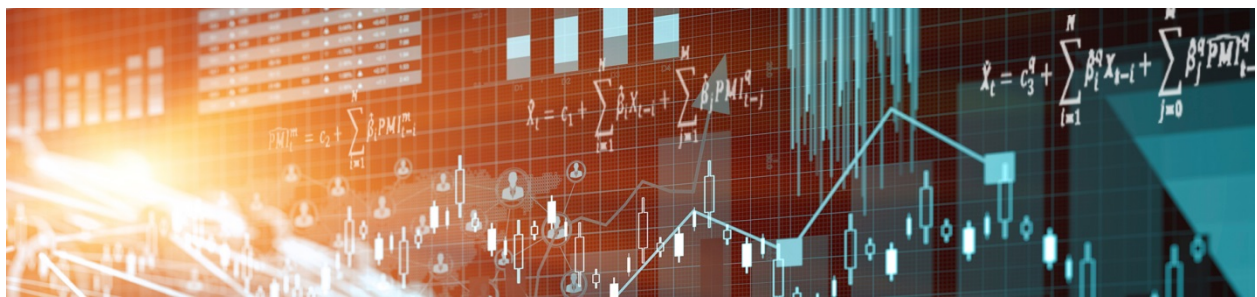


Staff Discussion Paper/Document d'analyse du personnel 2016-4

# Limits to Arbitrage and Deviations from Covered Interest Rate Parity



by James Pinnington and Maral Shamloo

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# **Limits to Arbitrage and Deviations from Covered Interest Rate Parity**

by

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## Abstract

We document an increase in deviations from short-term covered interest rate parity (CIP) in the first half of 2015. Since the Swiss National Bank's (SNB) decision to abandon its minimum exchange rate policy, both the magnitude and volatility of deviations from CIP have increased across several currency pairs. The effect is particularly pronounced for pairs involving the Swiss franc. These deviations are distinct from those observed during the financial crisis. We argue that they are a consequence of reduced liquidity in foreign exchange markets, rather than imbalances in international funding markets. A reduction in the supply of forward contracts, owing to limited dealer capacity following the SNB decision, led to wide bid-ask spreads in the forward market. This friction, pertaining specifically to the foreign exchange market rather than broader funding markets, allowed deviations from CIP to persist.

*JEL classification: F31, G15*

*Bank classification: Exchange rates; International financial markets*

## Résumé

Nous montrons que les écarts à court terme par rapport à la parité couverte des taux d'intérêt se sont creusés au premier semestre de 2015. Depuis la décision de la Banque nationale suisse de renoncer à sa politique de taux de change plancher, l'ampleur et la volatilité des écarts par rapport à cette parité se sont accrus pour plusieurs couples de devises. L'accroissement est particulièrement marqué pour les couples comprenant le franc suisse. Ces écarts diffèrent de ceux observés durant la crise financière. Nous avançons que ces écarts résultent d'une réduction de la liquidité des marchés des changes plutôt que de déséquilibres sur les marchés de financement internationaux : une contraction de l'offre de contrats à terme attribuable aux contraintes de capacité bilancielle des cambistes dans la foulée de la décision de la Banque nationale suisse s'est traduite par un large écart entre les cours acheteur et vendeur sur le marché à terme. Cette friction, qui s'observe spécifiquement sur le marché des changes plutôt que sur l'ensemble des marchés de financement, explique les écarts persistants par rapport à la parité des taux d'intérêt.

*Classification JEL : F31, G15*

*Classification de la Banque : Taux de change; Marchés financiers internationaux*

## 1. Introduction

We document an increase in deviations from covered interest rate parity (CIP) in the first half of 2015. Significant deviations occurred across a number of currency pairs, with magnitudes comparable to those seen during the 2008 financial crisis or the 2012 euro-area debt crisis (**Charts 1a** and **1b**). CIP deviations are among the most commonly studied violations of no-arbitrage conditions during the financial crisis (see Baba and Packer, 2009a and 2009b; Baba, Packer and Nagano, 2008; Mancini Griffioli and Ranaldo, 2010; and references within). Before 2008, such deviations were relatively short-lived (see Akram, Rime and Sarno, 2008). Since the crisis, however, large and persistent episodes of CIP deviations have reoccurred, first during the euro-area debt crisis and, most recently, in the first half of 2015.

