta}Df^2\left(1-h\right)^2 V_\omega\right]. \tag{14}$$

We first analyze the partial equilibrium solution in the firm's problem before considering the general equilibrium in section (2.5). In this section, cross-currency issuers are taken to be a representative firm that is a price taker in the credit and FX swap markets. That is, there can be many other identical firms of total measure one solving the same optimization problem. Their debt issuance in each market determines the bond yields and currency swap levels but they take the equilibrium prices as given when solving their optimizing problem. The issuer chooses fraction f of the debt to be issued foreign and hedging ratio h to minimize the total financing cost. There are two trade-offs in the firm's problem. First, issuing in Europe confers a saving of $C_U - C_E = -\left(d+\rho\right)$. However, the firm has a target optimal level of investor diversification, denoted by k. Straying away from this target in either direction incurs a quadratic cost $\frac{\phi}{2}\left(f-k\right)^2$. This cost might represent refinancing risk due to concentrated investor base or idiosyncratic capacity constraint for the specific issuing entity independent of the aggregate corporate credit demand[13]. In the context of the example provided in the introduction, AT&T cannot issue all of its bonds in EUR despite lower marginal cost because of its desire to diversify investor base.

Second, FX hedging poses another trade-off to the issuer. Unhedged foreign debt exposes the firm to exchange rate variance V_ω. However, hedged foreign debt incurs an additional cost equal to $\Delta - \rho$. Expected appreciation or depreciation of the currency does not appear in this static framework. This can be interpreted either as the issuer holding a myopic perspective on financing cost or the issuer believing that uncovered interest rate parity does not hold[14]. This assumption can be relaxed without major changes to the results.

[13] Conversations with Debt Capital Market specialists provided anecdotal evidence that diversification risk constitute an important determinant of issuers' currency choice. Some practitioners have noted that credit rating agencies consider the diversification of investor base to be an important factor in assigning credit ratings.

[14] Uncovered interest rate parity states that the expected currency valuation is the forward price. $E_t\left[S_{t+1}\right] = F_{d/f,t} = S_{d/f,t}\frac{1+r_d}{1+r_f}$

The optimal hedging ratio is best expressed in terms of the optimal fraction of foreign issuance:

$$h^{*}=1-\frac{\theta\left(\Delta-\rho\right)}{f^{*}DV_{\omega}}. \tag{15}$$

When there are no cost or benefit associated with hedging, $\Delta-\rho=0$, or when the firm is infinitely risk averse, $\theta=0$, foreign currency debt issuance are hedged completely. This is because the issuer is averse to volatile exchange rates[15]. If the carry for holding EUR exposure is sufficiently attractive, i.e. ρ is sufficiently negative, the firm might choose to leave part of their EUR issuance unhedged. Likewise, if CIP violations are large, the firm would choose a lower hedging ratio as a result of the additional hedging cost. I impose the assumption that the issuer cannot make a pure exchange rate bet, choosing $h>1$ or $h<0$.

In the interior case where $h\in(0,1)$, the optimal foreign issuance fraction is

$$f^{*} \quad = \quad k-\frac{1}{\phi}\left(d+\Delta\right). \tag{16}$$

The firm has a natural inclination to issue a fraction k of their total debt foreign due to investor diversification motives. With credit market frictions, foreign issuance increases in the credit spread advantage of issuing in EUR, $-d$. Countering this force, foreign issuance decreases in CIP deviation. The optimal foreign issuance fraction does not depend on the interest rate differential, ρ, or exchange rate volatility, V_{ω}. These two factors are weighed against one another in choosing the hedging ratio, h^{*}, and irrelevant for the determination of f^{*}.

So far, we have considered the simultaneous choice of f^{*} and h^{*} by the representative firm. In reality, many firms are not be able to engage in FX hedging due to institutional constraints such as the lack of expertise. This is particularly true of smaller firms and emerging market firms. Consider the case of an exogenously determined hedging ratio. The representative firm can be considered as a blend of many firms with varying degrees of hedging ability. Then the optimal hedging ratio can be written as

$$f^{*} \quad = \quad \frac{-\left(d+\rho\right)-h(\Delta-\rho)+k\phi}{\frac{1}{\theta}(h-1)^{2}DV_{\omega}+\phi}. \tag{17}$$

We consider a two limiting cases to guide the interpretation of empirical results. First, if the firm

[15] The incentive to hedge volatile cashflows can be rationalized in the framework of costly external finance and firm's incentive to keep sufficient internal funds available to take advantage of attractive investment opportunities (Froot, Scharfstein, and Stein 1992).

does not have the ability to hedge, $h = 0$, the sensitivities of f^* to ρ and d are equal. Cross-currency debt issuance flows should respond equally to risk-free rate changes as they do to credit spread changes. Second, if the firm hedges its FX exposure completely, $h = 1$, (17) collapses to (16), interest rate differential ρ is again irrelevant for determining cross-currency issuance flow. It is straight forward to show the following proposition:

Proposition 1: *If $h > \frac{1}{2}$, then $\frac{\partial f^*}{\partial(-d)} > 2\frac{\partial f^*}{\partial(-\rho)}$. If more than half of the issuance flows are currency hedged, then the sensitivity of cross-currency issuance flow to credit spread differential is more than twice as large as the sensitive to interest rate differential.*

This proposition holds even if firms have operations or investments abroad, so long as the investment opportunities and operating cash flows do not negatively covary with credit spread differential more than they do with the risk-free rate differential. I test this prediction in the empirical section and draw conclusions regarding the relative volume of hedged versus unhedged foreign currency debt issuance.

2.4 Cross-currency basis swap market

Currency swap traders have a quadratic cost of providing liquidity in the currency basis swap market. They choose the optimal size of swap position s given the price of basis swap Δ and risk tolerance γ, and they solve the following

$$\max_s s\Delta - \frac{1}{2\gamma}s^2. \tag{18}$$

Thus, the equilibrium price of basis swap satisfies

$$\Delta = \frac{1}{\gamma}s = \frac{1}{\gamma}Dfh. \tag{19}$$

That is, the cost of hedging increases in amount of total hedging needs and decreases in swap trader risk tolerance.

2.5 General equilibrium and comparative statics

Combining equations (13), (16), (15), and (19) for four endogenous variables, we can solve the model and obtain the following solution:

$$
\begin{aligned}
d^* &= \frac{V_P\left(-D\theta(-2k\phi+2\rho+\phi)+V_\omega\left(-D(D+\gamma(1-2k)\phi)-\left(\delta_E-\delta_U\right)\left(\gamma\phi+D\right)\right)+\theta\phi\left(\delta_U-\delta_e\right)\right)}{2DV_P\left(\theta+\gamma V_\omega\right)+\tau V_\omega(\gamma\phi+D)+\theta\tau\phi} \\
f^* &= \frac{V_P\left(\delta_E-\delta_U+D\right)\left(\theta+\gamma V_\omega\right)+\tau\left(-\theta\rho+\theta k\phi+\gamma k\phi V_\omega\right)}{2DV_P\left(\theta+\gamma V_\omega\right)+\tau V_\omega(\gamma\phi+D)+\theta\tau\phi} \\
\Delta^* &= \frac{\tau\phi\left(DkV_\omega+\theta\rho\right)+DV_P\left(V_\omega\left(\delta_E-\delta_U+D\right)+2\theta\rho\right)}{2DV_P\left(\theta+\gamma V_\omega\right)+\tau V_\omega(\gamma\phi+D)+\theta\tau\phi} \\
h^* &= \frac{\gamma\tau\phi\left(DkV_\omega+\theta\rho\right)+\gamma DV_P\left(V_\omega(D+\delta_E-\delta_U)+2\theta\rho\right)}{D\tau\left(-\theta\rho+\theta k\phi+\gamma k\phi V_\omega\right)+DV_P(D+\delta_E-\delta_U)\left(\theta+\gamma V_\omega\right)}
\end{aligned}
$$

The general equilibrium solution delivers similar comparative statics and intuitions as in the partial equilibrium:

- $\frac{\partial d^*}{\partial(\delta_E-\delta_U)} < 0$ An exogenous increase in euro bond demand relative to dollar bond demand compresses the relative credit spread.

- $\frac{\partial f^*}{\partial(\delta_E-\delta_U)} > 0$, $\frac{\partial f^*}{\partial(\delta_E-\delta_U)\gamma} > 0$ An exogenous increase in euro bond demand relative to dollar bond demand increases debt issuance in euro. The impact is stronger when the currency swap market has more risk tolerant intermediaries.

- $\frac{\partial \Delta^*}{\partial(\delta_E-\delta_U)} > 0$ An exogenous increase in euro bond demand increases the hedging cost such that it is more costly to swap EUR to USD.

- $\frac{\partial \triangle}{\partial \gamma} < 0$, $\frac{\partial^2 \Delta}{\partial\partial(\delta_E-\delta_U)\partial\gamma} < 0$ More risk tolerant intermediary in the currency market wealth reduces deviations in CIP and the impact of credit demand on CIP deviations.

I show in the next section that the empirical results that reflect these comparative statics.

3 Empirical analysis

3.1 Data and Descriptive Summary

3.1.1 Credit spreads

I measure credit risk with the average Option-Adjusted Spread (OAS) of corporate bond portfolios tracked by Bank of America Merrill Lynch (BAML) Global Index Systems. The indices track corporate bonds with specific credit ratings and denomination currency. For USD, EUR, and GBP, the indices are additionally categorized into maturity buckets.

Figure 7 presents time series of single A credit spreads for USD, EUR, GBP, JPY and AUD. Credit risks associated with bonds of different denomination currency appear to be strongly correlated around the financial crisis. Yen-denominated credit risk appear to be low throughout the entire sample period. This might be reflecting Japan's low interest rate throughout the last two decades and domestic investors' reaching-for-yield behaviors that had compressed the Yen credit risk premium. Figure 7 Panel B presents credit spreads relative to the USD credit spread. Relative credit spreads show a substantial amount of variations over time. In addition to sharp movements during the financial crisis, relative credit spreads also had large movements during the European debt episode in 2011 and in the late 1990s and early 2000s.

3.1.2 Corporate debt issuance

I obtain corporate debt issuance data from the Thomson Financial Securities Data Company (SDC) Platinum Global New Issues data set over the period from 1996 to 2015. For my main analysis, I focus on corporate debt issued by public firm in five major free-floating funding currencies - USD, EUR, GBP, JPY, AUD. These five currencies represent over 90% of all debt issued globally in the database. I filter out debt issuances of less than $50 million and focus exclusively on public firms. Small issuance amounts and debt issuances by private firms are unlikely to be currency hedged and are therefore excluded in the analysis. I also exclude short-term debt with maturity of less than 2 years and AAA-rated bonds. The relative credit spreads of AAA corporate bonds denominated in different currencies are more stable, therefore firms are less motivated by financing cost savings when they issue abroad. The weighted average maturity of the issuance in the filtered sample is 8.9 years.

I define net bilateral issuance flow between two currency pairs, for instance, the euro and dollar, as the amount of dollar debt issuance by European firms minus the amount of euro debt issuance by U.S. firms. I express this net amount in billions of dollars (converted using the exchange rate at the time of issuance) and denote it as $Iss_t^{EU\rightarrow US}$. Figure 11 graphs the net bilateral issuance flows between each of the foreign currency regions and the U.S. The time series show a substantial amount of variations at the monthly level. I smooth this volatility by using 6 month averages in my later analysis. I focus on bilateral flows with the U.S. since the U.S. corporate bond market is the largest with around 60% of the global corporate debt issuance in the sample. When firms in other regions consider issuing abroad, the natural choice is to issue in the dollar.

3.1.3 Broker-dealer leverage

I construct leverage ratio for U.S. broker-dealers using the Federal Reserve Flow of Funds data. Following Adrian, Etula and Muir (2014), I define broker-dealer leverage as

$$BDLev_t = \frac{\text{Total Financial Assets}_t^{BD}}{\text{Total Financial Assets}_t^{BD} - \text{Total Financial Liabilities}_t^{BD}}.$$

Figure 10 plots the time series for $BDLev_t$. Leverage ratio spiked up just prior to the global financial crisis. Post-crisis leverage has been subdued as a result of risk limits and regulatory pressures.

3.1.4 Currency basis and other market data

Pricing data on cross-currency basis swaps, interest rate swaps, exchange rates are from Bloomberg. Summary statics are provided in Table 1. Figure 1 presents the long-term deviations in covered interest rate parity as measured by the 10 year cross-currency basis.

