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Uncovering Covered Interest Parity: The Role of Bank Regulation and Monetary Policy

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Abstract:

We analyze the factors underlying the recent deviations from covered interest parity. We show that these deviations can be explained by tighter post-crisis bank capital regulations that made the provision of foreign exchange swaps more costly. Moreover, the recent monetary policy and related interest rate divergence between the United States and other major foreign countries has led to a surge in demand for swapping low interest rate currencies into the U.S. dollar. Given the higher bank balance sheet costs resulting from these regulatory changes, the increased demand for U.S. dollars in the swap market could not be supplied at a constant price, thereby amplifying violations of covered interest parity. Furthermore, we show that dollar swap line agreements existing between the Federal Reserve and foreign central banks mitigate pressure in the swap market. However, the current conditions that govern the provision of dollar funding through foreign central banks are not favorable enough to reduce deviations from covered interest parity to zero.

JEL Codes: F31, G15, G18, G2, E52

Keywords: covered interest parity, banking, monetary policy

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1 Introduction

Historically, many researchers have shown that covered interest parity (CIP) held, both across countries and across time, leading to the belief that CIP is one of the few binding laws in economics. Theoretically, converting the amount borrowed in a foreign currency using the foreign exchange (FX) spot market, and simultaneously hedging the resulting exchange rate risk using an FX forward contract, should result in the same overall cost for the investor as directly borrowing in the foreign currency.[1]

However, during the 2007–2008 global financial crisis, large violations of CIP were observed, especially with respect to the U.S. dollar. More recently, since mid-2014, large and persistent violations of CIP have re-emerged (despite measures of credit and liquidity risk being low), again with particular respect to the U.S. dollar, substantially increasing the cost of borrowing dollars through the FX swap market. For example, depending on the maturity, swapping euros into dollars at the end of 2016 was about 80 to 100 basis points more expensive than directly borrowing dollars in the cash market. Figure 1 shows the historical development of CIP deviations (also referred to as the cross-currency basis) since 2002, including its recent widening.

In this paper, we first collect some stylized facts on the FX swap market and covered interest parity, and then shed light on the key economic drivers behind these recent parity violations. Given that banks are the single most important participants in the swap market (for example, the 10 largest participants in the swap market are banks that account for two-thirds of the market turnover), we highlight the role of banks in the CIP arbitrage opportunity. In particular, we argue that the breakdown of CIP can be attributed to two main factors: (1) heightened post-crisis bank capital regulations that increased bank balance sheet costs and inhibited banks' arbitrage trading between the dollar cash and the FX swap market (see Du, Tepper, and Verdelhan 2017; Sushko et al. 2016); and (2) a divergence in interest rates between the United States and foreign nations that has led to a large demand by foreign banks to swap their domestic currency

[1] Such a simultaneous spot purchase and forward sale of foreign currency is commonly known as an FX swap.

into higher-yielding dollars (as argued in Bräuning and Ivashina 2017) that could not be accomodated at a constant price due to the tightened bank capital regulations.

We first test the effect of capital regulation on CIP deviations based on a regulatory change directly related to the Basel II guidelines, enacted on January 1, 2013, that increased the capital charges for CIP trades made by U.S. banks. For example, the capital charges on a one-year CIP trade increased by about 50 percent following the new regulation. As a result, U.S. banks significantly decreased their provision of FX swaps by up to 10 percent after the regulation was implemented. Specifically, we find that banks with a low Tier 1 capital ratio (relative to total assets) significantly reduced their provision of FX swaps after the new regulation was implemented. For example, we estimate that a bank with a 1 percentage point lower Tier 1 ratio reduced the supply of FX swaps by 19 percent more than did the average capitalized bank. In addition to the reduction in swap volumes, we also find that the cost of swapping foreign currency into U.S. dollars increased significantly after the policy change, as manifested in an overall increase in CIP violations. Moreover, these CIP violations were especially pronounced for swaps with a longer maturity, the exact type of contract that, as we show, de facto faced larger capital charges after January 1, 2013.

In a second step, we argue that the divergence of monetary policy and related nominal interest rates between the United States and other major advanced countries led to a large increase in the demand for U.S. dollars, which could not be supplied in the swap market at a constant price given the post-crisis changes in bank capital regulations (meaning after the regulatory changes, the supply of dollar swaps was no longer perfectly elastic). Therefore, this excess demand for swapping other currencies into U.S. dollars led to pressure in the FX swap market and an increase in the forward premium beyond what is implied by CIP. In line with this argument, we show that an expansionary monetary policy in foreign currency areas—measured by a decrease in the interest rate paid on excess reserves, an increase in the central bank's balance sheet, or the introduction of a negative policy rate—are all significantly related to CIP violations.

We further show that when CIP violations are large—meaning the cost of obtaining dollars through the swap market is high—European banks increasingly satisfy their demand for U.S. dollars through the European Central Bank's (ECB) dollar facilities, which were made available through swap line agreements between the Federal Reserve and foreign central banks. Indeed, we find that an increase in direct dollar lending by the ECB to European banks reduces pressure on the swap market and mitigates violations of CIP. However, the effects are quantitatively small, given that the conditions offered by the ECB dollar facilities are more attractive to banks only if the cross-currency basis is large enough, meaning that for moderate CIP violations it is still cheaper to access dollars through the private FX swap market.

The remainder of this paper is structured as follows. In Section 2, we provide background on the FX swap market. Section 3 discusses the concept of covered interest parity. In Section 4, we analyze the reasons behind the recent CIP violations. Section 5 concludes.

2 The FX Swap Market

Understanding recent developments in the FX swap market will lay the framework for how deviations from covered interest parity have developed. In this section, we therefore discuss some key concepts of FX swaps and establish a few stylized facts about the market.

An FX swap is a simultaneous spot purchase and forward sale of foreign currency that takes place between two investors. For example, investor E (who holds euros) exchanges euros today with investor D (who holds dollars), and both agree to unwind the transaction at a future point in time. Thus, an FX swap is effectively a contract in which investors borrow in one currency and lend in another (or, similar to a repo contract, use the other currency as collateral). The cost of the FX swap is determined by the forward premium—the percentage difference between the forward exchange rate and the spot exchange rate between the two currencies being exchanged.[2]

[2]For more information on the mechanics of FX swaps, see http://www.bis.org/publ/rpfx16fx.pdf.

Furthermore, the FX swap market is an over-the-counter market where the majority of deals are made on a bilateral basis, although some trades are brokered by a third party. FX swaps are not centrally cleared (FX swap and forward contracts are exempt from the trade execution, mandatory clearing, and margin requirements mandated under the Dodd-Frank Act). Therefore, detailed transaction-level data are not readily available for analysis. However, in March and October, the Federal Reserve Bank of New York conducts a biannual survey of the most important FX dealers regarding, among other issues: (i) total turnover volume, (ii) maturity composition, and (iii) currency composition in the FX swap market.

Figure 2, Panel (a), shows that the reported aggregate monthly volume in the FX swap market almost doubled from 2005 to 2016, with the latest figure indicating that the monthly turnover in April 2016 corresponds to almost USD 2 trillion. Given the role of the USD as the world's dominant currency in international trade and finance, swaps against the USD comprise by far the most volume in the FX swap market. Figure 2, Panel (b), shows that in April 2016, all swaps against the USD accounted for about 90.3 percent of the total volume, with the USD/EUR pair at 29.26 percent, followed by the USD/JPY pair (16.72 percent), and the USD/GBP pair (10.89 percent). Figure 3 shows the reported FX swap volume proportions by maturity. The maturity breakdown of the April 2016 report indicates that about 60 percent of all swap volume has a maturity length of under one week, followed by 39 percent between one week and one year, and under 1 percent over one year. Hence, the vast majority of dollars borrowed in the FX swap market are concentrated in very short maturities, leading to significant rollover risk, given that banks' dollar assets typically have longer maturities.

Banks, corporations, and other investors utilize the FX swap market to hedge foreign exchange rate risk or to engage in arbitrage activity.[3] However, banks play a crucial role in the FX swap market and are the most important participants. In particular, the

[3]Recent research suggests that nonfinancial corporations increasingly utilize long-term FX swaps to hedge their foreign currency bond issuance (Liao 2016). Nevertheless, FX swaps with maturities above one year account for less than 1 percent of the market's value, according to the NY Fed FX Volume Survey.

market is highly concentrated among the 10 largest global banking institutions, which account for about two-thirds of the entire FX swap volume in the 2016 Euromoney FX Survey. Data from this survey indicate that Citi accounts for 14 percent of the turnover in the swap market, followed by Deutsche Bank with 9 percent, and UBS and J.P. Morgan each with 9 percent.

In particular, banks use FX swaps to synthetically fund assets denominated in foreign currency by tapping their funding sources in their domestic deposit markets and converting these funds to foreign currency using FX swaps (Ivashina, Scharfstein, and Stein 2015; Bräuning and Ivashina 2017). Thus, the FX swap market plays a key role in funding bank assets denominated in foreign currencies. To gauge the economic relevance of FX swaps in funding banks' foreign currency assets, we turn to data from the Bank for International Settlements (BIS). In particular, we use the BIS Locational Banking Statistics to compute the difference between foreign banks' dollar assets and dollar liabilities, known as the dollar funding gap, which we treat as a proxy for banks' demand for synthetic dollar funding at a given point in time. Figure 4 shows that the outstanding amount of synthetic U.S. dollar funding is economically sizable. For example, in 2016:Q2 Japanese banks funded almost 50 percent (or USD 1.2 trillion) of all their dollar-denominated assets through the FX swap market.

Given the important role of the FX swap market to synthetically fund bank assets denominated in foreign currencies, deficiencies in the reallocation of funds across currencies through the FX swap market can therefore adversely affect global banks' portfolio allocations, in addition to impairing financial stability and monetary policy transmission. Moreover, given that banks are the most important players in the FX swap market, understanding their behavior in this market is crucial to understanding deviations from CIP.

3 The Covered Interest Parity Condition

Covered interest parity is a classic no-arbitrage relationship that implicitly postulates the pricing of an FX swap. Specifically, CIP states that the interest rates on two similar assets that differ only in their currency denomination should be identical after hedging for foreign exchange risk. For example, using USD and EUR, the theoretical CIP condition is defined as

$$1 + i_{USD} = \frac{F}{S}(1 + i_{EUR}), \tag{1}$$

where i_{USD} is the interest rate in dollars, i_{EUR} is the interest rate in euros, S is the spot exchange rate of USD in terms of EUR, and F is the forward exchange rate of USD in terms of EUR. Note that both interest rates and the forward exchange rate have the same maturity. Moreover, both of these interest-bearing monetary assets should, except for their currency denomination, also be similar in other dimensions, such as the credit risk profile and liquidity.