We focus our analysis on pairs involving the Swiss franc (CHF) during the first half of 2015. The aim of this paper is twofold: first, to document CIP deviations in this episode, and second, to identify the constraints that put pressure on the CIP relationship for a sustained period of time.

The CIP relationship implies that, in integrated capital markets, agents are indifferent between funding themselves in different currencies. Equivalently, agents are indifferent between lending in different currencies. To illustrate, a European bank with U.S.-dollar assets can choose to fund itself via wholesale dollar funding markets. Alternatively, it can use its euro deposit base to purchase dollars in the spot market and hedge the exchange rate risk by exchanging dollars back to euros in the forward market. CIP guarantees that both choices result in equal funding costs to the illustrative bank.

What causes deviations from CIP? The CIP relationship assumes that the spot exchange rate and the interest rate differential pin down the forward exchange rate. It relies on a no-arbitrage pricing argument. In practice, forward contracts are provided by a finite set of financial intermediaries, typically the foreign exchange (FX) desks of investment banks or dealers, whose balance-sheet capacity is limited. Local changes in the demand or supply of these contracts can cause their prices to deviate from the levels implied by CIP. For example, increased hedging activity by corporations can put upward pressure on the price of forward contracts. This is in line with a broader strand of academic literature arguing that market-specific demand and supply factors explain the empirical properties of derivative prices better than the pure no-arbitrage theory.<sup>1</sup> For instance, during the financial crisis, many banks could not access wholesale dollar funding markets, due to dollar shortages and perceived counterparty risk. Unable to borrow dollars directly, they increased their borrowing in euro funding markets and exchanged the funds into dollars via FX swap markets, contracting to sell dollars forward.<sup>2</sup> The increased demand for forward contracts put upward pressure on the forward EURUSD exchange rate, causing it to deviate from the level implied by interest rate differentials and the spot exchange rate. European banks with dollar assets faced similar dollar funding difficulties during the euro-area debt crisis. Increased demand from these banks to convert euro deposits to dollars via the FX swap market led to large CIP deviations in the EURUSD market during this period.

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<sup>1</sup> See Bates (2003, 2008); Gârleanu, Pedersen and Poteshman (2009); Adrian and Shin (2010); Cheng, Kirilenko and Xiong (2014); and Etula (2009).

<sup>2</sup> Banks are typically prohibited from taking on unhedged exchange rate positions on their balance sheets.

Identifying the source of deviations from CIP is an important policy question. Ivashina, Scharfstein and Stein (2012) document that European banks cut their dollar lending, owing to funding difficulties they faced during the euro-area debt crisis. Further, a higher cost of engaging in FX swaps increases the cost of cross-border activity for firms that use these contracts to manage their balance sheets. Having correctly identified USD funding pressures as the source of CIP deviations in 2008 and 2012, central banks launched dollar funding swap lines with the U.S. Federal Reserve to address it. There is evidence that these dollar operations reduced both the level and volatility of deviations from CIP (Mancini Grifolli and Ranaldo, 2010, among others). Indeed, the real costs associated with dysfunctional cross-border funding markets were large enough for some to advocate a permanent and international mechanism for the provision of liquidity, for instance, by the International Monetary Fund (see Obstfeld, 2009).

We provide an explanation for the sustained deviations from CIP during the first half of 2015. We argue that they arose from reduced liquidity in foreign exchange markets, rather than from imbalances in international funding markets. The SNB's abandonment of its minimum exchange rate policy against the euro led to increased exchange rate volatility. In the absence of an alternative policy to guide market expectations, uncertainty around exchange rate movements rose significantly, leading to large bid-ask spreads in the market for forward contracts. Supporting this view, we show that option-implied uncertainty measures increased significantly across currency pairs involving the Swiss franc. Further, we show that the mispricing of forward contracts, as measured by the midpoint of the bid-ask spread, did not last beyond a few days after the SNB decision. However, large bid-ask spreads remained. These observations imply that the deviations from CIP arose from illiquid foreign exchange markets, rather than relative funding shortages.