3.2 Results

In the following section, I first show the relation between issuance flow and relative credit spreads in different denomination currencies. Lower relative credit spread in a particular currency predicts an increase in issuance volume in that currency. Issuance flow is also much more sensitive to credit spread differential than interest rate differential, suggesting a high ratio of FX hedging. Second, I examine the impact of issuance flow on cross-currency basis. Large amount of cross-currency issuance is accompanied by changes in currency basis, suggesting that debt issuance related FX hedging distorts the currency forward market. Third, I explore the direct relation between relative credit spread and CIP distortion and show that the effective relative credit spread forecasts currency basis movements. Finally, I examine QE demand shocks to the credit market, the effects on credit spreads and issuance flows.

3.2.1 Forecasting cross-currency issuance flow using relative credit spread

Univariate forecasting Table 2 presents several variations of univariate time-series forecast of cross-currency debt issuance using credit spread differential between the Eurozone and the U.S. The baseline regression shown in column 1 is specified as the following,

$$Iss_{t+1}^{EU \to US} = a + b \cdot \text{CrdSprdDiff}_t^{EUR-USD} + u_{t+1}$$

where $Iss_{t+1}^{EU\rightarrow US}$ is the net bilateral debt issuance flow between Eurozone and the U.S., and $\text{CrdSprdDiff}_t^{EUR-USD}$ is the credit spread (OAS) differential between EUR-denominated corporate debt and USD-denominated corporate debt. The regression coefficient of 0.0675 (s.e.=.0212) indicates an increase of US$1.9 billion in monthly net issuance flow from the Eurozone to the U.S. for a one standard deviation increase in Single-A Euro credit spread relative to dollar credit spread. In column 2, the relative credit spreads are adjusted for currency hedging cost by adding on the associated currency basis. Firm typically considers the cost of hedging in its cross-currency debt issuance decision if it lacks currency exposure on asset-side of its balance sheet. Thus it is reasonable to also include basis as a cost in constructing the effective credit spread differential. The smaller coefficient on the effective credit spread differential indicates that FX hedging costs due to CIP violations dampen the issuance flows and the firms' ability to integrate the credit markets. Column 3 applies the same regression to the average monthly issuance flow over the next 6 months as the dependent variable of interest. The reason for averaging is twofolds. First, we expect some delays in firm's debt issuance response due to various institutional constraints. This represents slowness in the movement of capital as discussed by Duffie (2010) and in the cross-market case by Greenwood, Hanson, and Liao (2015). I show the slow response of issuance flows by plotting the (simple) impulse response function of shocks to the effective credit spread differential on the net bilateral issuance flows in Figure 12. Issuance flows peak two months after a shock to the credit spread differentials, but cross-currency issuance remain elevated many months after the shock. Second, the debt issuance is lumpy. This can be seen directly in the time series in Figure 11. Large spikes in monthly issuance flow are often the result of a few large issuances.

Columns 4-6 examines time-series forecast of cross-currency debt issuance as a fraction of total issuance with the following regression test

$$issPct_{t+1}^{EU\rightarrow US} = a + b \cdot \text{CrdSprdDiff}_t^{EUR-USD} + u_{t+1}$$

where $issPct_{t+1}^{EU\rightarrow US} = Iss_{t+1}^{EU\rightarrow US}/IssuanceTotal_{t+1}^{EUR+US}$. The results are similar, however the interpretation is different. Expressing issuance flow as a fraction of total issuance amount is equivalent to examining the choice of issuance currency conditional on financing needs. This is different from examining the dollar amount of issuance flow, which might reflect opportunistic timing of issuance. Conditioning on total issuance amount also can address seasonal trends. For instance, August and December are typically low in corporate debt issuance. The baseline regression in column 4 has a coefficient of 0.0734 (s.e.=.0112), indicating that each additional basis point in relative credit spread increases net issuance flow by 0.073% of total issuance.

Multivariate forecasting Table 3 presents the multivariate version of the forecasting regression. Columns 1 and 4 controls for lagged issuance flow. Columns 2 and 5 controls for dollar swap rate, interest rate differential, dollar credit spread and log change in exchange rate. Columns 3 and 6 controls for these variables in addition to lagged values. The regression coefficients are smaller in comparison to univariate regressions, but they remain both statistically and economically significant. The most striking result is that cross-currency issuance flows are much more sensitive to credit spread differential than they are sensitive to interest rate differential. In the full multivariate forecast regression shown in column 3, the coefficient on relative credit spreads is more than twice as large as the coefficient on swap rate differentials[16]. Each basis point increase in the relative credit spread of single A European corporate bond is associated with $49 million of additional issuance flow next month, but each basis point increase in the interest rate differential is only associated with $13 million of additional issuance flow in the following month. This is supportive of the hypothesis that firms are engaged in FX-hedged opportunistic issuance in which they issue in currencies with lower credit spread but not necessarily lower overall yield. As discussed in Section 2.3, the statistically insignificant coefficient on swap rate differential indicates that much of the foreign issuance are FX hedged. The relative magnitude of the coefficients on credit spread and rate differentials offers an empirical test of proposition 1.

I extend the analysis to other currencies pairs and report the results in Table 4. Effective relative credit spread is a predictor of future issuance flows for the Eurozone, U.K., Japan and Australia. The size of the coefficient varies across currency region, with the Eurozone having the largest coefficient. This variation reflects the relative size of debt capital market and issuance needs in each region. Consistent with the hypothesis of hedged cross-currency issuance, interest rate differential does not appear to be a significant predictor of issuance flow between the four currency regions and the U.S.

3.2.2 Impact of issuance flows on cross-currency basis

Foreign currency debt issuance are often hedged for currency risk immediately following issuance using currency basis swaps. In this section, I assess the price impact of issuance flow on cross-

[16] Swap rate is used to proxy for risk-free benchmark rate in the analysis. Swap rate reflects the underlying hedging instrument used when firms consider hedging needs in issuance decisions as discussed in section 1.

currency basis, or alternatively distortion to Covered Interest Rate Parity. First, I examine the contemporaneous relation between cross-currency issuance flow and currency basis using monthly aggregate data. Second, I show the impact of issuance on currency basis at the daily horizon.

European firms' debt issuance in dollar exerts EUR lending/USD borrowing (pay Euribor vs receive $Libor) pressure on cross-currency basis. In the following regression specification,

$$\triangle basis_t = a + b \cdot IssEUtoUS_t + \varepsilon_t$$

where $IssEUtoUS_t$ indicates the amount of dollar debt issuance by European firms, we would expect the coefficient b to be positive. Similarly, U.S. firms' debt issuance in euro exerts EUR borrowing/USD lending (receive Euribor vs pay $Libor) pressure on currency basis, pushing CIP deviation towards the opposite direction. In the following regression

$$\triangle basis_t = a + b \cdot IssUStoEU_t + \varepsilon_t$$

where $IssUStoEU_t$ indicates the amount of euro debt issuance by U.S. firms, we should see a negative coefficient b. Combining the two single direction flows, we should expect to see a positive coefficient in the regression of currency basis on net issuance flow

$$\triangle basis_t = a + b \cdot Iss_t^{EU \to US} + \varepsilon_t.$$

Table 5 presents regression results showing the impact on currency basis by issuance flows between the U.S. and the Eurozone. All the coefficients have signs that are as predicted. Since the U.S. has a larger corporate bond market, the issuance flows into the U.S. is stronger than outward issuance flows. Correspondingly, the regressions detect larger and more significant coefficients for issuance flows into the U.S. (column 2) than for outwards flows (column 3). Column 4 adds an interaction between U.S. broker-dealer leverage and net issuance flows. As predicted by the comparative statics in Section 2.3, higher broker-dealer leverage, a proxy for more arbitrageur capital, reduces the impact of issuance flow on currency basis. Figure 13 graphically illustrate the result in Table 5, columns 1 and 5. The time series display strong correlation between issuance flows and changes in CIP at both the low and high frequencies. The plot also shows that fluctuations in currency basis were small prior to 2008. This likely reflects the fact that large amount of arbitrage capital, primarily those that utilize banks' balance sheets, were available prior to the global financial crisis.

Table 5 column 6 presents regression results showing the impact of issuance flow on currency basis controlling for contemporaneous changes in exchange rate. The coefficient on exchange rate movement is highly statistically significant. This can be interpreted as a linkage between CIP deviations and UIP (uncovered interest rate parity) deviations. Price pressures in currency forwards is linked to the price pressures on the spot exchange rate. As it becomes more costly to swap into a currency, some firms and end-users of forwards (or swaps) might forgo hedging altogether and opt for unhedged exposure. Dealer hedging of cross-currency basis swaps might also exert an impact on the spot exchange rate directly.

I expand the analysis to other currencies in Table 6. The signs on issuance flow coefficients are all in the right direction. The lack of statistical significance in GBP is in part due to the variability introduced by other factors and anticipatory effect of issuance[17] when analyzing using monthly observations. In panel B, I assess the impact of broker-dealer leverage-weighted issuance flow measures on the currency bases. I find that leverage strengthen the impact of issuance flows.

I further enhance the identification by using daily observations in the analysis. Conversations with issuers and debt capital market teams at investment banks have indicated that debt issuance are typically hedged either immediately before or after the issuance date. I observe clear patterns of issuance impact on CIP in days surrounding cross-currency debt issuance. Table 7 presents regression results at the daily interval. For each currency, I regress the daily change in currency basis in days surrounding an issuance ($t-1$, $t-2$, etc) on the net issuance flow amount of date t. For instance, the first column shows the impact of net issuance flow of date t on the daily change in currency basis of date $t-5$. Observations with absolute net issuance flow amount less than \$100 million are excluded in the regression since the price impact is likely small. The sample sizes for each currency indicates the number of days net issuance flow at date t is greater than \$100 million in absolute value. The regression coefficients show that the issuance impact on currency basis is largest in size and most statistical significant on date $t-1$, t, and $t+1$. The coefficients are reduced and often loses statistical significance on dates further away from t. This result corroborates the hypothesis that large issuance flows have observable impact on CIP deviation surrounding the issuance date. In the euro-dollar currency basis, the regression coefficients have statistical significance even as early as date $t-5$. This indicates that issuers might have entered currency hedge a week in advance of the issuance. Alternatively, this might be reflecting cross-currency issuance waves in which multiple

[17]Some hedge funds are able to time the issuance and forecast the impact on the currency basis. This anticipatory effect reduces the impact on basis when the issuance actually occurs.

large issuances occur in a short period of time.

3.2.3 Forecasting of cross-currency basis using credit spread

I examine the direct relation between relative credit spread and CIP violation in Table 8. When the relative credit spread is low, more firms opt to issue in the associated currency. The exchange rate hedging of the issuance flow in turn exerts price pressure on currency basis, causing a violation of CIP. Table 8 presents the results of the following forecasting regression

$$\triangle basis_{t+1} = a + b \cdot \text{CrdSprdDiffEff}_t + \varepsilon_{t+1}.$$

The dependent variable is the future six-month change in currency basis. Six-month change is chosen because issuance flow responds slowly to credit spread differences, as shown Table 2. Using three-month change in basis as the dependent variable does not alter the result significantly. The magnitude of coefficients ranges between 0.086 (for GBP) and 0.14 (for JPY) in the regressions with controls. That is, roughly every 10 basis point difference in the effective credit spread of single A rated bonds translates into 1 basis point of impact on subsequent CIP deviation. Given the size and liquidity of the currency forward market, this measurable violation in long-term CIP due to a single force is notable. In addition, market anticipation of cross-currency issuance likely dampens the measurable forecasting power of effective credit spread.

3.3 QE Response

Large Scale Asset Purchasing programs by central banks can generate large demand shocks in the local credit market even though the purchase might not be directly in corporate bonds. As local investors reach for higher yields, they switch from government bonds to corporate bonds. The relative ease of investors reaching-for-yield within a single currency as oppose to across currencies generates variations in credit spread differentials. To explore this exogenous source of variation, I conduct a long-term event study on the impact of Federal Reserve QE in global credit spreads. I follow the bootstrapping methodology from Mamaysky (2014). I start with the set of QE announcement dates identified by Fawley and Neely (2013). Then I select major announcement dates on which the 10-year Treasury yield changed by more than 10 basis points in absolute value. After applying this filter, we are left with eight announcement dates spread across QE1, QE2 and QE3. The average response following these eight dates is compared against a benchmark distribution obtained by randomly drawing eight dates from November 2008 to September 2012 as counterfactual announcement dates. The p-value is calculated as the fraction of simulated counterfactual responses that are smaller than the response to the actual Federal Reserve Quantitative Easing announcement dates. Table 9 shows the result from this analysis. We see from the table that credit spreads reacted very little on the initial announcement of QE announcement. Over the course of the next 15 trading days, U.S. single-A corporate credit spread tightened by over 16 basis points. While the displaced investors reach for higher yield corporate bonds in their local currency, they are unable to reach for yield across currencies. We see that credit spreads in other currencies widens relative to the U.S. It is interesting to point out that the credit spread of Yen and Aussie bonds relative to the dollar credit spread actually widened more than 16 basis points. This means that Japanese and Australian government bonds rallied over this period along with the U.S. treasury. Investors had an easier time transmitting the demand shock across government bond markets in different countries than they had with credit markets. Thus, the global government bond market (or alternatively rates market) appears to be more integrated than credit markets.