After a logarithmic approximation, the CIP condition implies that the forward premium—the relative difference between the forward and spot exchange rate—is given by:

$$f := \log(F/S) = i_{USD} - i_{EUR}. \tag{2}$$

Equation (2) states that the cost of the FX swap equals the interest rate differential under the covered interest parity condition.[4] Note that the forward premium f is a rate, such that $f \cdot 100$ measures the percentage cost of the notional value of the swap. Furthermore, the forward premium does not have to be greater than zero; a negative forward premium is also referred to as a forward discount.

Figure 5 illustrates the decisions an investor faces in the FX swap market when covered interest parity holds. Suppose Investor A has USD that she would like to invest either domestically or abroad. Assuming perfect capital mobility and asset substitutability, the return Investor A makes on a dollar-denominated asset should be equivalent to the return

[4] Using a logarithm approximation, we can express the relative difference $\frac{F-S}{S}$ as $\log(F/S)$ for $F \approx S$.

that she makes on a similar foreign asset with a higher interest rate. Under CIP, the costs associated with engaging in an FX swap to hedge the foreign exchange risk should offset any extra return that Investor A gains from investing in the foreign asset.

A CIP deviation occurs if the cross-currency basis (*ccb*), defined as the approximate spread between the forward premium and the interest rate differential,

$$ccb := f - (i_{USD} - i_{EUR}), \tag{3}$$

is not equal to zero. For example, a positive cross-currency basis, as we have seen for most currencies against USD in recent periods, means that the cost of hedging exchange rate risk is larger than is implied by the CIP. Alternatively, one may interpret a positive basis as the excess cost of borrowing dollars through the swap market when compared to borrowing dollars directly in the money market.

Historically, the cross-currency basis has hovered near zero, as arbitrageurs have taken advantage of the mismatch between the money market and the FX swap market, driving the cross-currency basis down to zero. When credit risk and transaction costs are low, an investor can borrow an in-demand currency in the money market and sell the funds in the FX swap market. During periods when international capital mobility is almost frictionless, the CIP condition converges to zero, as all significant deviations in the cross-currency basis are arbitraged away by parties that have access to large amounts of in-demand currencies (for example, U.S. banks have easy access to dollars). Hence, the supply curve of swaps is perfectly elastic, meaning any volume in the swap market can be accommodated at a constant forward premium that is determined by the interest rate differential.

It is important to emphasize that the CIP conditions depend on the specific asset and maturity used in the CIP calculation, a fact that is not fully recognized in the previous literature. Figure 6 shows the three-month CIP deviation for EUR-USD computed using different interest rates. Given that banks are the most prominent participants in the swap market, using the interest rate paid on government securities may not be appropriate, as these rates may not represent the true marginal cost of funding for banks. Historically, Frenkel and Levich (1975) used interbank rates to evaluate the CIP condition, and the majority of papers thereafter have followed this practice. However, since the 2007–2008 global financial crisis, it became clear that London interbank offered rates (LIBOR rates) contain a significant credit risk premium that may bias CIP computations. Therefore, computing CIP conditions based on overnight index swap (OIS) rates seems more appropriate, as these rates contain little credit risk and liquidity risk premiums (see Liao 2016).

Additionally, there is little consensus in the literature on the specific maturity that should be used to calculate the cross-currency basis. The three-month and five-year maturities are commonly used in recent papers. However, given a frictionless swap market, the CIP condition should hold for all maturities. As Figure 7 shows, deviations from CIP vary widely given the particular interest rate and maturity (the results for other currency pairs are similar). Indeed, the figure shows that the term structure of CIP deviations varies and has been strictly increasing by maturity only in the past few years, while during the global financial crisis and the European sovereign crisis, CIP violations were more pronounced for short maturities.[5]

4 Recent Violations of CIP

Figure 8 plots CIP deviations based on the three-month OIS rates for different currencies against the USD over the past 15 years. The figure shows that prior to the 2007–2008 crisis, the cross-currency basis for all pairs was close to zero, meaning that the CIP condition held for most currency pairs. After the start of the 2007–2008 financial crisis, however, all currencies exhibit strong and persistent CIP violations stemming from the funding pressure in dollar markets due to heightened counterparty risk and capital scarcity (see Baba and Packer 2009; Coffey, Hrung, and Sarkar 2009). Similarly,

[5]Note also that the vast majority of borrowing in the FX swap market is concentrated in short maturities, while investors typically hold dollar assets with longer maturities. Therefore, even if the cross-currency basis is large at short maturities, foreign investors may still find it profitable to borrow dollars in the swap market and hold higher yielding longer-term assets.

the cross-currency basis widened during the European sovereign debt crisis that began in early 2010, fueled by increasing worries about Greek sovereign default risk, until it flattened out in late 2012. Similar to the financial crisis, European banks were unable to borrow dollars in cash markets and had to resort to using FX swap markets (Ivashina, Scharfstein, and Stein 2015).[6]

Since the global financial crisis and the European sovereign debt crisis, counterparty risk and USD funding shortages have subsided, leading economists to wonder why the cross-currency basis has started to widen again since mid-2014, despite measures of credit and liquidity risk being low. As already highlighted, Figure 1 shows that the recent parity violations are not driven by credit or liquidity risk as the LIBOR–OIS spread, a standard risk measure in the banking sector, exhibits a very low level—unlike the conditions that prevailed during the two crisis periods. Nevertheless, the EUR-USD basis widened recently up to 100 basis points, making it increasingly costly for European institutions to engage in synthetic dollar funding. Several authors have argued that the reason for this phenomenon lies in supply and demand factors that reduce the amount of arbitrage activity taking place in the dollar cash and swap markets in response to CIP violations (see Du, Tepper, and Verdelhan 2017; Sushko et al. 2016; Avdjiev et al. 2016).

In the remainder of this section, we will argue that the persistent deviations from CIP in recent years can be attributed to two main factors. First, similar to Du, Tepper, and Verdelhan (2017) and Sushko et al. (2016), we argue that heightened post-crisis bank regulations increased bank balance sheet costs and inhibited arbitrage trading between the cash and swap markets. Indeed, we add to this literature by providing original empirical evidence that a key event related to bank capital regulation reduced U.S. banks' swap provisions and increased the CIP deviations. Second, we argue that the recent monetary policy divergence between the United States and other foreign nations has led to "reaching-for-yield" behavior among investors who wish to swap foreign funds into

[6]For more details about the shortage of uninsured funding for U.S. branches of European banks during the European sovereign debt crisis, and the subsequent increase in internal capital reallocation from their European parents toward their U.S. branches, also see Correa, Sapriza, and Zlate (2016) and Fillat et al. (2017).

dollar-denominated assets. This resulting excess demand for dollars in the swap market could not be supplied at a constant price, given higher bank balance sheet costs, thereby amplifying the CIP deviation. Third, we present evidence that the central bank swap line agreements that allow foreign central banks to provide direct dollar funding to their counterparties helped alleviate pressure in the FX dollar swap market and reduced the cross-currency basis.

4.1 The Role of Changes in Bank Regulation

The regulatory changes enacted following the financial crisis are best known for tightening bank liquidity requirements and, in particular, introducing new capital regulations as outlined by the Basel II.5 and III ordinances. Due to these new constraints, it became more expensive for banks to maintain large balance sheets and fund CIP arbitrage between the dollar cash and swap market, an activity that previously would prevent large deviations from the covered interest parity condition. In this section, we focus specifically on the impact of Basel II.5 that, effective on January 1, 2013, in the United States, introduced stress-VaR (SVaR), a Value-at-Risk measure that is utilized when calculating a bank's capital ratio against its risk-weighted assets (RWA).[7] Following Du, Tepper, and Verdelhan (2017), we first illustrate the effect of this regulatory change on the cost of engaging in CIP arbitrage by computing the capital charges assessed against interbank CIP trades for five maturies at or below one year (a range that covers virtually all FX swaps).

As depicted in Figure 9, Panel a), capital charges on the CIP arbitrage trade increased substantially from 2012 to 2013. With the addition of the new 99 percent SVaR charge starting in 2013, banks face higher capital charges for CIP trades, since the new charge

[7]The SVaR regulation was introduced by the Federal Reserve's implementation of the market risk rule (MRR) that established regulatory capital requirements for bank holding companies (BHCs) and state member banks (collectively, banking organizations) with significant exposure to certain market risks. In particular, the MRR applies to each banking organization that has gross trading assets and liabilities equal to one billion or more, or gross trading assets and liabilities equal to 10 percent or more of total consolidated assets. For more information about the Federal Reserve's regulatory capital requirements, see https://www.federalreserve.gov/boarddocs/srletters/2009/SR0901.htm.

now includes a premium based on the VaR present during the stressed period of 2009. For example, our calculations show that the capital charges for a one-year CIP trade increased by roughly 50 percent (the figure depicts the average charges across CIP trades of dollars against five major currencies, see Figure 9 for details). Furthermore, Panel b) shows that as of January 1, 2013, the additional capital charges also increase with maturity based on the new calculation as specified by the Basel II.5 guidelines. Hence, longer-term CIP arbitrage became de facto more expensive for banks after this new regulation became effective.

To empirically evaluate the effects of this regulatory change on CIP deviations, we analyze the changes in FX swap volumes provided in the New York Federal Reserve's FX Volume Survey and the subsequent changes in CIP deviations around January 1, 2013, when the SVaR under Basel II.5 became effective in the United States. We interpret the regulatory change as an adverse shock to the amount of FX swaps supplied by U.S. banks. As depicted in Figure 10, Panel a), this supply shift led to a reduction in FX swap volumes by U.S. banks and an increase in the cost of swapping foreign currencies into dollars, assuming a constant demand. Indeed, the foreign banks that demand dollars in the swap market did not face additional capital charges during the period that we analyze.[8] Figure 11 shows the aggregate notional FX swap volume reported by U.S. bank holding companies in the quarterly Y-9C reports.[9] Clearly, after the January 2013 change, the steady growth in FX swap volumes dropped and flattened out, both when viewed in terms of the absolute FX volume and when scaled by banks' total assets.

In Table 2, we quantify the effects of the Basel II.5 regulatory change using a regression framework. In particular, we look at changes in individual bank-level FX swap volumes around the January 2013 regulatory implementation. The granularity of the data allows us to additionally exploit the cross-sectional variation in swap volumes, depending on bank characteristics, to identify the effect of the regulatory change. We expect that

[8]Risk-weighted capital requirements took effect in March 2013 for banks in Japan and in January 2014 for the euro area; see Table 1 for more key dates. Therefore, the January 1, 2013, change in the United States did not affect the banks in these two other currency areas, the financial institutions that are the major counterparties for dollar swaps.