Why did large bid-ask spreads persist? Bid-ask spreads represent a fee charged by the suppliers of forward contracts, typically dealers. We argue that exchange rate volatility led to higher hedging demand for forward contracts from corporates and non-bank financial institutions. The ability of dealers to charge high bid-ask spreads is consistent with an increase in demand for forward contracts. Further, long-term factors, such as the reduced leverage of financial intermediaries since the financial crisis, may have contributed to reduced competition in providing these contracts. Dealers are generally less able to devote their balance sheets to providing market liquidity in a variety of markets, including the currency forward market. Thus, the cost to the end-user of these contracts, such as corporates needing to manage their balance sheets, has increased.

We investigate our hypothesis as follows. First, we show that deviations from CIP increased substantially in magnitude and volatility for the EURCHF and USDCHF pairs after the SNB's decision. We then decompose deviations from CIP into three components: (i) foreign exchange market distortions, as measured by forward exchange rate mispricing; (ii) interbank market distortions, as measured by the relative funding pressures between the two currencies; and (iii) transaction costs, as measured by bid-ask spreads. We show that these components contributed differently to CIP deviations in various episodes. In particular, forward exchange rate mispricing played an important role during the financial crisis and the euro-area debt crisis. The forward rate was also briefly mispriced after the SNB decision, mainly owing to a sharp drop in the supply of forward contracts. However, we show that the persistent level of CIP deviations throughout the

first half of 2015 can be explained mostly by large bid-ask spreads and not by a mispricing of forward contracts.

Next, we discuss the spillovers of CIP deviations to other currency pairs and analyze CIP conditions for longer horizons. We show that deviations from CIP increased for a range of currency pairs after the SNB decision, and thus market dysfunction was not limited to pairs involving the Swiss franc. We also show that deviations have followed a similar pattern for horizons of up to 6 months.

Finally, we briefly discuss deviations from long-term covered interest rate parity in the market for cross-currency basis swaps. This contract is used to issue debt in foreign currency, rather than to manage funding needs. We show that imbalances in the relative levels of funding liquidity have affected this market, rather than the short-term FX swap market. Increased euro-area liquidity due to ECB actions, such as full allotment, long-term refinancing operations and quantitative easing, has suppressed corporate spreads in Europe relative to the United States, inciting U.S. firms to issue more euro-denominated debt. As a result, the cost of hedging currency exposure for longer durations has increased. We argue that, unlike deviations in short-term FX swap markets, the increase in the cost of long-term hedging has occurred gradually and is unrelated to the SNB's decision.

The remainder of the paper is organized as follows: in Section 2, we provide a brief overview of covered interest rate parity, the market for FX swaps and our decomposition of the CIP basis. Section 3 presents evidence that the SNB's decision to abandon its minimum exchange rate policy resulted in a large increase in CIP deviations across pairs involving the Swiss franc. Section 4 applies our decomposition to recent episodes of CIP deviations. Section 5 presents additional evidence for our hypothesis. Section 6 briefly discusses spillovers of CIP deviations to other currency pairs and other horizons. Section 7 discusses conditions in the longer-term cross-currency basis swap market. Section 8 concludes.

## 2. Covered Interest Rate Parity and the Foreign Exchange Swap

### 2.1 The covered interest rate parity condition

Consider the EURUSD exchange rate. In the absence of transaction costs, covered interest rate parity guarantees that the following holds:

$$1 + i_{t,t+s}^{USD} = \frac{F_{t,t+s}}{S_t} (1 + i_{t,t+s}^{EUR}),$$

where  $S_t$  is the spot exchange rate at time  $t$ ,  $F_{t,t+s}$  is the forward exchange rate contracted at time  $t$  for exchange at time  $t+s$ ,  $i_{t,t+s}^{USD}$  is the USD interbank interest rate from time  $t$  to time  $s$ , and  $i_{t,t+s}^{EUR}$  is the EUR interbank interest rate from time  $t$  to time  $s$ .