Ideally, I would extend this event study to issuance flow. However, due to the lag response of issuance to credit spread and lumpiness of issuance, event study methodology cannot be applied. Instead, I show tentative evidence by examining average issuance amount during QE periods. Figure 14 presents the bilateral issuance flow as a percentage of total issuance between Europe and the U.S. during various phases of the Fed and ECB QE programs. Consistent with the theory, we see elevated issuance flow into the U.S. during the Fed QE when dollar credit spread is tight relative to Euro credit spread. Since the start of ECB QE, we observe a reversal of net issuance flow back into the Eurozone.

3.3.1 Conclusion

In this paper, I examine the connection between violations of long-term covered interest rate parity and the relative pricing of credit risk in different currencies. Firms act as a natural arbitrageur that integrate the global credit market through their issuance decisions. The process of integrating one market (the credit market) could distort a separate market (the FX forward market). I showed that the bulk of issuance flow across major currencies are FX hedged. This reflects a globalization of funding sources rather than risky carry trade behavior by firms. Understanding who are the "noise traders" and what are the drivers of their behaviors are essential in resolving frictions. The term structure of arbitrage deviations could offer valuable information in diagnostics of market congestion.

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4 Figures

Figure 1 Long-term cross-currency basis (CIP deviations)

This figure presents the 10-year cross-currency basis swap levels (violations of covered interest rate parity at the 10 year horizon) between each of the four major free-floating funding currencies - EUR, GBP, JPY, AUD - and USD. Currency basis is a market determined spread that equilibrates the simultaneous borrowing and lending in two currencies at the respective floating reference rates. A positive currency basis indicates strong demand of simultaneously lending in the dollar and borrowing in the foreign currency (sell dollar in the spot market, buy dollar in the forward market). A negative currency basis indicates a strong demand of borrowing in the dollar and lending in the foreign currency (buy dollar in the spot market, sell dollar in the forward market). Currency basis conventionally is added to the foreign reference rate such that the lending and borrowing is deemed fair by both counterparties. E.g. A EUR borrower/USD lender pays $Euribor + basis$ and receives $\$Libor$, while the other party (EUR lender/USD borrower) receives $Euribor + basis$ and pays $\$Libor$.

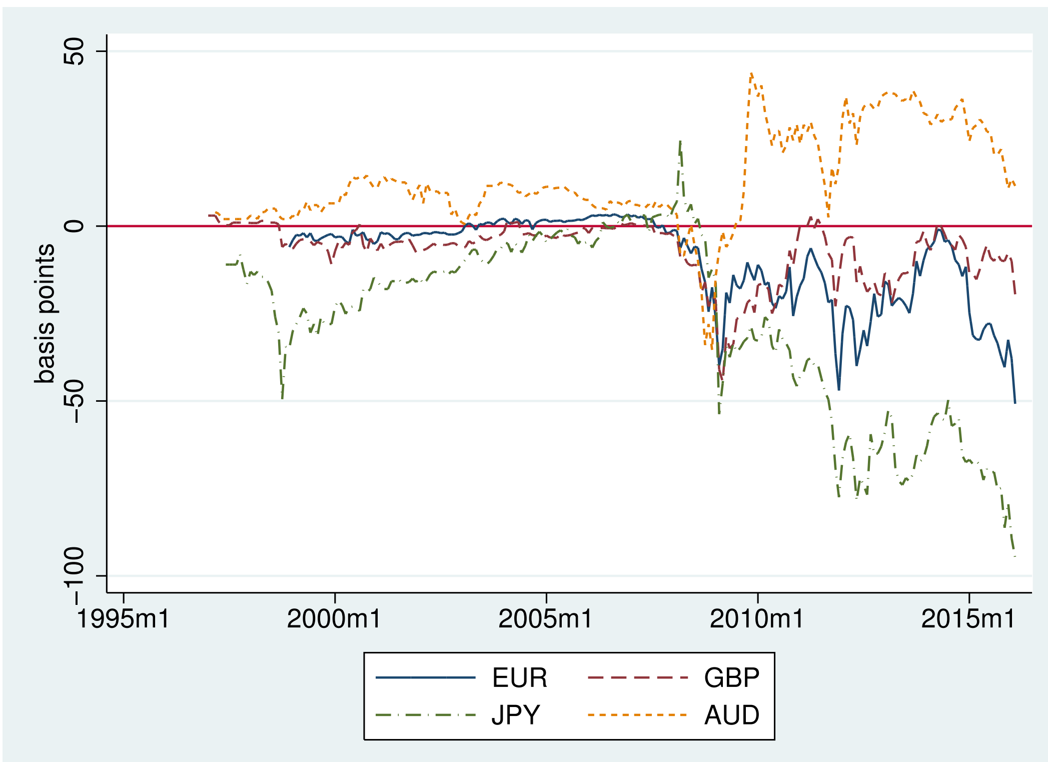
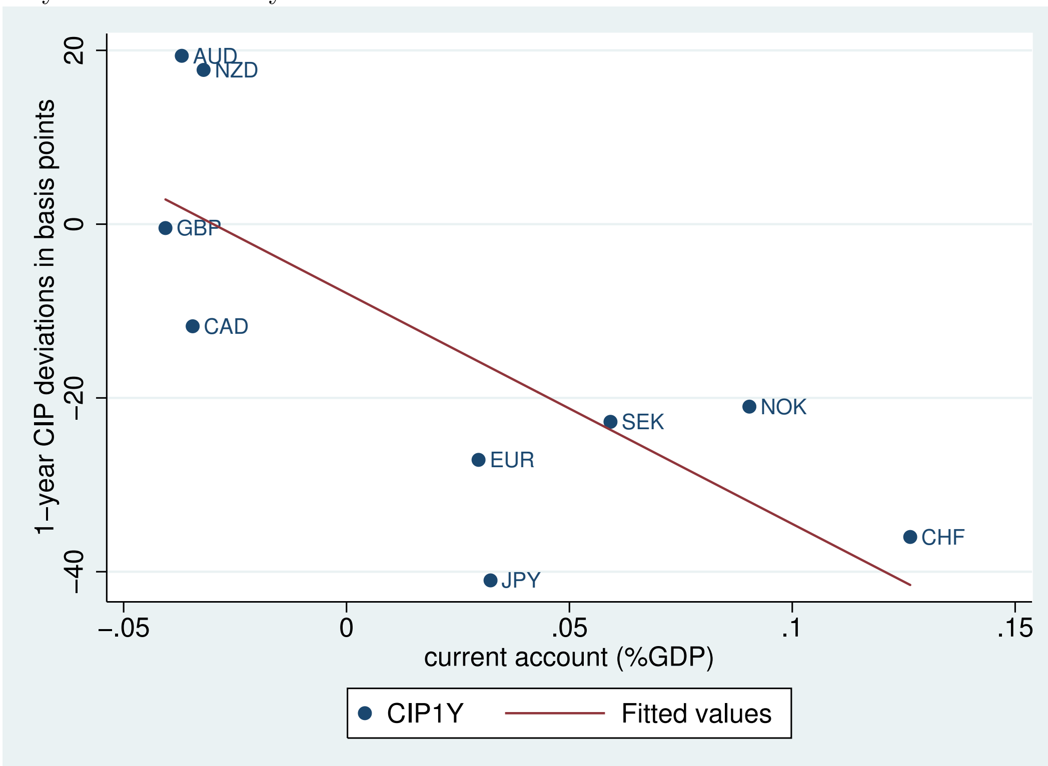


Figure 2 Cross-currency basis and current account

This figure presents a scatter plot of cross-currency bases (CIP deviations) at 1-year and 10-year horizons and current accounts as a percentage of GDP for G10 countries as of June 2015.

Panel A 1-year cross-currency basis and current account



Panel B: 10-year cross-currency basis and current account

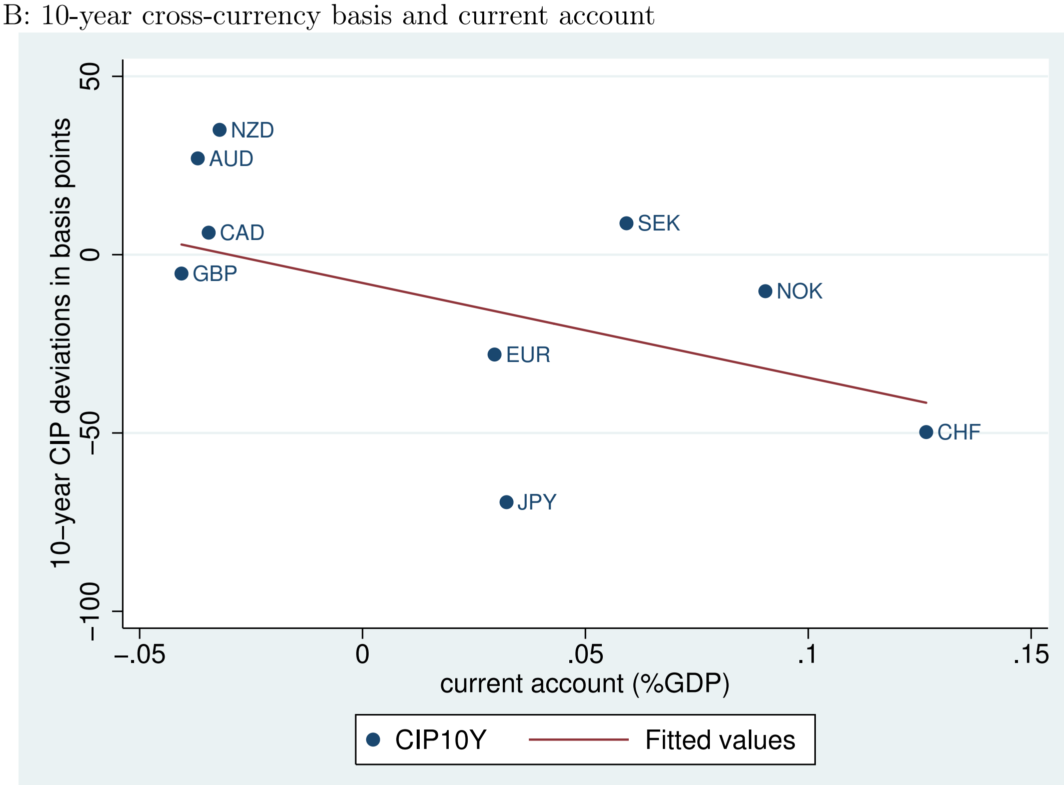


Figure 3 Cross-currency basis swap cash flows

This figure decomposes the cash flows of a lend EUR/borrow USD (receive *Euribor* + *basis* versus pay \$*Libor*) cross-currency basis swap into two floating-rate notes (FRNs) in EUR and USD. The euro lending cash flows are shown in blue and the dollar borrowing cash flows are shown in red. Upward arrows represent payments and downward arrows represent receivables. An initial exchange of €1 for \$1.1 (at the spot FX rate) is made at the swap initiation date. Floating rate coupons based on the *Euribor* and \$*Libor* reference rates are exchanged every quarter in the interim. A final exchange of the original principal amount (at the initial FX rate) is made at the maturity date. The other counterparty of this swap holds a borrow EUR/lend USD position and the reverse of the cash flows shown below.