[9]For simplicity, we refer to bank holding companies as banks.

those banks that had a better Tier 1 capital position prior to the regulatory change were less likely to cut back on their FX swap provisions. We test our hypothesis using linear regressions of the form:

$$\begin{aligned}\Delta\text{FX Swap Volume}_{i,t} = {} & \beta\text{Regulatory Change}_t \\ & + \gamma\text{Regulatory Change}_t \times \text{Tier 1 Capital}_i \\ & + \alpha_t + \alpha_i + \epsilon_{i,t},\end{aligned}$$

where ΔFX $\text{Swap}_{i,t}$ is the change in FX swaps for bank i (normalized with total assets), Regulatory Change_t is a dummy variable that equals one after the January 2013 regulatory change, Capital_i is the Tier 1 capital relative to the total assets of bank i before the regulatory change, and α_t and α_i represent a quarter and a bank fixed effect, respectively.[10] We run the regression using data from 2012:Q3 through 2013:Q2, meaning that we use a symmetric window comprised of the two quarters preceding and following the regulatory change enacted for U.S. banks on January 1, 2013.[11]

The estimated coefficients presented in Table 2 show that after the regulatory change, the provision of FX swaps by U.S. banks decreased significantly. Furthermore, when we control for any unobserved bank heterogeneity using bank fixed effects in column (2), the results hold. Our estimates indicate a reduction of 1.2 percentage points (a reduction of 5 percent relative to the mean value of swaps over assets). In column (3), we show that the reduction is less pronounced for banks that reported a higher Tier 1 capital ratio prior to the regulatory change. In column (4), we add time fixed effects to the specification and, hence, identify the effect of the regulatory change from cross-sectional differences in swap volumes that are dependent only on bank capitalization. The estimated coefficient of the interaction term remains quantitatively similar and indicates that banks with a

[10]Quarter fixed effects are included in the regressions only where we identify the cross-sectional differential effects.

[11]When choosing the sample period, we face a tradeoff between selecting a narrow time window around the regulatory change that is helpful for identification and taking into account the fact that banks do not immediately adjust their FX swap provision during the first quarter that the regulatory change takes effect.

1-percentage-point lower capitalization reduced their FX swaps by 19 percent more than did the average capitalized bank.[12]

To what extent did the adverse supply shock to the FX swap volumes filled by U.S. banks before the Basel II.5 standards went into effect alter the cost of swapping foreign currencies into the U.S. dollar? To answer this question, we next look at the effects that the increased capital requirement had on changes in the cross-currency basis. Because we do not have FX swap pricing information at the individual bank level, we use the currency-maturity-quarter level (in line with our previous discussion, we look at the cost of FX swaps against the U.S. dollar) to compute the change in the basis. Given that the new VaR regulation was implemented in January 2013, capital charges on longer-term swaps increased more than did the charges imposed on trades with shorter maturities (see Figure 9, Panel b), and we also analyze if a differential effect exists depending on maturity.[13] Specifically, we estimate a regression of the form:

$$\begin{aligned}\Delta \text{Basis}_{i,j,t} = {} & \beta \text{Regulatory Change}_t \\ & + \gamma \text{Regulatory Change}_t \times \text{Maturity}_{i,j} \\ & + \alpha_i + \alpha_j + \alpha_t + \epsilon_{i,t},\end{aligned}$$

where $\Delta\text{Basis}_{i,j,t}$ is the change in the cross-currency basis of currency i and maturity j at time t, Regulatory Change_t again is a dummy variable that equals one after the January 2013 regulatory change, $\text{Maturity}_{i,j}$ is the maturity (in years) of currency i's basis, and α_t, α_i, and α_j are time, currency, and maturity fixed effects, respectively. In line with the previous analysis, we run the regression using quarterly data from 2012:Q3 through 2013:Q2.[14]

[12] When we exclude the "adjustment" period 2012:Q4 and compare the FX swap position in 2013:Q1–2013:Q2 with the one present in 2012:Q2–2012:Q3, our estimate in specification (2) yields an even stronger average reduction of 3.1 percentage points (or 10 percent relative to the mean).

[13] The previous analysis of the FX swap volumes at the bank level does not permit us to disentangle the volumes in different maturities and currencies due to the high level of aggregation in the Y-9C reports.

[14] To compute the cross-currency basis at a quarterly frequency, we take the average of the daily basis in each quarter, thereby also netting out any end-of-quarter effects in the basis, as documented by Du, Tepper, and Verdelhan (2017).

Table 3 shows that after the new regulation went into effect, in addition to U.S. banks reducing their FX swaps, the USD basis increased—meaning that the CIP deviation became even more pronounced. This effect holds after controlling for currency and maturity fixed effects in columns (2) and (3). Our estimates indicate that the cross-currency basis widened by an additional 2 basis points on average. Moreover, as column (4) shows, the increase in the CIP deviation was more pronounced for FX swaps of longer maturities. This finding is in line with the fact that post-crisis regulatory changes made longer-term swaps more costly. For example, the cross-currency basis for a 10-year FX swap widened by 10 basis points more than did a one-week FX swap following the regulatory change, after controlling for a general trend in the CIP deviation by netting out time fixed effects. The increase in longer-term CIP deviations after January 2013 can also be seen in Figure 7, as the CIP term structure inverted around this date.

In addition to the SVaR regulation implemented on January 2013 that we focused on in this section, other regulatory changes also reduced banks' incentives to arbitrage away a positive basis. For example, for the eight globally systematically important banks (G-SIBs) located in the United States, the Tier 1 capital ratio increased from 4 percent to a range of 9.5–13.0 percent under Basel III, which was agreed upon in January 2013. More generally, the total capital ratio was raised from 8 percent to the 11.5–15.0 percent range. Higher capital requirements ensure that these G-SIBs do not take on excess leverage; thus, banks are now less willing to partake in arbitrage activities as compared to the pre-crisis period. The reforms also include a non-risk-based leverage ratio that includes a bank's off-balance-sheet exposure to market risk. Furthermore, all CIP trades, regardless of maturity, will tend to expand a bank's balance sheet. In response to the global financial crisis, mandatory leverage ratios for banks were implemented, starting in January 2014 for U.S. institutions. These ratios require banks to hold a percentage of their capital relative to all on-balance-sheet and off-balance-sheet items, limiting the scope of CIP trades that they otherwise might have engaged in. For the G-SIBs, the minimum leverage ratio is 5 percent, meaning that banks would require higher cross-currency basis conditions in order to justify the loss in balance sheet space.

Given that these regulatory measures were largely focused on banks, the question arises regarding why other investors did not step in to make use of the arbitrage opportunity. One reason might be that other less-regulated nonbank investors, such as hedge funds, may not have stepped in and arbitraged away a positive basis because they may face funding constraints. For example, it is difficult for hedge funds to obtain the necessary funding to arbitrage the CIP violation, as hedge funds cannot quickly borrow large amounts of cash at the rates (LIBOR, OIS) typically used for the CIP calculation and would have a tough time pitching this strategy to investors. Moreover, in order to obtain funding for the swap, hedge funds would need to coordinate with their regulated prime brokerage firms, which face capital regulations that are similar to those imposed on banks.[15]

4.2 Monetary Policy Divergence and CIP Violations

In the previous subsection, we have shown the effects of a key regulatory change on the cross-currency basis in a narrow time window. In January 2013, U.S. banks' capital requirement for CIP trades tightened, the FX swap provision by U.S. banks declined, and the cross-currency basis concurrently widened. We interpret this regulatory change as an adverse supply shock which, under a constant demand for swaps, increased the price of hedging. However, Figure 7 shows that after the immediate increase in the CIP deviation following the regulatory change, the cross-currency basis reverted back to zero and only started to widen again in 2014. Since then, we have seen a positive and increasing basis for most currencies against the USD. In this section, we argue that the key factor behind the recent widening of the cross-currency basis is the surge in demand for USD-denominated assets resulting from international monetary policy differences and related interest rate differentials between the United States and foreign countries. This surge in demand for USD could not be fully absorbed by dollar-providing banks due to

[15]However, the large and growing CIP violation has very recently started to attract other cash-rich investors to provide dollars in the swap market, see https://www.wsj.com/articles/negative-yielding-japanese-government-bonds-attractive-to-foreign-investors-1488197662 (February 27, 2017).

the new banking regulations, as discussed in the previous subsection. This mismatch between demand and supply pushed up the cross-currency basis, as depicted in a stylized form in Figure 10, Panel b).

Higher yields in the United States led to foreign investors moving large amounts of capital into dollar-denominated assets. For example, Bräuning and Ivashina (2017) estimate that foreign banks' deposits at the Federal Reserve increased by 18 percent, while their holdings of U.S. Treasuries increased by 10 percent when the interest rate paid on excess reserves (IOER) difference between the United States and the foreign bank's home country increased by 25 basis points. With the ECB cutting the deposit facility rate below zero in June 2014 and the Bank of Japan moving its deposit rate into negative territory in January 2016, international banks have further incentives to swap capital out of their domestic currencies and turn to dollar-denominated assets that will produce higher yields. This excess dollar demand triggered by monetary policy differences, acting in concert with higher capital constraints, is a key contributing factor in the recent and persistent widening of the cross-currency basis.

Figure 12 illustrates the relationship between CIP deviations and the divergence of monetary policy in the United States from that of other major economies that led to diverging nominal interest rates. In Figure 12, we plot the three-month U.S. Treasury yield together with the average three-month government yield of the five other major currency areas (the Eurozone, U.K., Japan, Switzerland, and Canada). Clearly, the two lines are strongly negatively correlated, highlighting the divergence in interest rates between the United States and other advanced countries. This graph overlays the average three-month CIP deviation for FX swaps from each of the five foreign currencies into the USD. It is apparent that when the two respective interest rate measures diverge, the average CIP basis widens.

Next, we analyze the effect of monetary policy changes on the cross-currency basis in more detail. Our analysis focuses on three measures of monetary policy, (i) changes in the differential between the interest rate on excess reserves in the United States and the foreign currency under consideration (in percentage points); (ii) changes in the (log) size of the balance sheet of the central bank in the foreign currency area as a proxy for its quantitative easing and related policies; and (iii) the introduction of a negative interest rate on excess reserves in the foreign currency area (a dummy variable that is equal to one after the negative rate policy was introduced).

Empirically, we use a linear regression framework to estimate the effect of foreign monetary policy on the CIP deviation:

$$\begin{aligned}\Delta\text{Basis}_{i,j,t} = {} & \beta\Delta\text{IOER Rate Differential}_{i,t} \\ & + \gamma\Delta\log(\text{Central Bank Assets})_{i,t} \\ & + \omega\text{Negative Interest Rate Dummy}_{i,t} + \alpha_i + \alpha_j + \alpha_t + \epsilon_{i,j,t},\end{aligned}$$

where $\Delta\text{Basis}_{i,j,t}$ is the change in the dollar basis for currency i in maturity j at quarter t, while α_i and α_j are currency and maturity fixed effects, respectively. The time fixed effect, α_t, will account for any macroeconomic variation (including monetary policy) in the United States, such that we identify the effect on the CIP from changes in foreign monetary policies. Moreover, currency and maturity fixed effects account for any time-invariant heterogeneity in the basis of different currency pairs and maturities. In our analysis, we focus on the period from 2013:Q1 to 2016:Q3, meaning that we start the analysis after the key regulatory change which tightened bank capital regulation. As before, we focus on the cross-currency basis of swaps into the USD, and consider multiple maturities for each currency.