The CIP condition states that lending domestic currency yields the same proceeds as purchasing foreign currency, lending the foreign currency and selling for domestic currency at a forward rate contracted at the start of the trade. Alternatively, borrowing domestic currency costs as much as borrowing foreign currency, converting the proceeds to domestic currency and hedging the exchange rate risk on the outstanding loan. To use the currency pair in this example, borrowing

USD at USD LIBOR costs as much as borrowing EUR at EURIBOR, selling for USD and hedging the exchange rate risk on the outstanding EURIBOR loan.

A set of spot and forward exchange rates and a foreign interest rate thus imply a “synthetic” interest rate to borrow or lend domestic currency. Under no-arbitrage, the synthetic rate and the actual rate are equal; otherwise, arbitrageurs would enter the market and take advantage of the discrepancy.

We refer to the difference between the synthetic interest rate and the actual interest rate for a currency as the “basis.” The basis is never exactly equal to zero because of the presence of bid-ask spreads in the spot and forward markets. Incorporating bid-ask spreads and approximating the USD basis can be expressed as follows:

$$basis^{USD} \approx \log\left(\frac{F_{Bid}}{S_{Ask}}\right) - (i_{USD} - i_{EUR}),$$

where the subscripts “Bid” and “Ask” indicate the bid and ask prices in the spot and forward markets. Note that the existence of bid-ask spreads implies that the basis is not symmetric, i.e.,  $basis^{USD}$  is not typically equal to  $-basis^{EUR}$ .

## 2.2 The foreign exchange swap

An FX swap combines spot and forward trades into a single transaction. Upon initiation of the contract, domestic currency is sold for foreign currency at the spot rate. Upon termination, the foreign currency is used to repurchase the domestic currency. The contract thus involves short-term borrowing in one currency and lending in another while avoiding exchange rate risk. FX swaps are the most common form of transactions in the foreign exchange market.

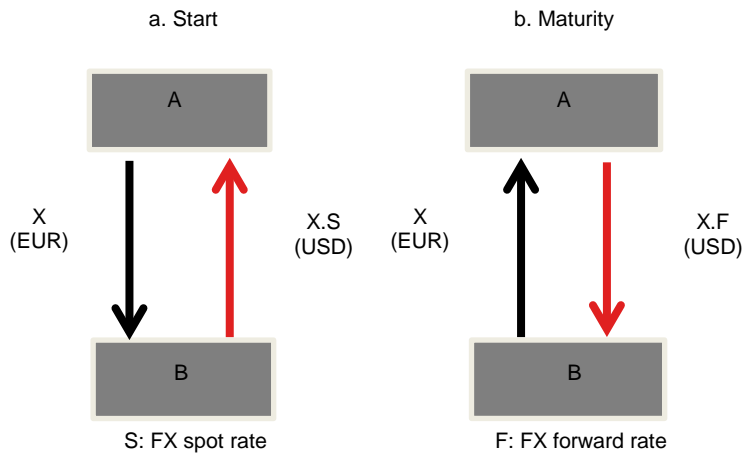
A financial institution needing foreign currency can either (i) borrow directly in that currency or (ii) borrow in domestic currency and purchase currency using an FX swap. The latter leads to a funding rate often referred to as the “swap-implied rate” for the foreign currency. The swap-implied rate is akin to the synthetic interest rate discussed above since the FX swap combines spot and forward rates.

For example, when a financial institution raises dollars via the euro interbank market, it sells euros for dollars at the EURUSD spot rate while contracting to exchange in the reverse direction at the maturity date of the contract (see **Figure 1**). Under CIP, the cost of funding using either method should be equal.

The FX swap is a liquidity-management tool, used to manage exchange rate mismatches. Global banks use FX swaps to fund their foreign currency assets, while multinational corporations use them to manage their cash flows in different currencies. The market is predominantly short term, with most of the activity occurring between 3 months to 1 year.