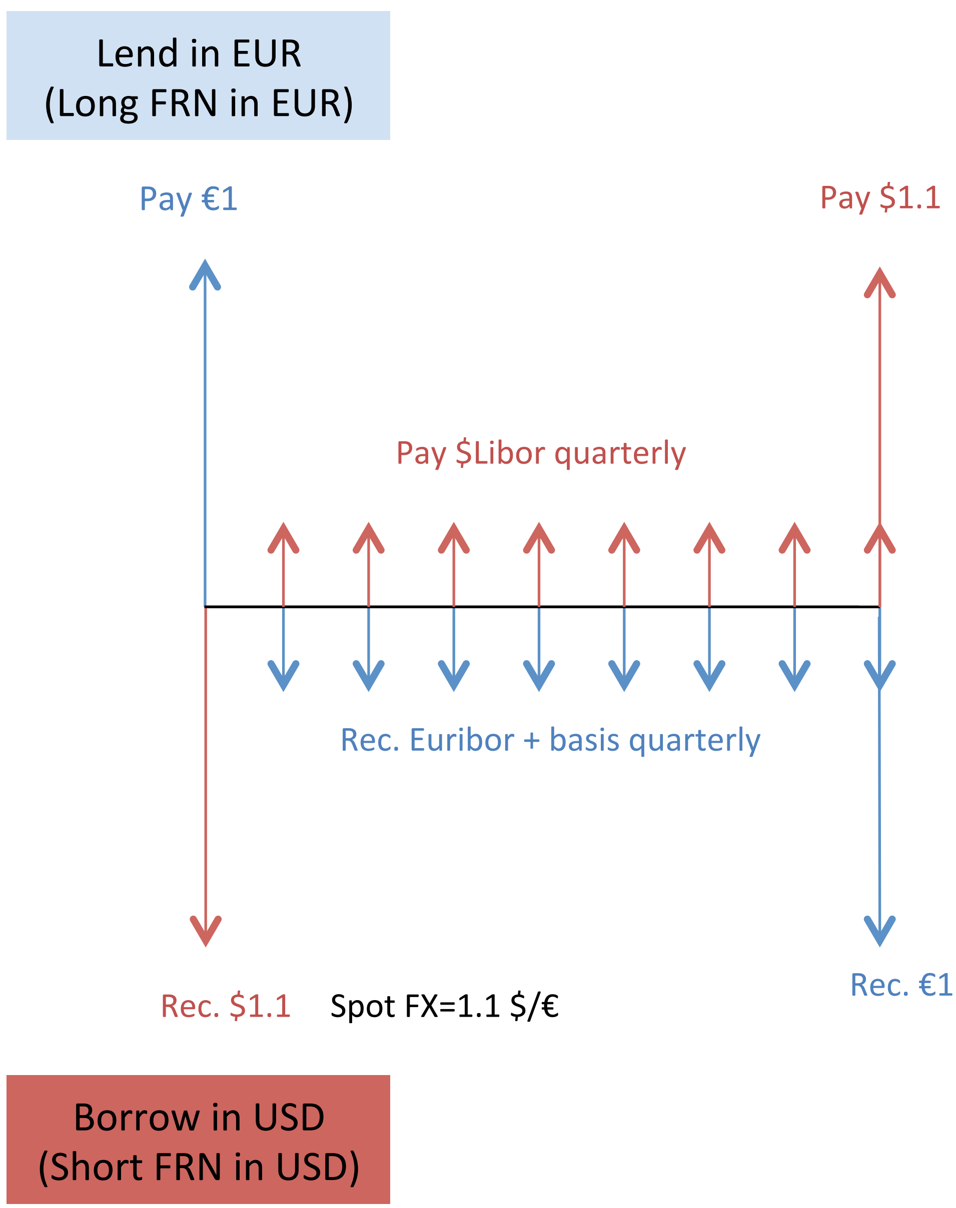


Figure 4 Yield decomposition and synthetic local bond

This figure presents the decomposition of corporate bond yields and the yield of a synthetic dollar bond. The synthetic fixed-rate dollar bond is constructed from the euro bond after hedging with the appropriate market instruments. The difference in short-term funding rates between the two currencies become irrelevant to the bond issuer when the issuer engages in FX hedging using cross-currency basis swap. The difference in term spreads become irrelevant when fixed-to-floating swaps are used to lock in the fixed coupon payments. The only remaining difference between a vanilla dollar bond and a synthetic dollar bond is the credit spread differential between EUR- and USD- denominated bonds. FX hedged cross-currency issuance captures this credit spread differential as a saving to the issuer.

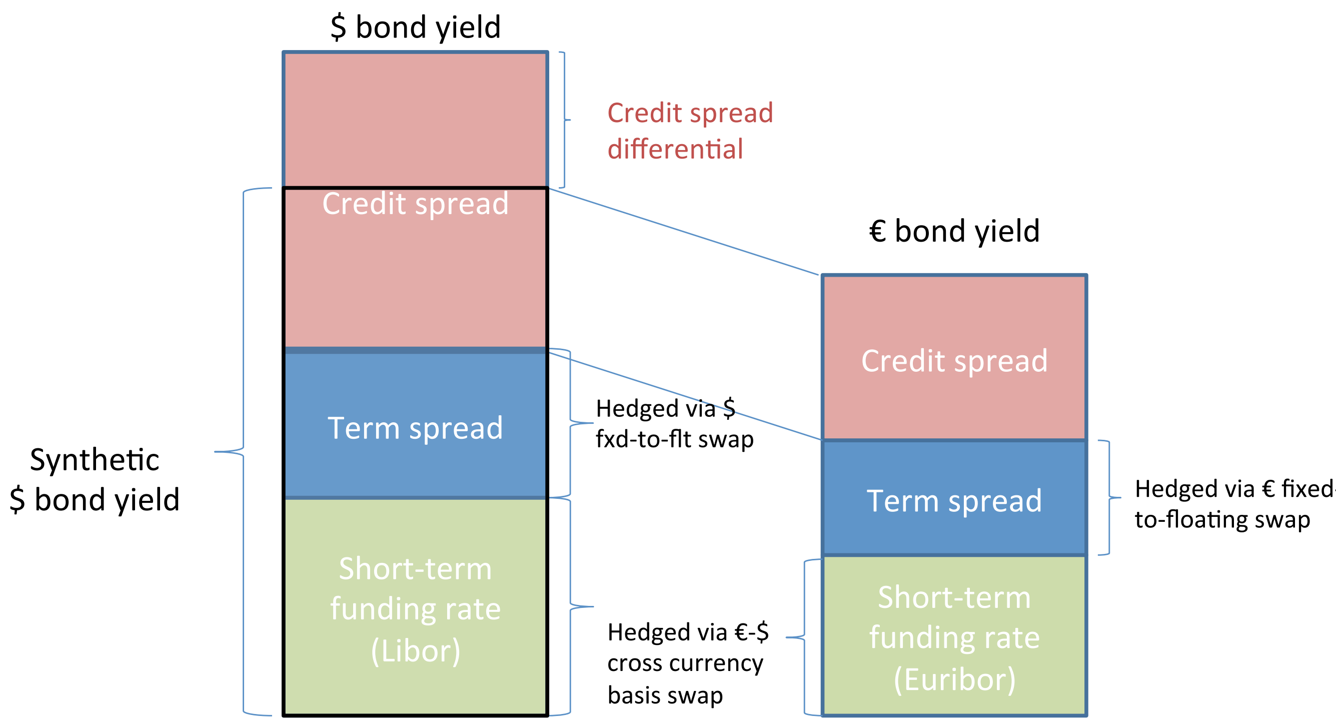


Figure 5 Cross-currency basis (CIP violations) for EUR-USD

This figure plots the historical 3 month and 10 year deviations in CIP as measured by cross-currency basis. Cross-currency basis swap is a simultaneous lending and borrowing of funds in EUR and USD for a defined maturity at the floating reference rates.

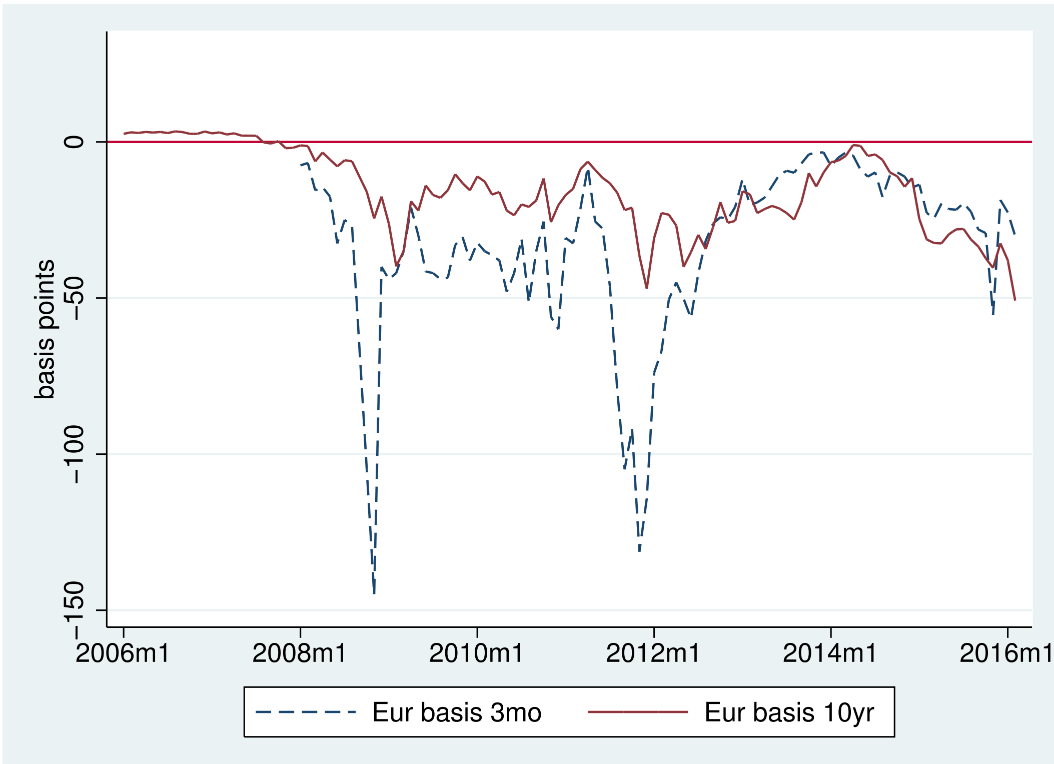


Figure 6 Term structure of cross-currency basis (CIP violations) in April 2015

This figure presents the term structure of CIP violations as measured by cross-currency basis of varying tenors on April 21, 2015.

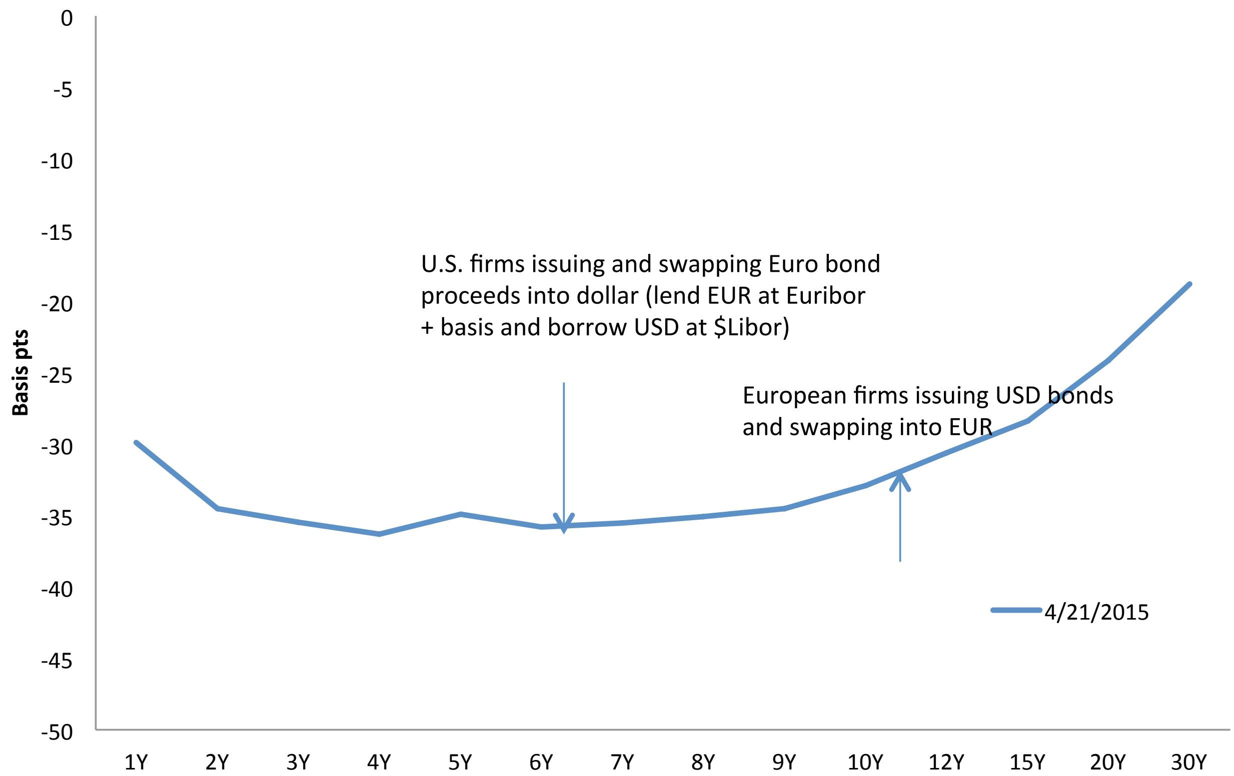
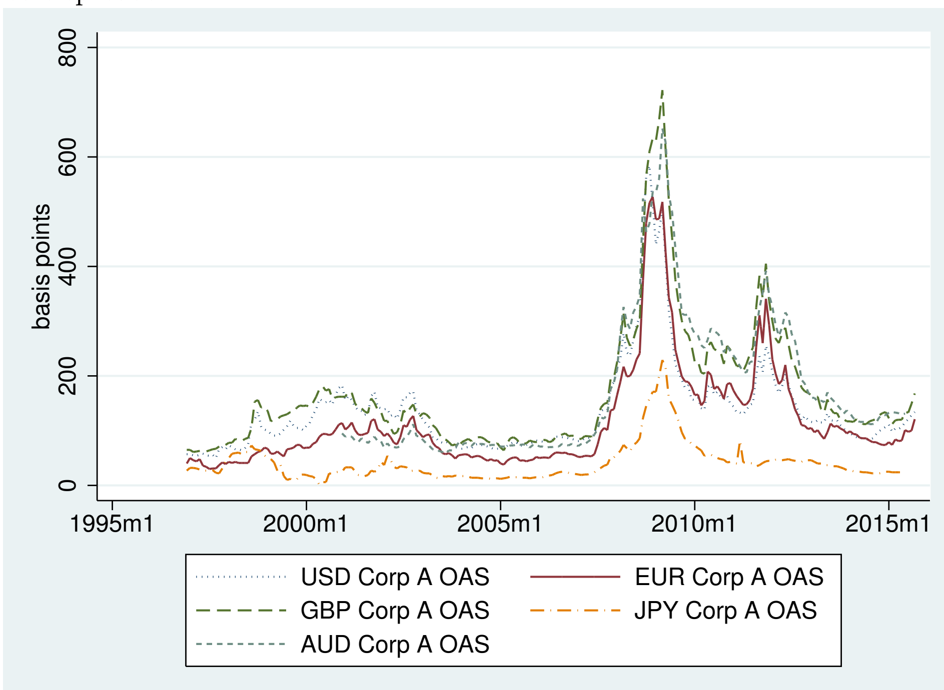