As Table 4 shows, changes in the IOER rate differential are positively related to the cross-currency dollar basis. Our estimates indicate that when the interest rate differential between the United States and a foreign currency areas increases by 1 percentage point, the cross-currency basis for that currency increases by 39 basis points, after controlling for currency and maturity fixed effects (see column 1). In column 2, we add the log changes in the size of the foreign central bank's balance sheet as a proxy for its quantitative easing and related policies, such as the ECB's long-term refinancing operations. These policies compressed longer-term yields and generated additional bank reserves in the foreign country. Our estimates indicate that a 50 percent increase in a foreign central bank's balance sheet is positively associated with an increase in the violation of CIP by 30 basis points. Finally, in column 3, we show that in the quarters after a foreign central bank implemented a negative interest rate on bank reserves, there is an additional widening of the cross-currency basis by 7 basis points—after controlling for the interest rate differential and the foreign central bank's balance sheet size. In column 4, we add time fixed effects to control for any unobserved common time variation in the basis, such as changes in U.S. monetary policy or global growth factors. Overall, our results remain qualitatively robust, although we lose significance on the negative interest rate dummy, potentially due to the fact that we do not observe large variation in this variable, while the quantitative effects of the interest rate differential and the foreign central bank's balance sheet become larger.

4.3 The Role of a Central Bank's Dollar Swap Lines

Given the large dollar basis, a natural question emerges as to why foreign banks do not seek alternative dollar funding sources (in order to avoid the increasing cost of synthetic dollar funding through the FX swap market) to lower the demand for dollar FX swaps and thus reduce the cost of obtaining USD. While direct market-based dollar funding sources for foreign investors are often limited, the Federal Reserve has established dollar swap lines with foreign central banks that allow foreign central banks to provide dollar funding to their counterparties.[16] For example, these swap lines would allow the ECB to borrow dollars from the Federal Reserve and to provide these dollars to European banks through regular monetary policy operations, for instance, through repo operations.[17]

[16]For example, foreign banks that operate in the United States through branches are not subject to deposit insurance and therefore are limited in their ability to collect retail deposits. More recently, money market fund reforms have contributed to a reduction of dollars supplied to foreign banks. In 2014, the Securities and Exchange Commission issued requirements for money market funds to move from a fixed share price to floating net asset value, causing a substantial outflow into government money market funds.

[17]The ultimate credit risk is not transfered to the Fed, but borne by the ECB. For details on the ECB's dollar facilities, see https://www.ecb.europa.eu/pub/pdf/other/art1_mb201408_pp65-82en.pdf and https://www.ecb.europa.eu/mopo/implement/omo/pdf/EUR-USD_tender_procedure.pdf.

Figure 13 shows the amount allotted through the ECB's dollar-providing tender operations, as well as the interest rates that the ECB has set for each operation. During the years including the global financial crisis and the European sovereign debt crisis, there was substantial recourse to the ECB's facility (up to USD 200 billion). In recent years, the alloted amounts have been relatively small despite the large and persistent positive cross-currency basis. So why are European banks not borrowing more from the ECB even though all bids are fully filled through fixed-rate full allotment tenders? To answer this question we compare the cost of an FX swap (forward premium) with the cost of the ECB tender operations (of the same maturity) from 2014–2016. Figure 14 shows the cost differential for one-week tenders (the most frequently conducted operations), along with the total volume of USD allotted. The evidence shows that despite the widening EUR-USD basis since mid-2014, the forward premia of a one-week swap was higher than the fixed rate of the dollar tenders (neglecting the additional cost of collateral) since 2016. Hence, only in the recent period has it become profitable for banks that have access to the FX swap market to satisfy their USD demand through the ECB instead of the swap market. Indeed, we see that when the cost differential between FX swaps and ECB dollar tenders turns positive, there is a sharp increase in recourse to the ECB facility.

In Table 5, we use a regression framework to analyze if the recourse to the ECB's dollar facility is positively related to the cost of using the FX swap market:

$$
\begin{aligned}
\text{Total Allotment}_{j,t} = {} & \beta \text{Lagged CIP Basis}_{j,t} \\
& + \gamma \text{Fixed Rate of Tender Operation}_{j,t} \\
& + \alpha_j + \epsilon_{j,t},
\end{aligned}
$$

where Total Allotment$_{j,t}$ is the total Dollar provisions provided in a tender operation on day t with maturity j, Lagged CIP Basis$_{j,t}$ is the EUR-USD cross-currency basis on the day prior to the operation for the same maturity, Fixed Rate of Tender Operation$_{j,t}$ is the fixed rate at which the tender was conducted, and α_j denotes maturity fixed effects. We expect that when it becomes more costly to swap EUR into USD, European banks increase their dollar borrowing from the ECB. In line with our previous analysis, we focus on the dollar tender operations conducted from January 2013 through October 2016, which were held as fixed-rate full allotment tenders (in all tenders, all bidders were served at a fixed rate and there was no rationing). In column 1, we find that on days following a larger CIP deviation—hence, when synthetic dollar funding is more expensive—the total amount alloted in the ECB dollar tenders increases. The result holds after controlling for the fixed rate at which the operation was conducted, as well as the maturity of the operation.[18] Column 2 shows that the total amount per bidder increases on days after the EUR-USD basis widened (in unreported results, we also find that the number of bidders increased).[19]

In column (3), we focus on the effect of the USD allotment in the ECB's tender operations on the price in the FX swap market. We find that on days when banks obtained more dollar liquidity from the ECB, the cross-currency basis decreased, evidence suggesting that the dollar operations relieve pressure in the dollar swap market. Our estimates indicate that an allotment of USD 1 billion closes the USD-EUR basis by 2.5 basis points on the allotment day. Qualitatively, in unreported results we find a similar effect when we estimate the same-day effect of multiple allotments in different maturities on the changes in the basis for each respective maturity. Overall, the results suggest that these dollar swap lines helped to mitigate funding pressures in the FX swap market and helped prevent a further widening of the cross-currency basis.

5 Conclusion

This paper explores the causes of recent deviations from the CIP condition. We show that the recent deviations can be explained by tighter post-crisis bank capital regulations

[18]In all the regressions, we compare the CIP violations and the allotment in the same maturity bucket. For example, we compare the recourse to a three-month dollar tender with the excess cost of a three-month swap (the cross-currency basis).

[19]When we focus on days with multiple tender operations for different maturities on the same day (held at the same point in time), we can also add day fixed effects to account for any time-varying variation, thereby substantially strengthening our identification. Despite the drop in the number of observations, we still find that the total allotment amount increased on days following a larger CIP violation.

that increased the cost of supplying dollars in the FX swap market, thereby inhibiting CIP arbitrage between the dollar cash market and the swap market. In addition, the recent divergence in monetary policy and related interest rates between the United States and other major countries triggered a surge in demand for swapping from low-yield currencies into the U.S. dollar. This large demand for dollar swaps could not be supplied at a constant price given the post-crisis bank capital regulations, thereby leading to a widening of the cross-currency basis. As a consequence of the elevated basis, foreign investors who rely heavily on borrowing dollars through the FX swap market face higher dollar refinancing costs. These developments have important policy implications, as foreign investors play an economically significant role in the United States—for example, by holding more than 50 percent of all outstanding Treasury debt securities and providing about 25 percent of total bank credit. Given the large cost of borrowing USD in the swap market, the return on foreign investors' dollar-denominated assets, such as U.S. Treasuries, diminishes—thereby contributing to the recent selloff of Treasuries by foreign investors and the increase in bond yields. Finally, we discuss how the direct dollar liquidity provision by foreign central banks, supplied through central bank swap line agreements, can help to mitigate funding pressures. Our findings show that these dollar swap lines will provide an effective ceiling on the cross-currency basis and prevent a further escalation of the deviations from CIP. A crucial determinant of the cross-currency basis level is the price at which foreign central banks provide dollar liquidity.

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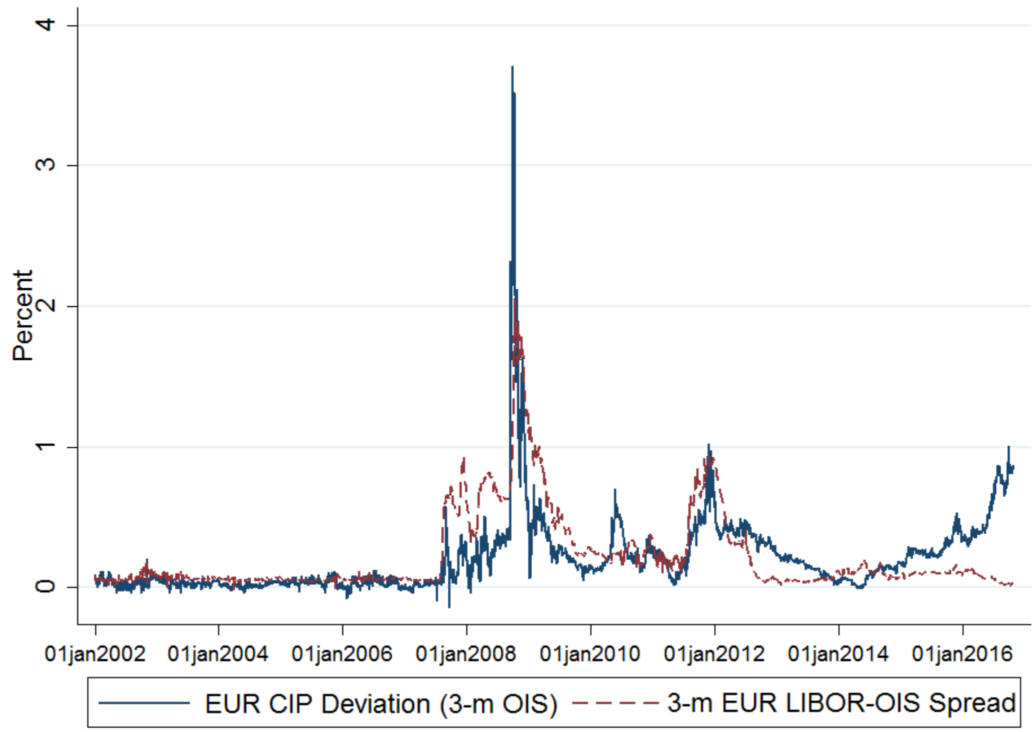
A Figures