**Figure 1: The mechanics of a foreign exchange swap**



Source: Baba and Packer, 2009b

### 2.3 Deviations from CIP: A decomposition exercise

To identify the sources of deviations from CIP, we decompose the expression for the basis into three components, again using the EURUSD pair to illustrate:

$$\begin{aligned}
 basis_{USD} &= \log\left(\frac{F_{Bid}}{S_{Ask}}\right) - (i_{USD,INTERBANK} - i_{EUR,INTERBANK}) \\
 &= [1] \log\left(\frac{F}{S}\right) - (OIS_{USD} - OIS_{EUR}) \\
 &+ [2] (i_{EUR,INTERBANK} - OIS_{EUR}) - (i_{USD,INTERBANK} - OIS_{USD}) \\
 &+ [3] \log\left(\frac{F_{Bid}}{F}\right) + \log\left(\frac{S}{S_{Ask}}\right)
 \end{aligned}$$

We refer to the first component as foreign exchange market distortions. It represents the degree of forward rate mispricing. In the presence of perfect capital mobility, CIP implies that the forward to spot exchange rate differential is equal to the expected interest rate differential. We represent this as the difference between overnight index swap (OIS) rates for the currencies involved in the swap.

We refer to the second component as interbank market distortions. It represents the difference in funding pressures between the two currencies. We proxy distortions in funding markets using the difference between interbank rates and OIS rates. The second component is thus computed as the difference between these two spreads.

We refer to the third component as transaction costs. It represents bid-ask spreads and is negative. The USD basis is equal to the profits realized by borrowing USD and lending EUR while hedging exchange rate risk. The further  $F_{Bid}$  and  $S_{Ask}$  are from their midpoints, the lower the profits from this trade become.

During the financial crisis, USD funding markets became extremely expensive and at times completely inaccessible. Consequently, both U.S. banks and foreign banks with USD assets sought to borrow USD synthetically via EUR. This trade involved borrowing EUR on the interbank market, exchanging EUR for USD on the spot market, and simultaneously hedging the exchange rate exposure by buying a forward contract. The sheer number of participants executing this trade, combined with limited capacity on the part of dealers, affected the price of forward contracts and pushed the forward exchange rate away from that implied by the CIP condition. The swap-implied USD borrowing rate became expensive compared with USD LIBOR. However, arbitrageurs were unable to take advantage of this difference because of lack of access to dollar funding.

The direction of the basis, as well as the decomposition above, reveals the source of deviations from the no-arbitrage condition. We use this decomposition to analyze the nature of deviations from CIP during the first half of 2015.

### **3. The CIP Condition Since the SNB Decision**

We refer to the relatively tranquil period between August 1, 2012 (the end of the euro-area debt crisis) and January 14, 2015 as the “pre-SNB” period. The second sample, “post-SNB,” runs from January 15, 2015 to June 29, 2015.

The top panel of **Table 1** shows the means of the CIP bases for the EURCHF and USDCHF pairs in the pre- and post-SNB periods. The means increased significantly for both currency pairs in the post-SNB period, except for the 90-day USDCHF basis, where the difference is not significant. Further, mean bid-ask spreads in both the spot and forward markets almost doubled in size. The lower panel of **Table 1** indicates that there was a significant increase in the variance of both the bases and bid-ask spreads.

**Table 2** tests the same differences in a smaller window around two of the SNB’s decisions. The top panel shows the absolute values of the bases during the 10 days before and the 10 days after December 18, 2014. On this day, the SNB imposed a negative interest rate of -25 basis points on deposits and announced a target range for the 3-month CHF LIBOR of -75 to 25 basis points. The absolute basis did not increase significantly for either USDCHF or EURCHF. In contrast, repeating the test using the January 15, 2015 exchange rate decision shows that the absolute level of the basis increased significantly for both currency pairs. This supports our hypothesis that changing interest rate differentials, forward exchange rate mispricing or the introduction of negative interest rates did not contribute to the dislocations in the foreign exchange market observed during the first half of 2015.