Figure 7 Credit spreads

This figure plots the historical single-A Option Adjusted Spreads of corporate bonds denominated in different currencies. The bonds are from the Bank of America Merrill-Lynch bond indices. Credit spread differentials are expressed relative to the credit spread of dollar-denominated bonds.

Panel A: Credit spreads



Panel B: Credit spread differentials (relative to dollar credit spread)

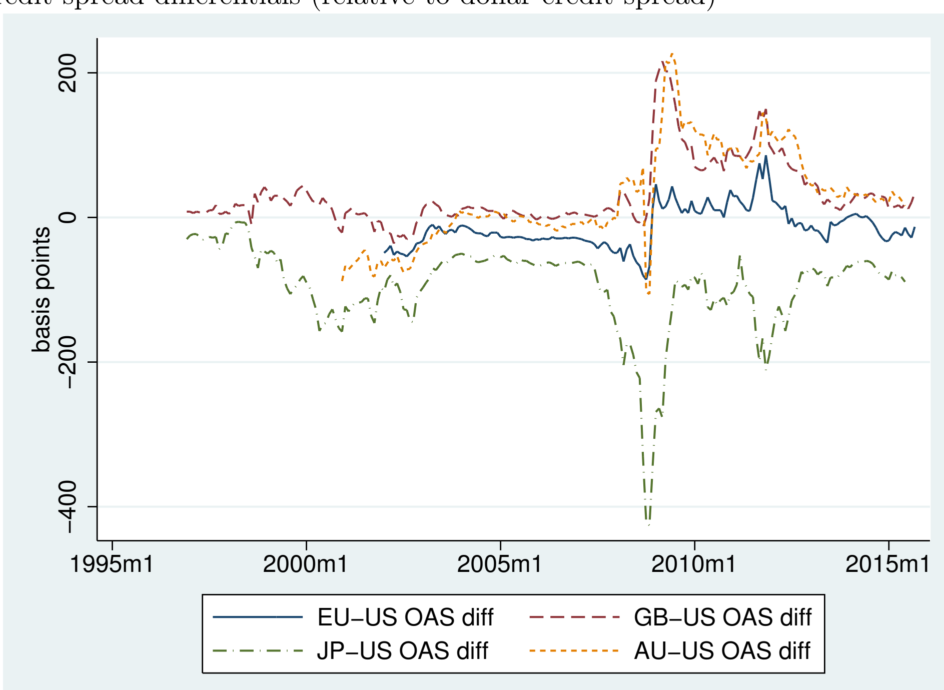


Figure 8 Model setup

This figure presents a setup of the model as described in Section 2.

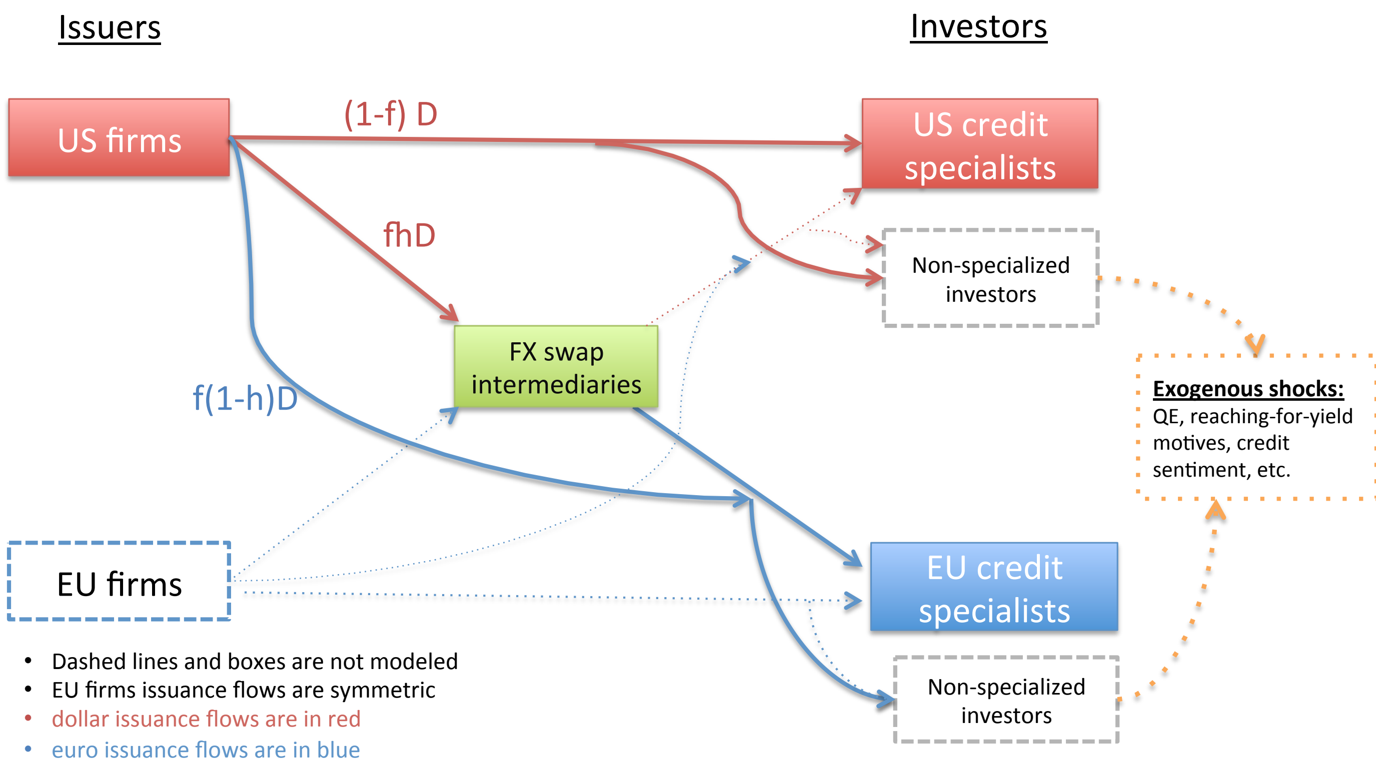


Figure 9 Term structure of cross-currency basis (CIP violations) in April 2015

This figure presents the term structure of CIP violations as measured by cross-currency basis of varying tenors on April 21, 2015.

Figure 10 Broker-dealer leverage

This figure plots the historical U.S. broker-dealer leverage calculated using data from the Federal Reserve Flow of Funds. Broker-dealer leverage is defined by $BDLev_t = \frac{\text{Total Financial Assets}_t^{BD}}{\text{Total Financial Assets}_t^{BD} - \text{Total Financial Liabilities}_t^{BD}}$.

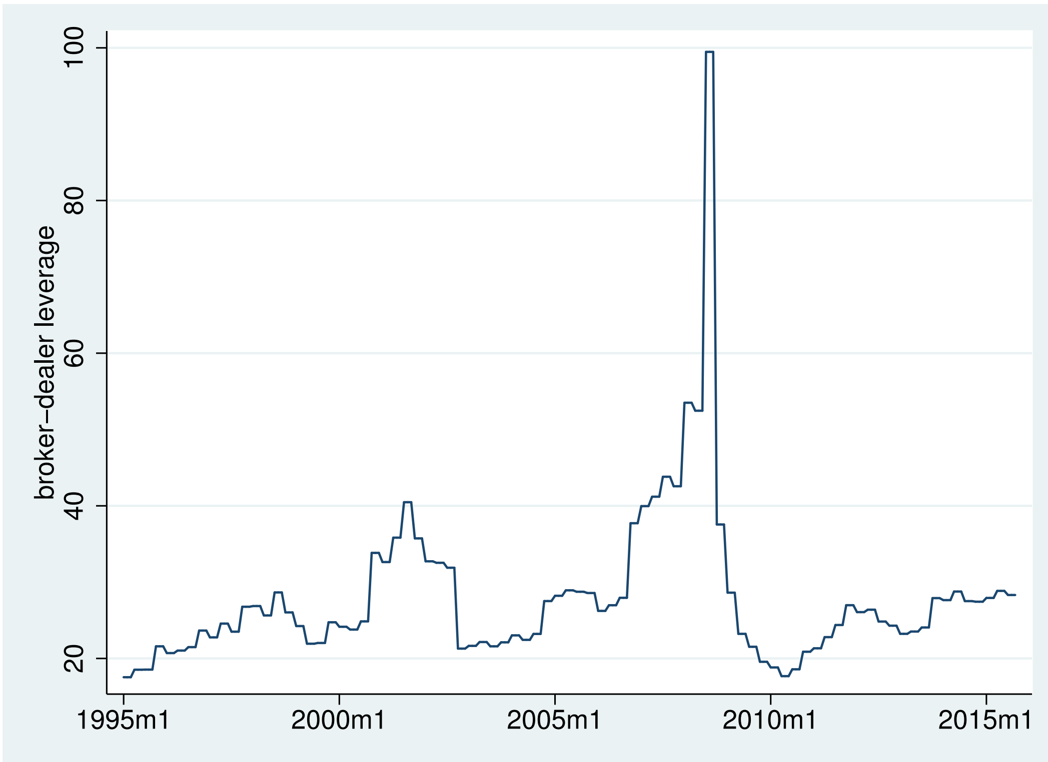


Figure 11 Net bilateral monthly issuance flows

This figure plots the historical monthly net bilateral issuance flows for each of the four currency pairs. Net bilateral issuance flow is defined as the amount of debt issuance by foreign firms in dollar minus the amount of debt issuance by U.S. firms in the foreign currency.