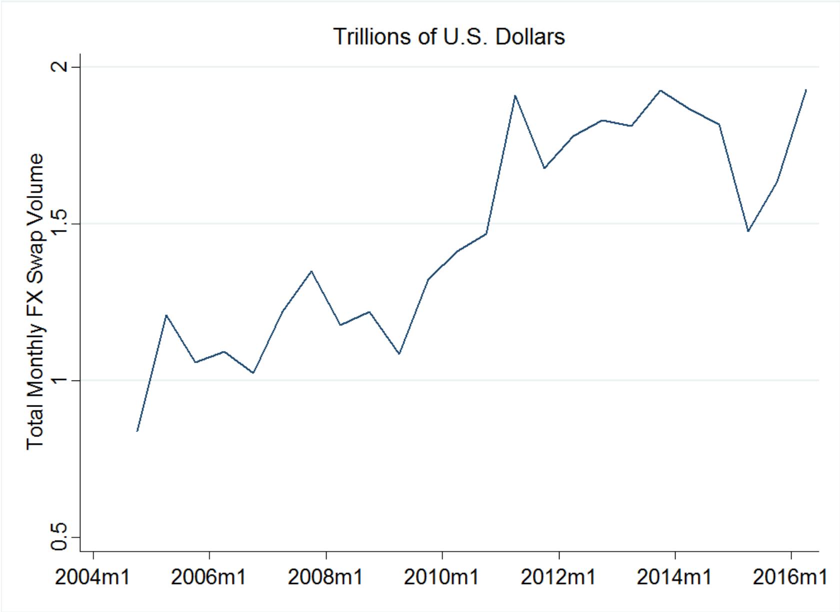
Figure 1: CIP Deviations and LIBOR-OIS spread



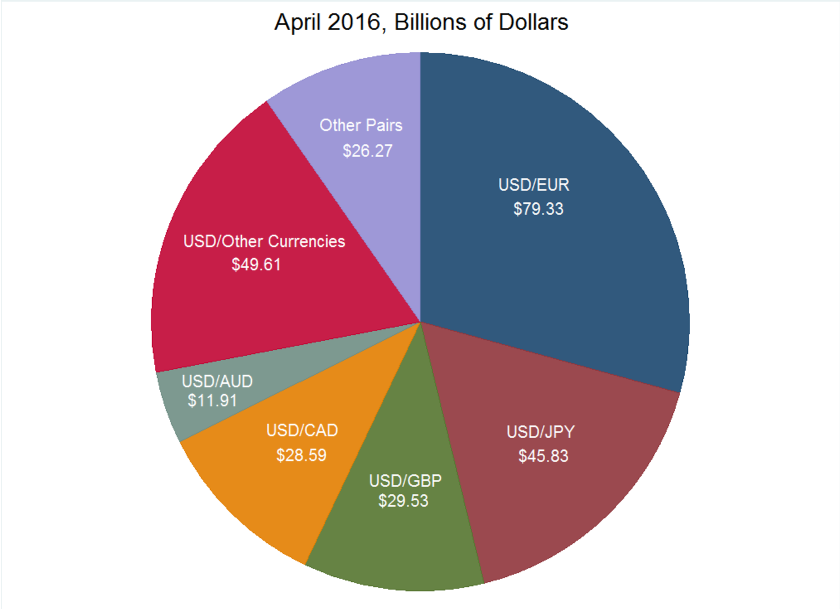
Notes: This figure depicts the three-month EUR deviations from CIP against the USD based on OIS rates (in percentage points) along with the EUR LIBOR-OIS spread (in percentage points), a standard measure of credit and liquidity risk in the banking sector. The recent CIP deviations are large, indicating an excessive cost of borrowing dollars in the FX swap market, despite measures of credit and liquidity risk being low. A similar pattern is observed for other major currencies and maturities.
Source: Bloomberg and authors' calculations.

Figure 2: Volumes in the FX Swap Market

(a) Total Monthly Volume of Foreign Exchange Swaps

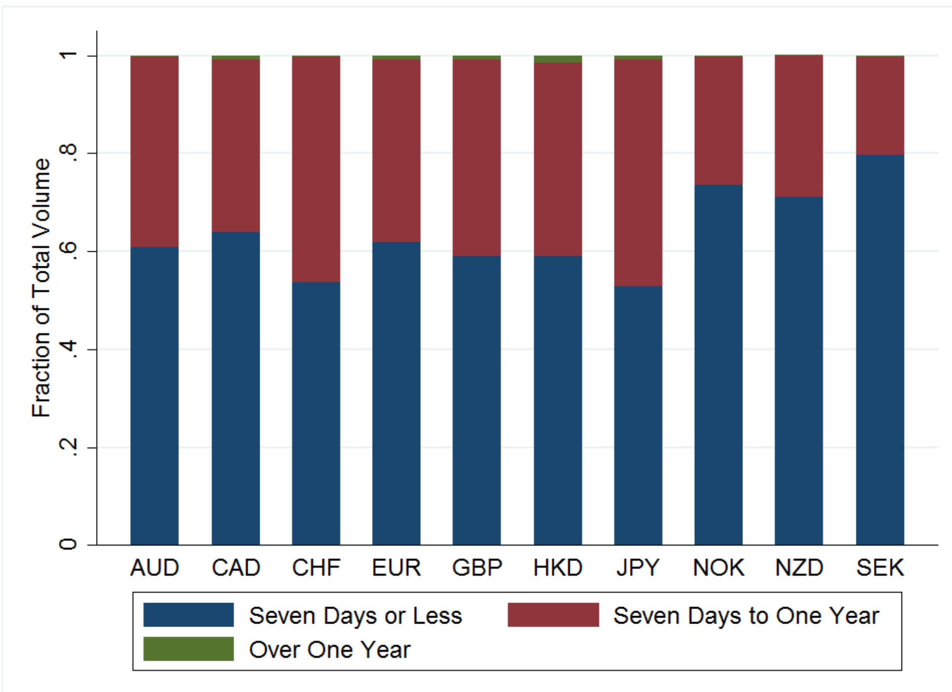


(b) Average Daily FX Swap Volume Composition By Currency Pairs



Notes: Panel (a) plots the monthly turnover volume of FX swaps reported on a biannual basis in April and October. Panel (b) shows the currency breakdown of the average daily total swap turnover volume in April 2016.
Source: Federal Reserve Bank of New York FX Survey and authors' calculations.

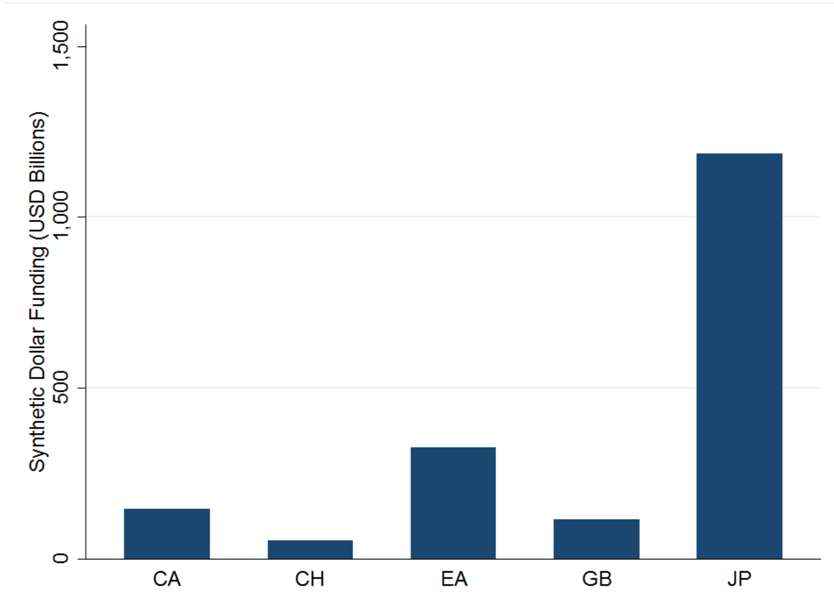
Figure 3: Maturity Breakdown of USD FX Swap Volume by Currency



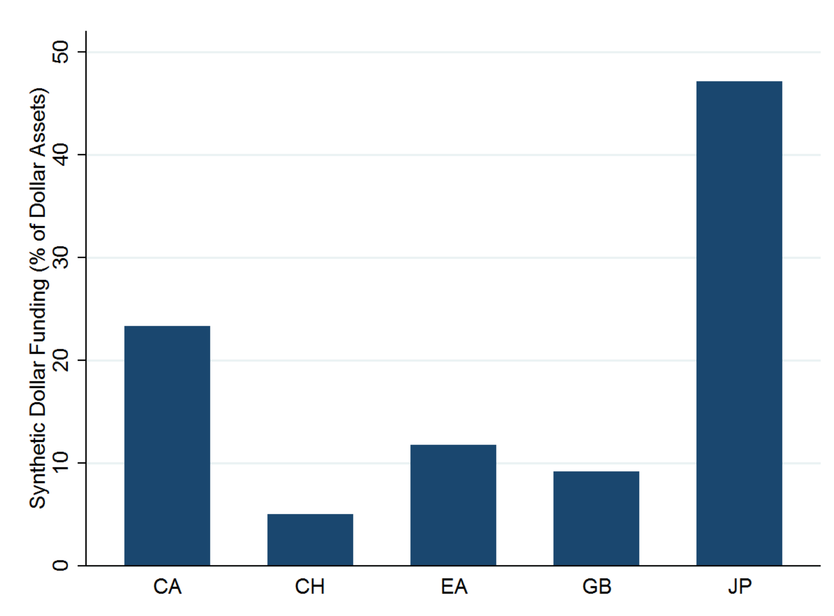
Notes: This figure depicts the maturity breakdown of the FX swap turnover volume reported in the April 2016 NY Fed FX survey.
Source: Federal Reserve Bank of New York FX Survey and authors' calculations.