### **4. A Decomposition**

In this section, we decompose post-SNB CIP deviations for the two currency pairs of interest. We then compare them to the CIP deviations observed in the EURUSD pair during the financial crisis.

#### **4.1 CHF interbank market**

It is important to recognize certain developments in the CHF interbank market that have arisen as a result of the way the SNB has implemented its policy of negative deposit rates. On

December 18, 2014, the SNB lowered its deposit rate and its target for the 3-month CHF LIBOR into negative territory; both these rates were again reduced when the minimum exchange rate was abandoned on January 15, 2015. However, negative deposit rates were applied only to reserves above a certain threshold.<sup>3</sup>

Typically, interbank rates trade above OIS rates. Both 3-month CHF OIS and CHF LIBOR have traded in negative territory since negative interest rates were imposed. However, throughout the post-SNB period, the 3-month CHF OIS rate traded above the CHF LIBOR rate, due to different fixing conventions (**Chart 2**).<sup>4</sup> The OIS fixing is defined as the interest rate at which banks are willing to lend, while the LIBOR fixing is defined as the interest rate at which banks are willing to borrow. Because the rate at which a bank is willing to lend depends on its level of reserves, its comparison with a benchmark borrowing rate is hampered. For this reason, when we decompose CIP deviations for pairs involving CHF, we do not consider funding distortions in the CHF market. Because CIP deviations represent the difference in the cost of borrowing in different currencies, it is CHF LIBOR that represents the relevant measure for the Swiss franc, and not the OIS rate.

## 4.2 Deviations in CHF foreign exchange markets

**Charts 3a** and **3b** plot the decomposed spread between the EURCHF swap-implied EUR interest rate and EURIBOR, or the EUR basis, at the 30-day horizon. The green line plots the EUR basis, abstracting from bid-ask spreads. The deviations rise to their highest levels on January 21, 2015, where the basis rose to 260 basis points. These positive deviations imply that there are potential profits to be made by borrowing EUR and lending CHF. These deviations are explained almost entirely by the mispricing of forward contracts, and return to long-run averages by the end of February 2015.

However, the purple line, which plots CIP deviations *including* bid-ask spreads, shows a strongly negative basis throughout the post-SNB period. The basis reaches -1400 basis points on March 4, 2015. Negative values indicate that CIP deviations cannot be arbitrated away, due to large bid-ask spreads. Borrowing EUR and lending CHF would yield negative profits. Furthermore, although the deviations of the midpoint of forward prices return to post-crisis norms, deviations arising from bid-ask spreads persist. **Charts 4a** and **4b** show a similar trend for the USDCHF pair.

## 4.3. Deviations from CIP during the financial crisis

**Charts 5a** and **5b** repeat the decomposition exercise for the EURUSD pair and show the decomposed spread between the swap-implied USD interest rate and USD LIBOR, or the USD basis, at the 30-day horizon. **Chart 5b** spans the financial crisis. As shown by the blue line, the spread between USD LIBOR and OIS reached unprecedented levels, reflecting severe dollar funding shortages. However, the extent of funding market distortions was much larger than that implied by the USD LIBOR-OIS spread, which applies only to LIBOR panel banks. Many banks were completely cut out of wholesale dollar funding markets and resorted to using FX swap

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<sup>3</sup> The threshold level is 20 times the level of required reserves.

<sup>4</sup> From December 18, 2014 to June 29, 2015, 3-month CHF LIBOR averaged -0.70%, while 3-month CHF OIS averaged -0.42%.

markets to borrow dollars. Our decomposition captures this effect in the foreign exchange market distortions component, as shown by the red line. The net effect of these two opposite forces was a positive USD basis (including transaction costs), implying arbitrage opportunities to be made by borrowing USD and lending EUR.

## 5. Supplemental Evidence

### 5.1 Funding liquidity

**Charts 6 – 8** provide multiple time series of funding pressures in dollar, euro and Swiss franc markets. They plot, respectively, the evolution of interbank-OIS spreads at the 1-month horizon,<sup>5</sup> the spread between interbank rates and sovereign bill yields at the 3-month horizon, and non-financial corporate spreads at the 1–3 year horizon.