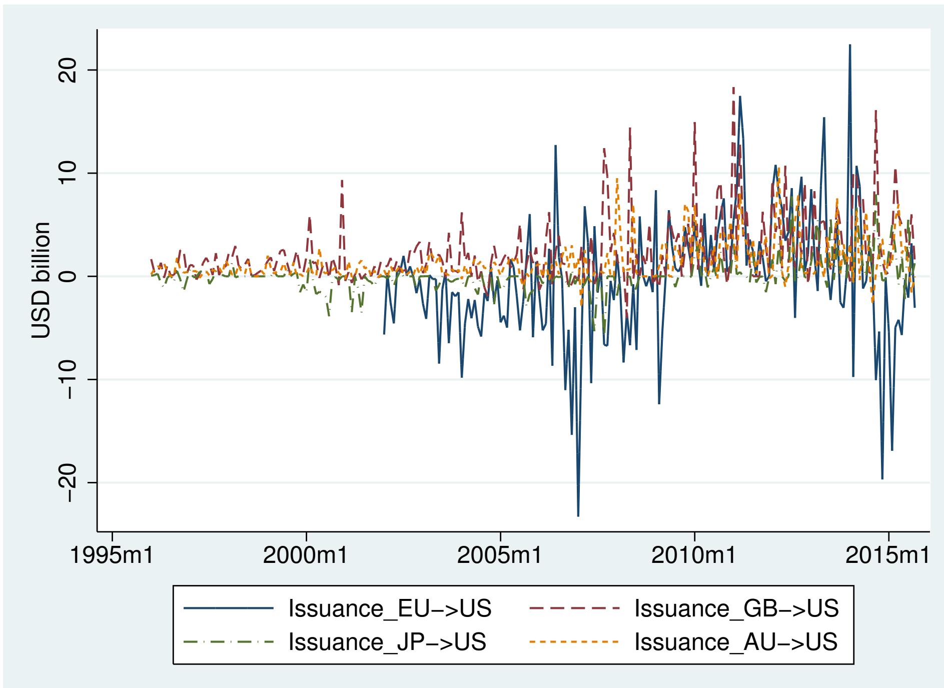


Figure 12 Impulse responses of monthly issuance flows to shock to effective credit spread differentials

Using monthly data, I estimate a first order vector autoregression (VAR) of the form

$$
\begin{aligned}
\text{Iss}_{t+1}^{F\to US} &= a_1 + b_1 \cdot \text{Iss}_t^{F\to US} + c_1 \cdot \text{CrdSprdDiffEff}_t + \varepsilon_{1,t+1} \\
\text{CrdSprdDiffEff}_{t+1} &= a_2 + b_2 \cdot \text{Iss}_t^{F\to US} + c_2 \cdot \text{CrdSprdDiffEff}_t + \varepsilon_{2,t+1}
\end{aligned}
$$

I plot the (simple) impulse response functions from shocks to CrdSprdDiffEff in month $t = 0$ on net bilateral issuance flows from months $t = 1,\ \ldots,\ 10$. Confidence intervals for the estimated impulse response are shown in gray.

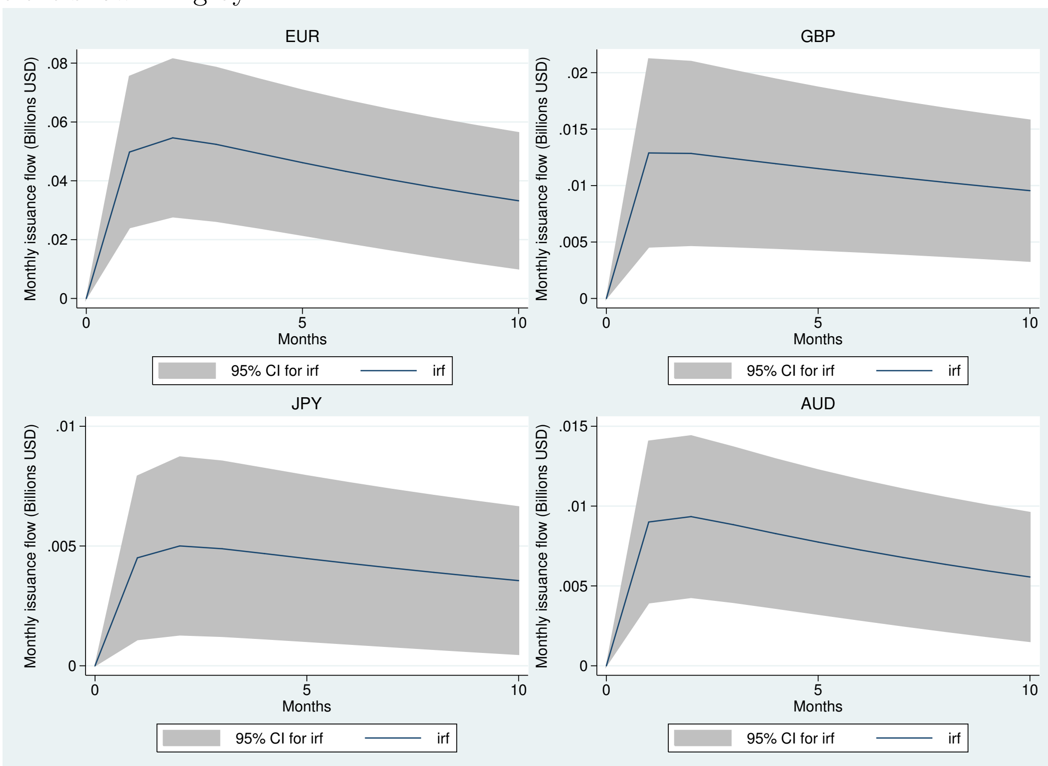
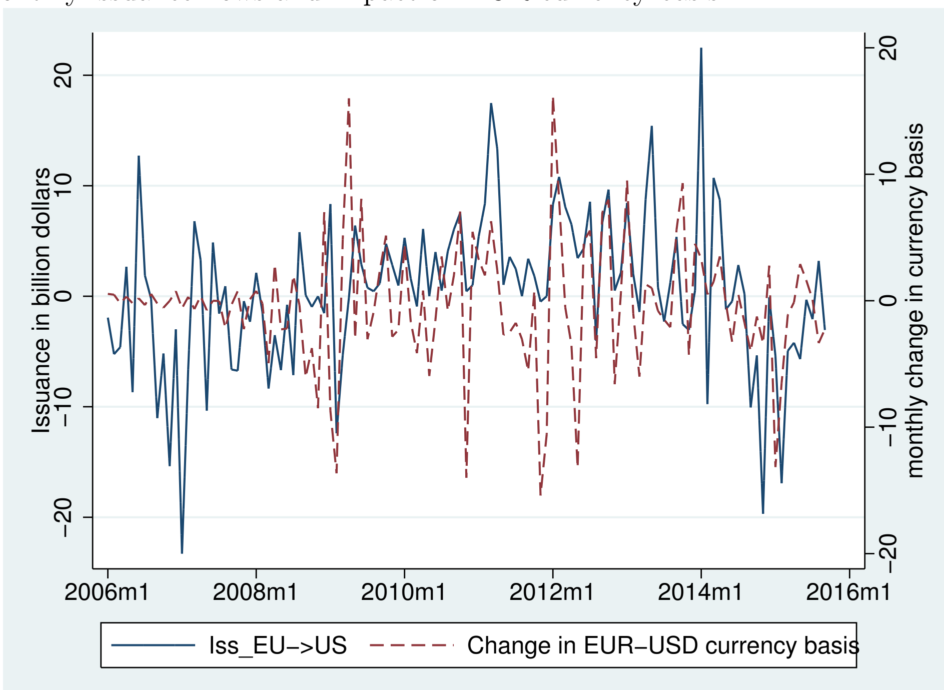


Figure 13 Monthly issuance flows and impact on currency basis for EUR-USD

This figure presents the net bilateral issuance flows between the Eurozone and the U.S. and monthly changes in 10-year cross-currency basis for EUR-USD. The figure graphically illustrates the regression in Table 5 column 1 and column 5. Net bilateral issuance flow is defined as the amount of debt issuance by European firms in dollar minus the amount of Euro-denominated debt issuance by U.S. firms.

Panel A: Monthly issuance flows and impact on EUR currency basis



Panel B: Leverage-weighted issuance flows and impact on EUR currency basis

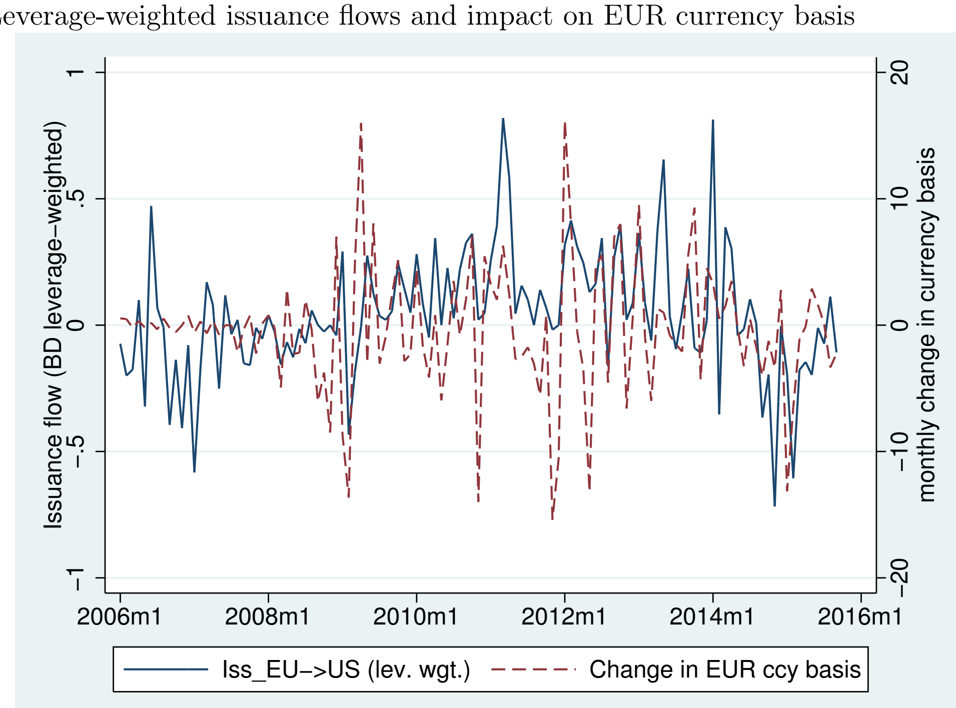
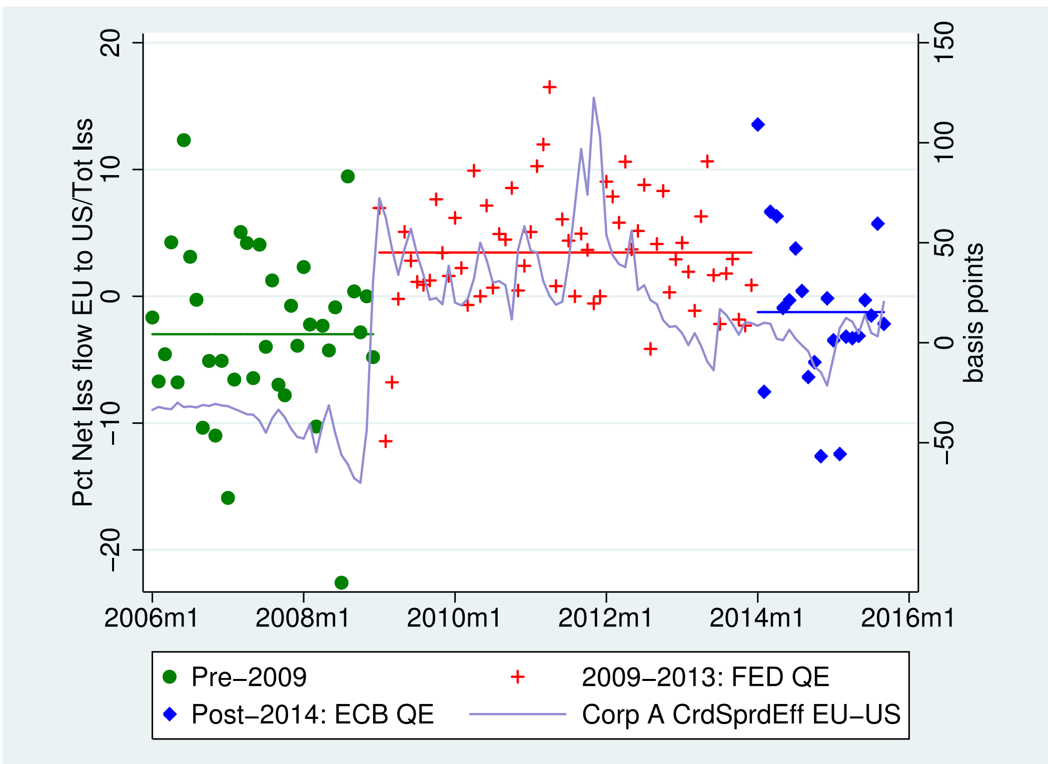


Figure 14 Issuance flow between the Eurozone and the U.S.

This figure plots the monthly net bilateral issuance flow as a percentage of the total amount of issuance (dots) and the effective credit spread differential between euro- and dollar- denominated single-A corporate bonds (grey line). Net bilateral issuance flow is defined as the amount of debt issuance by European firms in dollar minus the amount of euro-denominated debt issuance by U.S. firms. The monthly issuance flow percentages are plotted as dots and roughly divided into three periods: pre-Fed QE (before 2009), Fed QE (2009-2013), and ECB QE (2014-2015). The averages are drawn as horizontal lines. The effective single-A credit spread differential between euro- and dollar- denominated bonds is displayed in grey.



5 Tables

Table 1 Summary statistics
This table presents summary statistics on key variables used in the main analysis.