Figure 4: USD FX Swap Positions By Foreign Banks

(a) Absolute Amounts

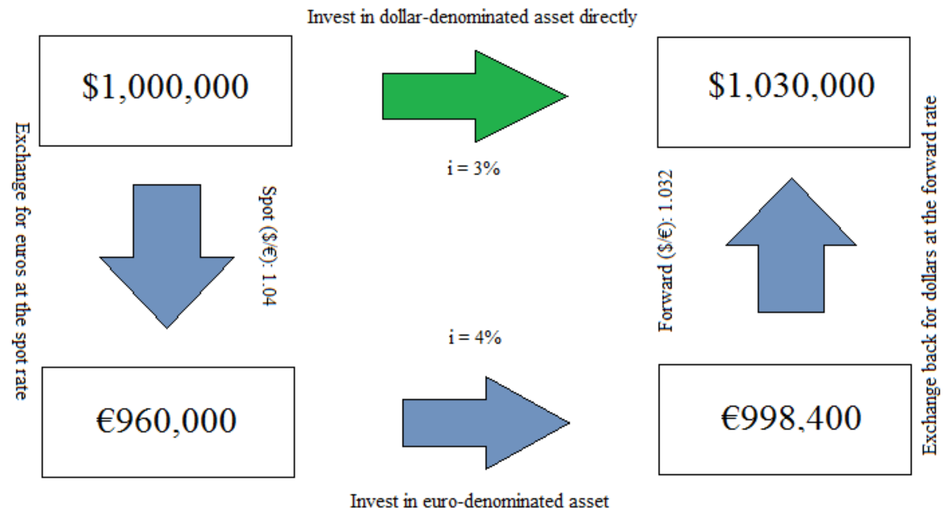


(b) Relative to Dollar Assets



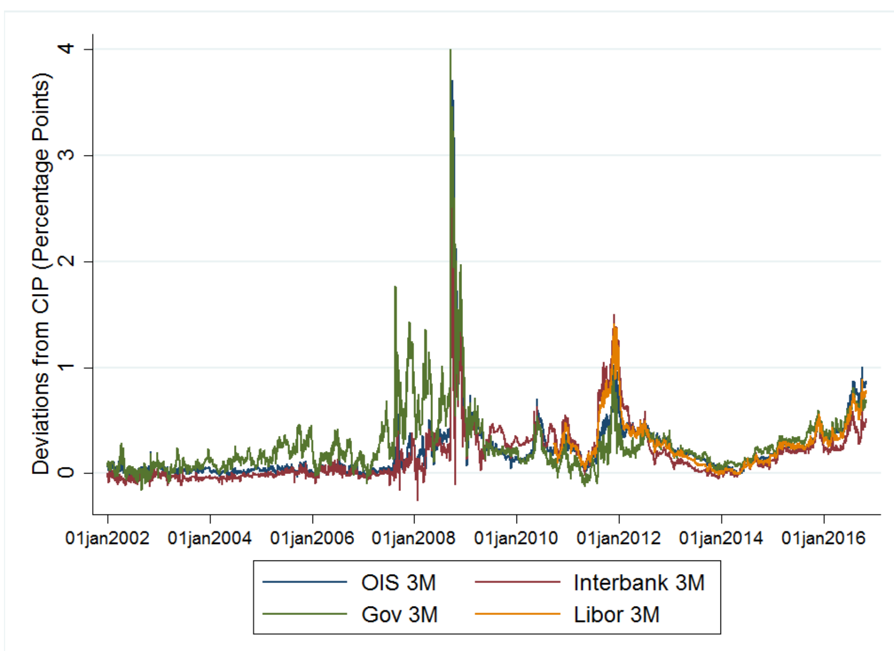
Notes: This figure depicts the difference between USD Assets and USD Liabilities for four major foreign banking sectors as of the end of 2016:Q2. Panel (a) shows this difference in dollars, while Panel (b) plots the difference scaled as a percentage of total USD-denominated assets. CA, CH, EA, GB, and JP refer to Canada, Switzerland, euro area, United Kingdom, and Japan, respectively. The funding gap can be thought of as a proxy for banks' demand for borrowing dollars in the FX swap market, the single most important source of synthetic dollar funding.
Source: Bank for International Settlements and authors' calculations.

Figure 5: A CIP Trade Cash Flow Diagram



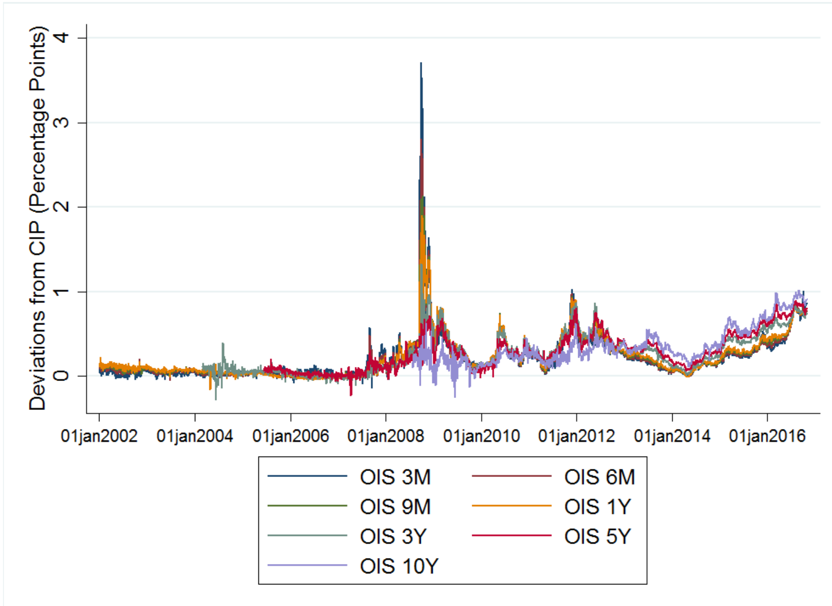
Notes: This diagram depicts the options an investor faces in the foreign exchange market when covered interest parity holds. In this scenario, the returns from investing abroad are identical to the returns from investing domestically in a substitutable asset.
Source: Authors' illustration.

Figure 6: EUR-Based CIP Deviations By Instrument



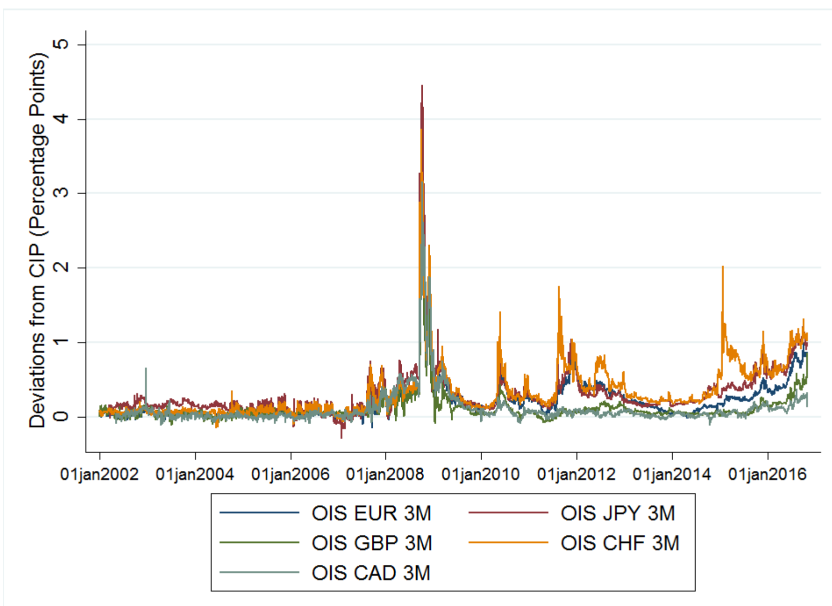
Notes: This figure depicts the three-month EUR deviations from CIP against the USD, measured in percentage points, for four common instruments: overnight index swap rates, unsecured interbank rates, government bond yields, and LIBOR swap rates.
Source: Bloomberg and authors' calculations.

Figure 7: EUR OIS-Based CIP Deviations By Maturity



Notes: This figure depicts the three-month EUR deviations from CIP against the USD, measured in percentage points, for seven maturities using overnight index swap rates.
Source: Bloomberg and authors' calculations.

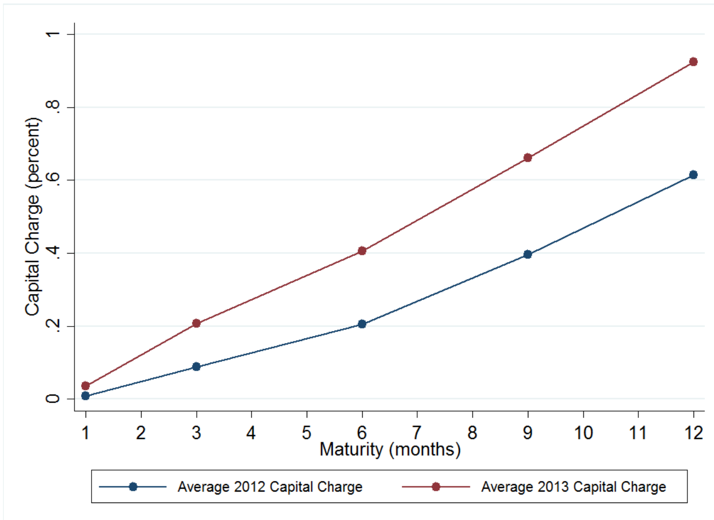
Figure 8: OIS-Based CIP Deviations By Currency



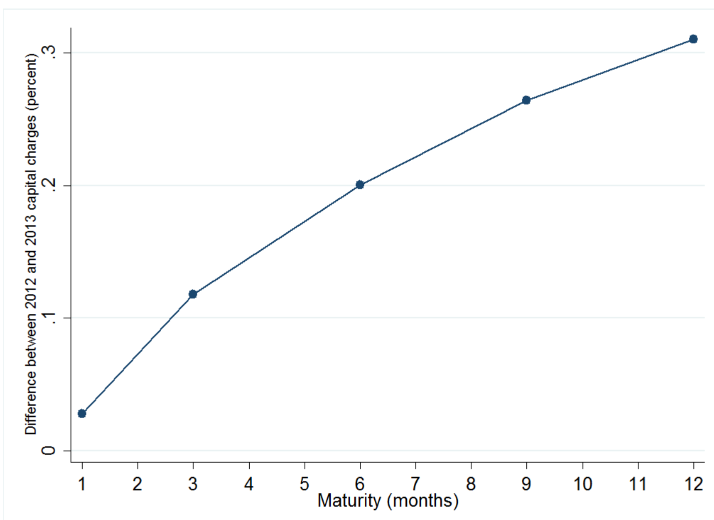
Notes: This figure depicts the three-month deviations from CIP, measured in percentage points, for five major currencies against the USD using overnight index swap rates. The covered interest parity condition implies that these deviations should be zero.
Source: Bloomberg and authors' calculations.