In the presence of stress in funding markets, we would expect to observe a widening of all of these spreads, as seen during the financial crisis and the euro-area debt crisis. Funding stress was most pronounced in dollar funding markets during the 2008 crisis, and later in euro funding markets in 2012. By contrast, apart from a slight increase in the corporate spreads of Swiss franc-denominated bonds, there were no signs of funding market stress in the first half of 2015.

### 5.2 Liquidity withdrawals from central banks

During the financial crisis, dollar funding shortages led to sustained deviations from covered interest rate parity. In response, global central banks enacted swap lines with the Federal Reserve to provide dollar liquidity to their banks. These were later converted to standing arrangements, which remain in place. If funding shortages were causing CIP deviations, for instance, in the USDCHF swap market, we would expect Swiss banks to draw on the dollar facility provided by the SNB. There has been no use of these facilities since 2009 (**Chart 9**). This supports our hypothesis that CIP deviations in the USDCHF market were not due to forward rate mispricing caused by USD funding shortages. Rather, the SNB decision led to increased exchange rate volatility, which resulted in widening bid-ask spreads in the spot and forward markets, and consequently, violations of the CIP condition.

### 5.3 Extreme movements in exchange rates

Large bid-ask spreads in the price of forward contracts may reflect uncertainty surrounding future exchange rate movements. **Charts 10** and **11** show proxies for the risk-neutral volatility, skewness and kurtosis of the distribution of returns for EURCHF and USDCHF, respectively.<sup>6</sup> All three variables were higher in the first half of 2015 than average levels in 2013 and 2014. These proxies suggest that a sudden abandonment of the exchange rate target, rather than, for instance, moving to a tolerance band, resulted in significant uncertainty about future exchange

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<sup>5</sup> As discussed earlier, the CHF LIBOR-OIS spread turns negative owing to the exclusion of deposits up to a threshold from negative interest rates at the SNB.

<sup>6</sup> The implied volatility proxy is the at-the-money implied volatility and reflects the cost of insuring against unexpected movements in the exchange rate. The skewness proxy is the difference in implied volatilities between a 25 delta call and a 25 delta put. It reflects the cost of insuring against large one-sided movements in the exchange rate. The kurtosis proxy is the difference between implied volatilities of out-of-the-money options and in-the-money options. It reflects the cost of insuring against large movements in the exchange rate in either direction.

rate movements. The ensuing large bid-ask spreads, in turn, have caused large and persistent deviations from CIP that cannot be arbitrated away.

#### **5.4 Forward positions of traders**

Finally, we provide supporting evidence for a reduction in the supply of forward contracts immediately following the SNB's decision, which contributed to forward rates that were sharply out of line with what would be implied by interest rate differentials. Thus, immediately following the decision, CIP deviations can be explained in large part by the first component of our decomposition. Ideally, we would like to observe the number of forward contracts supplied directly, but these data do not exist. Instead, we use data from the U.S. Commodity Futures Trading Commission (CFTC). The CFTC reports the aggregate large-trader positions of banks participating in various financial and non-financial futures. When a dealer provides a forward contract, it hedges its position in the futures market. Thus, we can use the number of positions of dealers as a proxy for the supply of forward contracts. This is only possible for currency pairs involving the U.S. dollar since a similar classification (commercial vs. non-commercial) does not exist in Europe.

**Charts 12a** and **12b** show the net and total non-commercial positions of dealers in USDCHF futures. Both proxies for the supply of forward contracts decreased significantly in the weeks following the SNB decision. Further, both proxies remain lower compared with the pre-SNB period, supporting our hypothesis that limited dealer capacity has contributed to wider bid-ask spreads.

#### **6. Spillovers**

In **Table 3**, we compute the CIP basis before and after the SNB decision for two additional currency pairs: EURUSD and EURGBP. In the post-SNB period, the mean basis increased for each currency pair, at both the 30- and 90-day horizons. Mean bid-ask spreads in the spot and forward markets similarly increased. The variances of the basis and bid-ask spreads increased for the EURGBP pair.