	N	Mean	S.D.	Min	Max
Net monthly bilateral issuance flows (in $billion)					
$Iss_t^{EU\to US}$	165	-0.227	6.182	-23.29	22.48
$Iss_t^{UK\to US}$	237	2.281	3.224	-4.062	18.34
$Iss_t^{JP\to US}$	237	0.0670	1.640	-5.877	7.936
$Iss_t^{AU\to US}$	237	1.305	1.939	-2.994	10.61
Net monthly bilateral issuance/Total issuance (percent)					
$issPct_t^{EU\to US}$	165	-0.273	6.021	-22.59	16.50
$issPct_t^{UK\to US}$	237	4.122	4.880	-4.780	29.84
$issPct_t^{JP\to US}$	237	-0.225	2.703	-9.611	12.67
$issPct_t^{AU\to US}$	237	2.499	3.328	-5.434	22.90
Credit Spread (BAML Single A OAS)					
US	226	136.0	86.31	50	584
EU	227	115.1	93.08	30	527
UK	227	166.9	116.3	61	722
JP	223	40.27	35.47	1	229
AU	175	173.3	129.1	58	652
Basis swap (10 year maturity) in basis points					
EU	165	-9.975	12.25	-47	3.375
UK	225	-6.772	8.166	-44.50	3
JP	220	-26.33	24.52	-78.50	25
AU	223	13.21	13.73	-35.38	44
Swap rate (10 year maturity) in basis points					
US	249	468.7	168.7	158.8	798.5
EU	165	329.8	124.9	55.60	547.9
UK	249	490.5	182.6	144.7	897.0
JP	249	163.9	79.11	48.50	480
AU	249	600.7	144.7	270	1068.2
Effective Credit Spread Difference					
EU-US	165	-4.128	35.82	-70	122.4
UK-US	225	37.76	51.16	-30.25	260.5
JP-US	217	-72.10	64.49	-417.5	9
AU-US	175	11.26	62.91	-99	229
Broker-Dealer Leverage					
BDLev	249	27.94	10.63	17.54	99.47

Table 2 Univariate forecasting of dollar-euro issuance flow

This table presents forecasting regression of future issuance flow using credit-spread differentials between euro and dollar. Net bilateral issuance flow is defined as the amount of debt issuance by European firms in dollar minus the amount of euro-debt issuance by U.S. firms. The sample period is from 2002 to 2015 with monthly observation. t-statistics in brackets are based on Newey-West (1987) standard errors allowing for serial correlation up to 6 months.

	Issuance flow in \$billions			Issuance flow/Total issuance in percent		
	(1) $Iss_{t+1}^{EU\to US}$	(2) $Iss_{t+1}^{EU\to US}$	(3) $Iss_{t+1}^{EU\to US}$ (6m avg)	(4) $issPct_{t+1}^{EU\to US}$	(5) $issPct_{t+1}^{EU\to US}$	(6) $issPct_{t+1}^{EU\to US}$ (6m avg)
CrdSprdDiff$_t$	0.0675			0.0736		
	[3.17]			[3.57]		
CrdSprdDiffEff$_t$		0.0588	0.0687		0.0635	0.0734
		[3.66]	[6.21]		[3.93]	[6.56]
cons	0.758	0.0579	0.215	0.808	0.0411	0.176
	[1.08]	[0.09]	[0.42]	[1.20]	[0.07]	[0.39]
N	164	164	164	164	164	164
R-sq	0.094	0.116	0.395	0.119	0.143	0.480

Table 3 Multivariate forecasting of dollar-euro issuance flow

This table presents multivariate forecasting regression of future issuance flow using credit-spread differentials between euro and dollar controlling for current issuance flow, swap rate differential, U.S. swap rate and credit spread, and changes in exchange rate in the last 6 months. Net bilateral issuance flow is defined as the amount of debt issuance by European firms in dollar minus the amount of euro-debt issuance by U.S. firms. The sample period is from 2002 to 2015 with monthly observation. Constants are not shown. t-statistics in brackets are based on Newey-West (1987) standard errors allowing for serial correlation up to 6 months.

	Issuance flow in \$billions (6 month average)			Issuance flow/Total issuance in percent (6 month average)		
	(1) $Iss_{t+1}^{EU\to US}$	(2) $Iss_{t+1}^{EU\to US}$	(3) $Iss_{t+1}^{EU\to US}$	(4) $issPct_{t+1}^{EU\to US}$	(5) $issPct_{t+1}^{EU\to US}$	(6) $issPct_{t+1}^{EU\to US}$
CrdSprdDiffEff$_t$	0.0621	0.0515	0.0490	0.0669	0.0660	0.0621
	[6.08]	[3.50]	[3.77]	[6.80]	[4.51]	[4.94]
RateDiff$_t$		0.0149	0.0131		0.00358	0.00229
		[1.13]	[1.03]		[0.32]	[0.22]
$Iss_t^{EU\to US}$	0.123		0.0857			
	[2.54]		[1.93]			
$issPct_t^{EU\to US}$				0.107		0.0971
				[2.21]		[2.00]
Δe		3.737	3.055		3.162	2.645
		[0.68]	[0.58]		[0.67]	[0.60]
Other controls		X	X		X	X
N	164	158	158	164	158	158
R-sq	0.429	0.487	0.502	0.505	0.544	0.564

Table 4 Multivariate forecasting of issuance flows in other currencies

This table presents multivariate forecasting regression of future issuance flow (average over the next 6 months) using credit-spread differentials between the foreign currency (EUR, GBP, JPY, AUD) and the dollar controlling for current issuance flow, swap rate differential, U.S. swap rate and credit spread, and changes in exchange rate in the last 6 months. Net bilateral issuance flow is defined as the amount of debt issuance by foreign firms in dollar minus the amount of debt issuance by U.S. firms in that currency. Observations are monthly. t-statistics in brackets are based on Newey-West (1987) standard errors allowing for serial correlation up to 6 months.

	Issuance flow in $billions (6 month avg.)				Issuance flow/Total issuance in percent (6 month avg.)			
	Eurozone	UK	Japan	Australia	Eurozone	UK	Japan	Australia
	$Iss_{t+1}^{EU\to US}$	$Iss_{t+1}^{UK\to US}$	$Iss_{t+1}^{JP\to US}$	$Iss_{t+1}^{AU\to US}$	$issPct_{t+1}^{EU\to US}$	$issPct_{t+1}^{UK\to US}$	$issPct_{t+1}^{JP\to US}$	$issPct_{t+1}^{AU\to US}$
CrdSprdDiffEff$_t$	0.0490	0.00890	0.0127	0.00621	0.0621	0.0168	0.0209	0.0147
	[3.77]	[3.36]	[3.03]	[3.08]	[4.94]	[3.79]	[3.20]	[3.48]
RateDiff$_t$	0.0131	-0.00464	-0.00169	0.00298	0.00229	-0.00403	0.00161	0.00283
	[1.03]	[-1.52]	[-0.63]	[1.11]	[0.22]	[-0.82]	[0.38]	[0.59]
Controls	X	X	X	X	X	X	X	X
N	158	224	217	175	158	224	217	175
R-sq	0.502	0.554	0.663	0.494	0.564	0.283	0.629	0.522
Sample period	2002-2015	1996-2015	1996-2015	2000-2015	2002-2015	1996-2015	1996-2015	2000-2015

Table 5 Currency basis: Issuance and leverage impact

This table presents contemporaneous regressions of monthly changes in 10-year currency basis (CIP deviations) on net bilateral issuance flow (column 1), one-way issuance flows (columns 2 and 3), net bilateral issuance flow interacting with broker-dealer leverage (column 4), leverage-weighted net bilateral issuance flow (column 5), and net bilateral issuance flow controlling for contemporenous change in log exchange rate (column 6). Net bilateral issuance flow, $Iss_t^{EU\to US}$, is defined as the amount of debt issuance by European firms in USD minus the amount of debt issuance by U.S. firms in EUR. Broker-dealer leverage is calculated from the Federal Reserve Flow of Funds, $BDLev_t = \frac{\text{Total Financial Assets}_t^{BD}}{\text{Total Financial Assets}_t^{BD} - \text{Total Financial Liabilities}_t^{BD}}$. Leverage-weighted issuance flow is defined by $IssLW_t^{EU\to US} = \frac{Iss_t^{EU\to US}}{BDLev_t}$. Observations are monthly from 2002-2015. t-statistics are reported in brackets.

	(1) Δbasis10yr$_t$	(2) Δbasis10yr$_t$	(3) Δbasis10yr$_t$	(4) Δbasis10yr$_t$	(5) Δbasis10yr$_t$	(6) Δbasis10yr$_t$
$Iss_t^{EU\to US}$	0.198			1.494		0.192
	[3.72]			[2.15]		[3.94]
$IssEUtoUS_t$		0.294				
		[3.84]				
$IssUStoEU_t$			-0.0924			
			[-1.31]			
$\ln BDLev_t$				-0.670		
				[-0.59]		
$Iss_t^{EU\to US} \cdot \ln BDLev_t$				-0.389		
				[-1.88]		
$IssLW_t^{EU\to US}$					5.794	
					[4.05]	
Δe						57.30
						[5.78]
cons	-0.151	-1.469	0.231	1.915	-0.231	-0.244
	[-0.46]	[-3.14]	[0.49]	[0.51]	[-0.71]	[-0.81]
N	164	164	164	164	164	164
R-sq	0.079	0.083	0.010	0.099	0.092	0.237

Table 6 Price impact of monthly issuance flow on currency basis

This table presents contemporaneous regressions of monthly changes in 10-year basis swap levels (CIP deviations) on bilateral and one-way issuance flows. Net bilateral issuance flow is defined as the amount of debt issuance by foreign firms in dollar minus the amount of debt issuance by U.S. firms in the foreign currency. Leverage-weighted issuance flow is defined by $IssLW_t^{F\to US} = \frac{Iss_t^{F\to US}}{BDLev_t}$, where $BDLev_t$ is the U.S. broker-dealer leverage calculated from the Federal Reserve Flow of Funds. D_{post07} is a dummy indicating the period after the onset of the financial crisis starting in 2008. Sample observations are restricted to months with non-zero net bilateral issuance flow. Panel A presents the impact of monthly issuance flows on currency basis. Panel B presents the impact of monthly issuance flows weighted by broker-dealer leverage. t-statistics are reported in brackets.

Panel A: Monthly Issuance flows

	EUR Δbasis10yr$_t$			GBP Δbasis10yr$_t$			JPY Δbasis10yr$_t$			AUD Δbasis10yr$_t$		
$Iss_t^{F\to US}$	0.222			0.0959			0.419			0.267		
	[4.07]			[1.32]			[2.46]			[1.90]		
IssFtoUS$_t$		0.290			0.0729			0.497			0.220	
		[3.60]			[1.00]			[2.31]			[1.52]	
IssUStoF$_t$			-0.133			-0.218			-0.368			-0.608
			[-1.88]			[-0.97]			[-1.14]			[-1.33]
D_{post07}	-0.931	-0.799	-0.232	-0.105	-0.0343	0.0897	-2.050	-1.959	-1.382	-0.235	-0.177	0.352
	[-1.35]	[-1.15]	[-0.34]	[-0.22]	[-0.07]	[0.20]	[-2.87]	[-2.77]	[-2.11]	[-0.40]	[-0.30]	[0.67]
cons	0.547	-0.873	0.733	-0.170	-0.196	0.142	0.759	0.320	0.790	-0.150	-0.169	0.178
	[1.08]	[-1.58]	[1.15]	[-0.55]	[-0.59]	[0.41]	[1.71]	[0.75]	[1.47]	[-0.44]	[-0.47]	[0.51]
N	159	159	159	218	218	218	144	144	144	204	204	204
R-sq	0.096	0.077	0.022	0.008	0.005	0.005	0.065	0.060	0.033	0.019	0.013	0.010
Sample period	2002-2015			1997-2015			1997-2015			1997-2015		

Panel B: Monthly Issuance flows weighted by leverage

	EUR Δbasis10yr$_t$			GBP Δbasis10yr$_t$			JPY Δbasis10yr$_t$			AUD Δbasis10yr$_t$		
$IssLW_t^{F\to US}$	6.638			3.811			11.88			8.209		
	[4.47]			[2.10]			[2.57]			[2.34]		
$IssFtoUSLW_t$		8.519			3.472			13.31			7.017	
		[4.16]			[1.90]			[2.43]			[1.99]	
$IssUStoFLW_t$			-4.110			-5.026			-11.34			-15.83
			[-1.88]			[-0.75]			[-1.11]			[-1.25]
D_{post07}	-1.145	-1.080	-0.231	-0.272	-0.210	0.0930	-2.120	-2.023	-1.373	-0.366	-0.327	0.387
	[-1.65]	[-1.54]	[-0.34]	[-0.55]	[-0.43]	[0.20]	[-2.95]	[-2.85]	[-2.10]	[-0.63]	[-0.55]	[0.73]
cons	0.573	-0.862	0.778	-0.230	-0.311	0.108	0.743	0.323	0.809	-0.178	-0.203	0.162
	[1.14]	[-1.62]	[1.19]	[-0.76]	[-0.96]	[0.31]	[1.69]	[0.76]	[1.46]	[-0.52]	[-0.58]	[0.47]
N	159	159	159	218	218	218	144	144	144	204	204	204
R-sq	0.114	0.100	0.022	0.021	0.017	0.003	0.068	0.064	0.033	0.028	0.021	0.009
Sample period	2002-2015			1997-2015			1997-2015			1997-2015		