Figure 9: Capital Charges Against Interbank CIP Trades

(a) Capital Charges by Maturity for U.S. Banks during 2012 and 2013



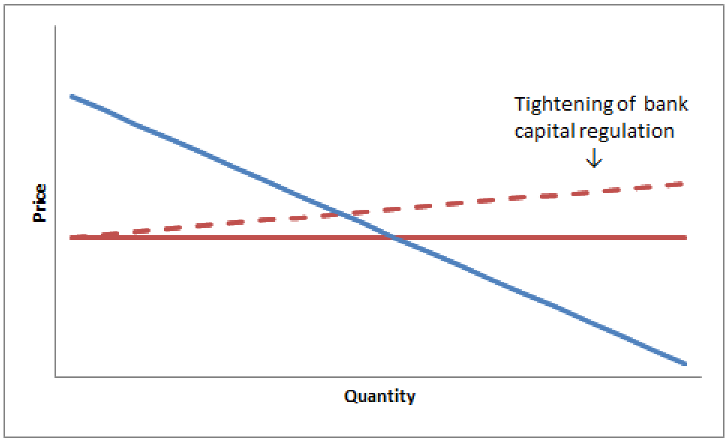
(b) Difference in Capital Charges Faced by U.S. Banks by Maturity between 2012 and 2013



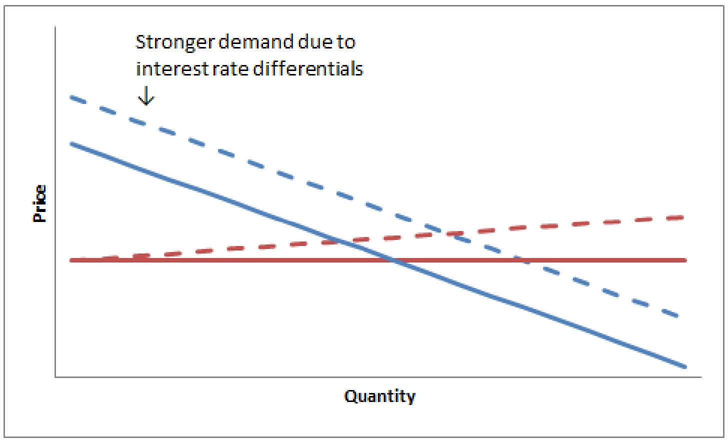
Notes: These two figures depict the increase in average capital charges faced by U.S. banks for the USD CIP trades against the currencies EUR, JPY, GBP, CHF, and CAD from 2012 to 2013. We compute the 99 percent Value-at Risk (VaR) measure for the trade by maturity as well as the 99 percent Stress Value-at-Risk, which is equal to the VaR in 2009. In 2012, the capital charge is computed as (VaR/26) x 12.5 x 3 x 0.08, where 26 adjusts for annualization, 12.5 and 3 are multipliers as specified by the Basel rules, and 0.08 is the minimum capital ratio faced by banks. In 2013, the capital charge is computed as (VaR+SVaR)/26 x 12.5 x 3 x 0.08, in which the new SVaR tacks on a higher capital charge for longer maturity trades. As shown in the figure, it is clear that capital charges on CIP trades increased from 2012 to 2013 and that the increase was higher for longer maturity trades.
Source: Authors' calculations.

Figure 10: Changes in Supply and Demand of Dollar Swaps

(a) Change in Supply due to Regulatory Changes

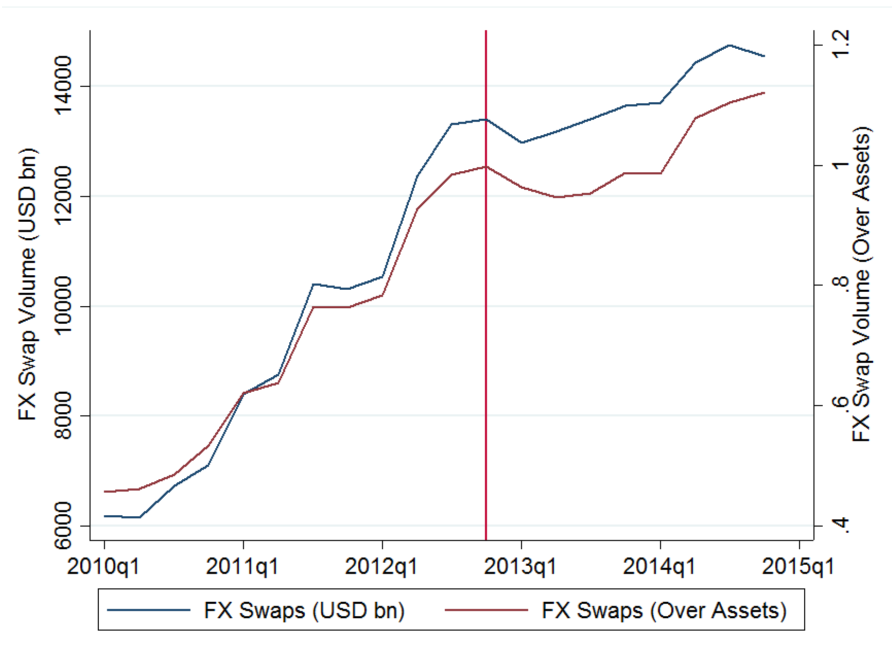


(b) Change in Demand due to Interest Rate Divergence



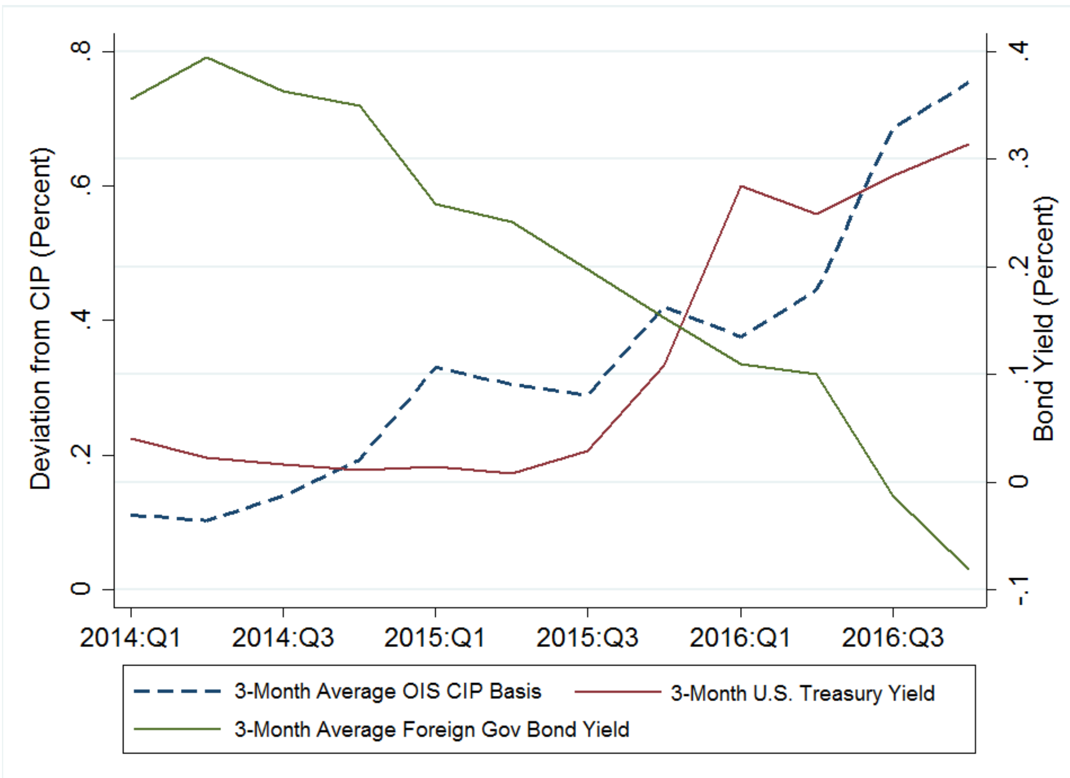
Notes: These two panels depict the change in the supply of FX swaps in dollars after the regulatory change was made, as well as the change in demand after a monetary policy divergence between the United States and other foreign countries. The solid lines represent the supply and demand curves before the change, and the dashed lines represent the supply and demand curves after the change.

Figure 11: FX Swaps of U.S. Banks and the Regulatory Change (Y-9C Data)



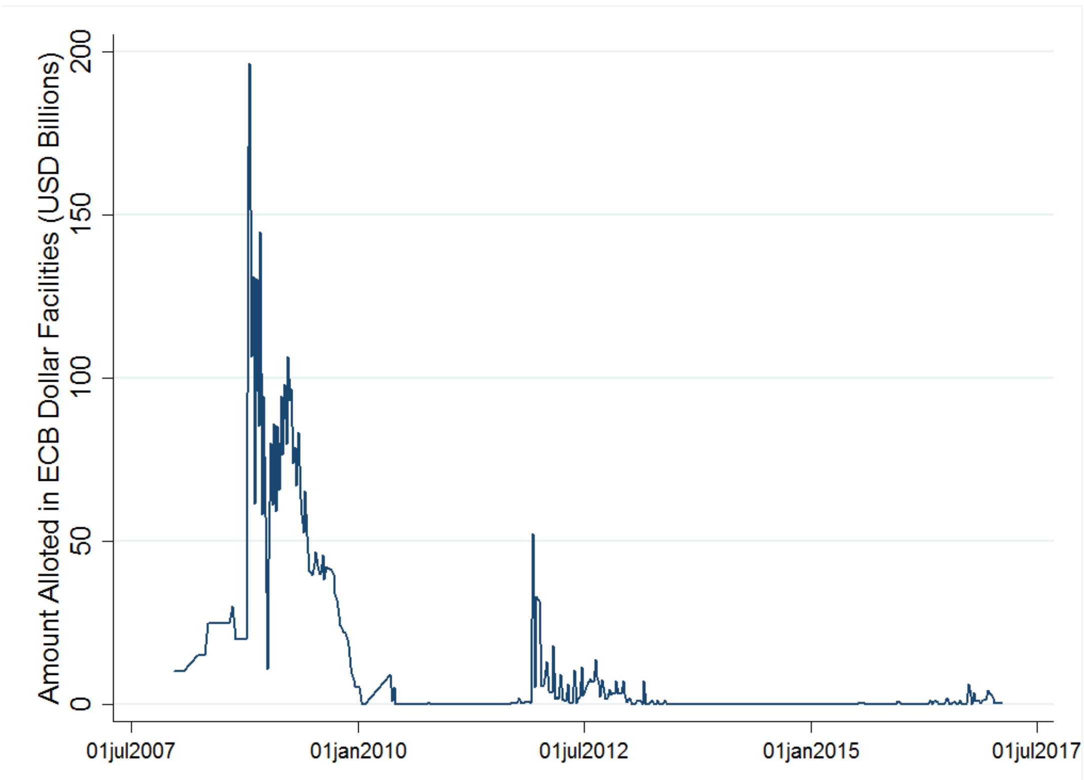
Notes: This figure depicts the overall and relative FX swap volume before and after major regulatory capital requirements were implemented in the United States, using the Federal Reserve's Call Reports Y-9C data. The blue line shows the overall growth of FX swaps of U.S. banks, in billions, while the red line plots the growth of FX swap volume scaled by banks' total assets. The vertical red line indicates the date at which the SVaR-related capital requirement in the United States started to take effect. *Source*: Federal Reserve and authors' calculations.