Table 7 Issuance flow impact on currency basis with daily observations

This table presents regressions of daily changes in 10-year currency basis (CIP deviations) in days surrounding issuance flows on the amount of net issuance flows of date t:

$$\Delta basis_{t+n-1 \to t+n} = a + b \cdot Iss_t^{F \to US} + \varepsilon_{t+n}$$

where $n = -5, -4, ..., 0, 1, ..., 5$. Net bilateral issuance flow is defined as the amount of debt issuance by foreign firms in dollar minus the amount of debt issuance by U.S. firms in the foreign currency. The sample includes all observations where date t net issuance is greater than $100 million. t-statistics are in brackets. ***, **, * indicate respectively p<0.01, p<0.05, p<0.1

$n =$	-5	-4	-3	-2	-1	**0**	1	2	3	4	5
						EUR $\Delta basis_{t+n-1 \to t+n}$					
$Iss_t^{F \to US}$	0.0243**	0.0533***	0.0257*	0.0280**	0.0459***	**0.0574*****	0.0372***	0.0123	0.00889	-0.0162	0.0237*
	[1.99]	[4.41]	[1.84]	[2.26]	[3.61]	**[4.91]**	[3.08]	[1.01]	[0.73]	[-1.40]	[1.89]
N	1055	1054	1049	1049	1050	**1049**	1051	1056	1053	1053	1053
R-sq	0.004	0.018	0.003	0.005	0.012	**0.023**	0.009	0.001	0.001	0.002	0.003
						GBP $\Delta basis_{t+n-1 \to t+n}$					
$Iss_t^{F \to US}$	0.00735	-0.0156	0.0113	0.0141	-0.00738	**0.0474****	0.0279*	0.0220	-0.00127	-0.00599	-0.00564
	[0.41]	[-0.82]	[0.61]	[0.72]	[-0.37]	**[2.35]**	[1.68]	[1.34]	[-0.07]	[-0.34]	[-0.33]
N	791	788	786	792	791	**784**	783	785	791	796	796
R-sq	0.000	0.001	0.000	0.001	0.000	**0.007**	0.004	0.002	0.000	0.000	0.000
						JPY $\Delta basis_{t+n-1 \to t+n}$					
$Iss_t^{F \to US}$	0.109**	0.0210	0.0187	-0.00453	0.122***	**-0.00339**	0.0856**	0.0442	0.0714*	-0.0145	-0.0587
	[2.49]	[0.52]	[0.41]	[-0.11]	[2.77]	**[-0.07]**	[2.12]	[0.92]	[1.69]	[-0.33]	[-1.24]
N	288	289	289	291	291	**290**	288	285	286	288	288
R-sq	0.021	0.001	0.001	0.000	0.026	**0.000**	0.016	0.003	0.010	0.000	0.005
						AUD $\Delta basis_{t+n-1 \to t+n}$					
$Iss_t^{F \to US}$	-0.0204	0.0532	-0.0140	0.0992**	0.0353	**0.144*****	0.104**	-0.0175	-0.0239	-0.0405	-0.125***
	[-0.39]	[1.14]	[-0.28]	[2.12]	[0.75]	**[2.90]**	[2.23]	[-0.37]	[-0.51]	[-0.81]	[-2.78]
N	577	576	579	578	578	**580**	580	579	579	581	582
R-sq	0.000	0.002	0.000	0.008	0.001	**0.014**	0.009	0.000	0.000	0.001	0.013

Table 8 CIP forecast with effective credit spread

This table presents forecasting regressions of future 6-month changes in cross-currency basis swap levels (CIP deviations) using the effective credit spread differentials. Multivariate regression controls for exchange rate movements, U.S. swap rate and credit spread, swap rate differential, and a dummy indicating the period after the onset of the financial crisis starting in 2008. t-statistics in brackets are based on Newey-West (1987) standard errors allowing for serial correlation up to 6 lags.

	EUR $\Delta \text{basis}_{t\to t+6}$		GBP $\Delta \text{basis}_{t\to t+6}$		JPY $\Delta \text{basis}_{t\to t+6}$		AUD $\Delta \text{basis}_{t\to t+6}$	
CrdSprdDiffEff_t	0.127	0.116	0.0642	0.0859	0.0416	0.139	0.103	0.116
	[2.83]	[2.50]	[3.06]	[4.49]	[1.53]	[2.37]	[2.14]	[3.66]
Other controls		X		X		X		X
D_{post07}	-7.597	-18.29	-4.173	-6.294	-5.780	-14.42	-5.977	-16.19
	[-2.45]	[-4.38]	[-1.35]	[-2.27]	[-2.19]	[-3.03]	[-1.38]	[-3.56]
cons	3.674	19.22	-1.074	7.992	3.690	10.09	2.289	39.30
	[2.55]	[3.06]	[-1.94]	[2.32]	[1.51]	[1.62]	[1.21]	[4.52]
N	159	153	219	219	214	214	172	172
R-sq	0.154	0.266	0.134	0.273	0.155	0.268	0.193	0.566

Table 9 Fed QE response

This table presents responses in treasury yield and credit spreads following Federal Reserve QE announcements using a bootstrap event-study method from Mamaysky (2014). The average response (in bps) in days following Fed QE announcement dates are displayed for the 10 year Treasury, dollar corporate single-A OAS, and credit spread differentials. *p*-value in parenthesis indicates the fraction of counterfactual "responses" from random draws in the sample period that are more extreme than the response following the actual QE announcements.

Days since announcement	10yr Treasury	USD corp A OAS	EUR-USD corp A OAS	GBP-USD corp A OAS	JPY-USD corp A OAS	AUD-USD corp A OAS
0	-13.1	-0.7	0.1	1.3	-0.5	2.2
	(0.000)	(0.206)	(0.491)	(0.116)	(0.742)	(0.109)
5	-9.6	-1.4	2.7	4.1	4.0	10.1
	(0.047)	(0.349)	(0.161)	(0.129)	(0.156)	(0.040)
15	-6.4	-16.2	10.3	11.6	20.2	35.4
	(0.229)	(0.047)	(0.044)	(0.056)	(0.012)	(0.000)

Appendix

A Cross-currency basis as CIP deviation

Cross-currency basis B is defined as the fair exchange of \$Libor vs foreign Libor $+B$.

Define the following variables:

- Z_T: Domestic zero rate
- Z_T^*: Foreign zero rate
- R : Dollar par swap rate
- R^* : Foreign par swap rate
- S : Spot currency exchange rate at time 0. Dollar per 1 unit of foreign currency. e.g. EURUSD
- F_T: Forward currency exchange rate at time 0
- T: Maturity
- B : A swap of 3-month dollar Libor is fair against 3-month foreign Libor $+B$

Without CIP deviation, the forward exchange rate can be expressed as

$$F = S\frac{(1+Z)^T}{(1+Z^*)^T}.$$

A simplified definition of CIP deviation can be expressed as Δ in the following equation

$$F = S\frac{1+r}{1+r^*-\Delta}.$$

Using a replication portfolio similar in methodology as Tuckman and Porfirio (2003), I show that

$$F. = \frac{S_0\,(1+Z)^T}{(1+Z^*)^T}\left(1+B\frac{\left[(1+Z^*)^T-1\right]}{R^*\,(1+Z^*)^T}\right)^{-1}$$

Consider the following replicating portfolio for a cross-currency basis swap

Positive=Receive, Negative=Pay

Transaction	t0 ($)	Interim ($)	T ($)	t0 (F)	Interim (F)	T (F)
Rec. Euribor + B vs pay $Libor cross-currency swap	$+S_0$	$-S_0 L_t$	$-S_0$	-1	$L_t^* + B$	$+1$
Spot FX	$-S_0$			$+1$		
Foreign: Pay fixed/rec. floating par swap in amount $\frac{B}{R^*}$					$B/R^* \left[L_t^* - R^*\right]$	
Foreign: Pay floating zero coupon swap (ZCS) in amount $\left(1+\frac{B}{R^*}\right)$					$-L_t^* \left(1+\frac{B}{R^*}\right)$	$\left(1+\frac{B}{R^*}\right)\left[(1+Z^*)^T - 1\right]$
Dollar: Rec. floating ZCS in amount S_0		$S_0 L_t$	$-S_0 \left[(1+Z)^T - 1\right]$			
Sell foreign fwd. of in amount $\frac{S_0(1+Z)^T}{F}$			$\frac{S_0(1+Z)^T}{F} F$			$-\frac{S_0(1+Z)^T}{F}$
	0	0	0	0	0	

Setting the foreign cash flow in time T equal to 0, we get

$$\begin{aligned}
\left(1+\frac{B}{R^*}\right)\left[(1+Z^*)^T - 1\right] + 1 &= \frac{S_0 (1+Z)^T}{F} \\
(1+Z^*)^T + \frac{B\left[(1+Z^*)^T - 1\right]}{R^*} &= \frac{S_0 (1+Z)^T}{F} \\
1 + \frac{B\left[(1+Z^*)^T - 1\right]}{R^* (1+Z^*)^T} &= \frac{S_0 (1+Z)^T}{F (1+Z^*)^T} \\
F &= \frac{S_0 (1+Z)^T}{(1+Z^*)^T} \left(1 + B\frac{\left[(1+Z^*)^T - 1\right]}{R^* (1+Z^*)^T}\right)^{-1} \\
F_{d/f} &= S_{d/f} \frac{(1+Z)^T}{(1+Z^*)^T} \left(1 + PV^*[B]\right)^{-1}
\end{aligned}$$

Now relating this to the simplified definition

$$F = S\frac{(1+Z)^T}{(1+Z^* - \Delta)^T}$$

We set the two relations equal to each other and obtain

$$\frac{1}{(1+Z^* - \Delta)^T} = \frac{1}{(1+Z^*)^T}\left[1 + B\frac{(1+Z^*)^T - 1}{R^* (1+Z^*)^T}\right]^{-1}$$

$$(1+Z^*-\Delta)^T = \left[1+B\frac{(1+Z^*)^T-1}{R^*(1+Z^*)^T}\right](1+Z^*)^T$$

LHS can be taylor approximated around $B=0$ as $(1+Z^*)^T+T(1+Z^*)^{T-1}B$, therefore

$$\begin{aligned}
(1+Z^*)^T+T(1+Z^*)^{T-1}\Delta &\approx \left[1+X\frac{(1+Z^*)^T-1}{R^*(1+Z^*)^T}\right](1+Z^*)^T \\
\frac{T\Delta}{1+Z^*} &\approx -B\frac{(1+Z^*)^T-1}{R^*(1+Z^*)^T} \\
\Delta &\approx -B\left[\frac{(1+Z^*)^T-1}{R^*(1+Z^*)^T}\right]\frac{1+Z^*}{T}
\end{aligned}$$

With the definition of a swap $R^*=\frac{1-(1+Z^*)^{-T}}{\sum_{t=1}^{T}\left(1+Z^*_{0,t}\right)^t}$, we get

$$\Delta \approx -B\left[\sum_{t=1}^{T}\left(1+Z^*_{0,t}\right)^{-t}\right]\frac{1+Z^*}{T}$$

Suppose zero rate for different maturities are constant, $Z_{0,t}=Z_{0,T}=z$, i.e. the zero curve is flat (this also implies flat swap curve). Generally zero curves are upward sloping. Assuming a flat curve bias the discount factor to be smaller, thus making a more conservative estimation. Then the PV becomes

$$\sum_{t=1}^{T}(1+z^*)^{-t} = -\frac{(z^*+1)^{-T}-1}{z^*}$$

and Δ becomes

$$\begin{aligned}
\Delta &\approx -PV\frac{1+z^*}{T}B \\
&\approx \left[\frac{(z^*+1)^{-T}-1}{z^*T}(1+z^*)\right]B \\
&\approx -\left[1+\frac{1}{2}(1-T)z^*+1/6(T^2-1)(z^*)^2\right]B
\end{aligned}$$

where the last line applies 3rd order taylor approximation.

B Appendix Figures

Figure B.1 Cross-currency basis swap with overnight rates

This figure presents a comparison of EUR-USD cross-currency basis swaps with short-term reference rates as Euribor and Libor (Red) and Fed Fund Effective rate and overnight Eonia rate from 2009 (when Bloomberg's overnight-based cross currency swap data begin) to 2015.