Figure 12: Government Bond Yields and Average OIS-Based CIP Deviations



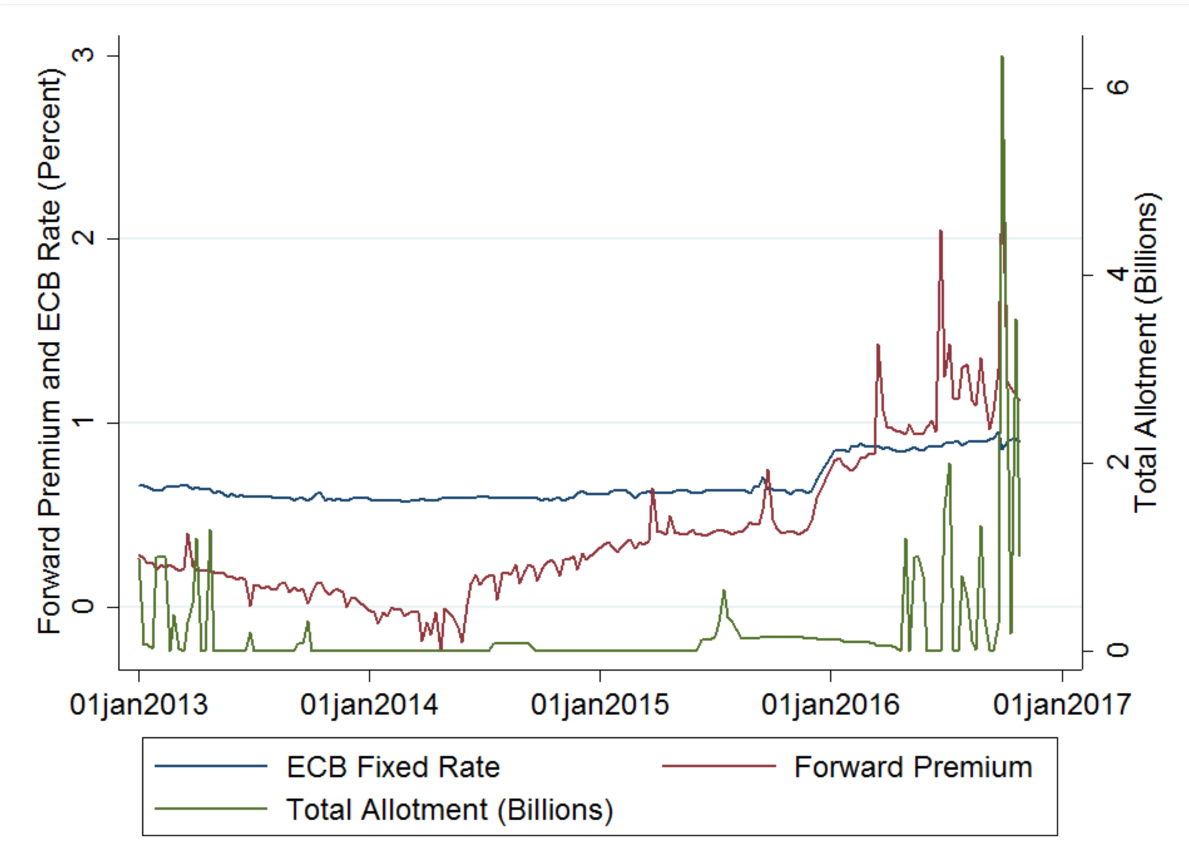
Notes: This figure plots the average three-month foreign government bond yield for five major areas along with an average three-month OIS CIP deviation. The interest rate differential is a key component of the CIP calculation; thus, an increase in the differential is reflected in the cross-currency basis.
Source: Bloomberg and authors' calculations.

Figure 13: Recourse to the European Central Bank's Dollar Facilities



Notes: This figure plots the amount alloted through all ECB's (fixed-rate) dollar tenders to euro-area banks.
Source: European Central Bank and authors' calculations.

Figure 14: Cost Differential Between One-Week FX Swap and a One-Week ECB Dollar Tender



Notes: This figure plots the difference between the cost of a one-week USD FX swap (forward premia) and the fixed rate charged for a one-week dollar loan by the ECB (left scale). The right scale depicts the recourse to the ECB one-week tender (in USD billions).
Source: Bloomberg, European Central Bank, and authors' calculations.

B Tables

Table 1: Key Regulatory Changes Affecting CIP Deviations

Country/Region	**US**	**CA**	**JP**	**EA**	**UK**	**CH**
Regulation						
Risk-Weighted Capital Requirements	Jan-13	Jan-13	Mar-13	Jan-14	Jan-14	Jan-13
Leverage Ratio Increase	Jan-14	Jan-15	Jan-18	Jan-15	Jan-15	Jan-18
Liquidity Coverage Ratio	Jan-15	Jan-15	Mar-15	Oct-15	Oct-15	Jan-15
Higher G-SIB/D-SIB Buffers	Jan-16	Jan-16	Mar-16	Jan-16	Jan-16	Jan-13

Notes: This table lists the key effective dates by country (CA = Canada; JP = Japan; EA = euro area; UK = United Kingdom; CH = Switzerland) as reported by the Basel Committee on Banking Supervision's (BCBS) progress report on adoption of the Basel regulatory framework. Updated biannually since 2011, the report tracks the adoption status of the Basel standards for 26 member jurisdictions and 4 broad regulatory standards relevant to this paper: risk-based capital, the leverage ratio, liquidity standards, and G-SIB/D-SIB (Global/Domestic Systemically Important Banks) requirements. New risk-based capital requirements introduce a minimum common equity capital ratio, the capital conservation buffer, and minimum Tier 1 and Total Capital ratios. The updated leverage ratio is a non-risk based measure that requires bank to hold a minimum amount of capital against both on-balance and off-balance sheet items. Next, the liquidity coverage ratio (LCR) requires banks to hold high-quality liquid assets that are subject to a 30-day stressed funding scenario. Finally, the G-SIB/D-SIB requirements ensure that the world's most systemic banks are subject to even higher standards for the other categories mentioned above. The dates listed in this table reflect the points at which the initial Basel framework was adopted by each member jurisdiction, starting with Basel II.5. Each member country has agreed to follow the phase-in arrangements, which increases each capital and liquidity requirement on a yearly basis until 2019. More information on the Basel III standards and the implementation dates can be accessed at http://www.bis.org/bcbs/index.htm.

Table 2: Regulatory Reform and FX Swap Volumes by U.S. Banks

	Change in FX Swap Volume (pp)			
VARIABLES	(1)	(2)	(3)	(4)
Regulatory Change (Post 2012:Q4)	–0.012*	–0.012*	–0.033*	
	(–1.91)	(–1.88)	(–1.97)	
Regulatory Change * Tier 1 Capital (over Assets)			0.224*	0.223*
			(1.88)	(1.87)
Bank Fixed Effects	No	Yes	Yes	Yes
Time Fixed Effects	No	No	No	Yes
Observations	126	125	117	117
R-Squared	0.018	0.180	0.188	0.239

Notes: This table shows the effect of the tighter capital requirements on FX swap volumes. The dependent variable is the change in bank-level FX swap volume (over assets) by U.S. bank holding companies as reported in consolidated FR Y-9C reports. The indpendent variable is a dummy variable that equals one as of January 2013. The sample includes quarterly observations from 2012:Q3 through 2013:Q2 as reported by 35 U.S. banks. A constant is included in all regressions. Standard errors are clustered at the bank level. Robust t-statistics are shown in parentheses. The symbols indicate *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Regulatory Reforms and CIP Violations

	Change in CIP Violation (pp)			
VARIABLES	(1)	(2)	(3)	(4)
Regulatory Change (Post 2012q4)	0.017**	0.017**	0.017**	
	(2.31)	(2.29)	(2.22)	
Regulatory Change * FX Swap Maturiy (in Years)				0.011***
				(2.64)
Currency Fixed Effects	No	Yes	Yes	Yes
Maturity Fixed Effects	No	No	Yes	Yes
Time Fixed Effects	No	No	No	Yes
Observations	356	356	356	356
R-Squared	0.018	0.208	0.247	0.373

Notes: This table shows the effect of the tighter capital requirements on CIP deviations. The dependent variables is the change in the quarterly CIP violation based on OIS rates (in percent). An increase in the CIP basis indicates that swapping into USD becomes more costly. The independent variable is a dummy variables that equals one as of January 2013. The sample includes quarterly observations from 2012:Q3 through 2013:Q2. CIP deviations are computed for these currencies: AUD, CAD, CHF, EUR, GBP, HKD, JPY, NOK, NZD, and SEK, all against the USD in all available maturities. A constant term is included in all regressions. Standard errors are clustered at the currency-maturity level. Robust t-statistics are shown in parentheses. The symbols indicate *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Monetary Policy and CIP Violations After Post-Regulatory Reforms

	Change in CIP Violation (pp)			
VARIABLES	(1)	(2)	(3)	(4)
Change in Interest Rate Differential (pp)	0.389***	0.745***	0.738***	0.817***
	(4.57)	(7.95)	(7.74)	(8.77)
Change in (Log) Central Bank Balance Sheet		0.293***	0.331***	0.488***
		(5.48)	(6.11)	(5.77)
Introduction of Negative Interest Rate Policy			0.068***	0.000
			(6.76)	(0.03)
Currency Fixed Effects	Yes	Yes	Yes	Yes
Maturity Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	No	No	No	Yes
Observations	1,125	912	912	912
R-Squared	0.089	0.330	0.333	0.487

Notes: This table shows the effect of monetary policy on CIP deviations. The dependent variables is the change in the quarterly CIP violation based on OIS rates (in percent). An increase in the CIP basis indicates that swapping into U.S. dollars becomes more coimstly. The independent variable Change in Interest Rate Differential measures the change in the difference between the interest rate paid on central bank deposit (reserves) between the U.S. and the foreign currency area.Change in (Log) Central Bank Balance Sheet measure the log change in the foreign central bank's balance sheet size as a measure of quantitative easing and related unconventional policies. Negative Interest Rate Policy is a dummy variable that equals one for quarters when the foreign central bank introduced a negative interest rate on reserves. The sample includes quarterly observations from 2013:Q1 through 2016:Q1.CIP deviations are computed for currencies the CAD, CHF, EUR, GBP, and JPY all against the USD in all available maturities. A constant is included in all regressions. Standard errors are clustered at the currency-maturity level. Robust t-statistics are shown in parentheses. The symbols indicate *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Effects of ECB Dollar Provision through Central Bank Swap Line Agreement

VARIABLES	Total Allotment (bn) (1)	Allotment per Bidder (bn) (2)	Change in CIP Basis (pp) (3)
Lagged CIP Basis (percent)	3.187***	0.244***	
	(10.15)	(4.13)	
Fixed Rate of Tender Operation (percent)	–1.123**	–0.133	
	(–2.21)	(–0.62)	
Total Allotment (billions)			–0.026***
			(–2.03)
Maturity Fixed Effects	Yes	Yes	Yes
Observations	108	108	108
R-Squared	0.431	0.054	0.089

Notes: The table shows the relationship between the ECB dollar liquidity provision and the EUR-USD basis. "Lagged CIP Basis" denotes the cross-currency basis on the day before the tender operation. "Change in CIP Basis" is the change in the basis on the day of the operation relative to the day before the operation. The sample includes all dollar tenders with positive allotments from January 2013 through October 2016. All tenders in the sample were held as a fixed-rate operation and no bidder was rationed, meaning the operations were conducted with full allottment. A constant term is included in all regressions. Robust t-statistics are shown in parentheses. The symbols indicate *** p<0.01, ** p<0.05, * p<0.1.