**Charts 13** and **14** plot CIP deviations at the 1-month, 3-month and 6-month horizons for EURCHF and USDCHF, respectively. For both pairs, similar trends are observed across the three horizons. The basis is widest and most volatile at the 1-month horizon.

We interpret these findings as evidence for important spillover effects from the widening of the basis in one specific market. When deviations from CIP become large for a given currency pair, banks and corporates may try to hedge their positions using different maturities or using different currencies, increasing demand for forward contracts in those markets. Thus, the effects of illiquidity in the market for a specific currency, particularly if it is a widely traded one, can have implications for a wider set of currency markets and maturity horizons.

#### **7. Excess Liquidity and Deviations from Long-Term Covered Interest Rate Parity**

During the financial crisis, deviations from CIP were caused by an absolute shortage of dollar funding. Relative levels of liquidity across a currency pair can have a similar effect (Botazzi et al., 2012). Indeed, some have argued that recent actions by the European Central Bank, which have led to unprecedented excess liquidity in the euro area, have caused deviations from CIP.

We argue that the short-term CIP deviations observed in the first half of 2015 are not due to funding imbalances but instead arise from illiquidity in foreign exchange markets. However, we do observe recent trends in the market for cross-currency basis swaps that we conclude are indeed due to imbalances in the relative level of liquidity across currency pairs.

These contracts are similar to FX swaps in that they allow access to funding via foreign currency without taking on exchange rate risk. Because of the way they are structured, they differ from FX swaps in their typical maturity horizon and are used by a different set of end-users. They are liquid only for maturities of 2 years and above and are mainly used by multinational corporations who issue long-term debt in a different currency to hedge the currency risk.

**Charts 15 and 16** show EUR (CHF) bond issuance by U.S. corporates, as well as the difference between USD and EUR (CHF) corporate spreads to government securities. As EUR- and CHF-denominated corporate spreads have fallen relative to USD corporate spreads, U.S. companies have issued more bonds in those currencies. In turn, the increased EUR- and CHF-denominated issuance by U.S. companies has increased the price of the cross-currency basis swap that these companies pay in order to hedge the currency risk.<sup>7</sup> We contend that these trends arise from an abundance of euro-area liquidity, as well as divergent monetary policy. We also note that these trends started in early 2014, while the increase in short-term deviations from CIP occurred after the SNB's decision in January 2015.

## **8. Conclusion**

We document an increase in deviations from short-term covered interest rate parity in the first half of 2015. The effect is most pronounced for pairs involving the Swiss franc and arose immediately after the SNB abandoned its minimum exchange rate policy against the euro. We provide evidence that these deviations emanated from deteriorating liquidity in the foreign exchange market. We argue that they did not arise from a decline in funding liquidity, as was the case during the financial crisis. In particular, we show that bid-ask spreads in the spot and forward exchange markets widened sharply as uncertainty about future exchange rate movements increased, leading to persistent deviations from CIP.

Should policy-makers worry about a failure of the CIP condition? FX swap markets affect the real economy because they allow banks to conduct cross-border lending and permit corporations with currency exposures to manage their balance sheets. As such, an increase in the cost of engaging in an FX swap will affect real activity.

We draw two policy conclusions from our analysis of the recent episode of large CIP deviations. First, it shows that abandoning exchange rate targets without an alternative policy in their place to guide market expectations can affect market functioning beyond short-term exchange rate volatility. Second, our analysis underlines the importance of reduced dealer competition and potentially inadequate balance-sheet capacity to meet demand in times of market volatility.

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<sup>7</sup> Charts 15 and 16 show the price, or alpha, of cross-currency basis swaps quoted against the U.S. dollar (in basis points). Alpha represents the cost of borrowing in a foreign currency (EUR or CHF) and swapping the proceeds back to dollars. A lower alpha corresponds to a higher hedging cost for the firm borrowing abroad. Thus, the declining alpha observed during 2014 is consistent with the increased hedging costs.

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## Appendix

Table 1: CIP deviations during the pre- and post-SNB period - USDCHF and EURCHF (basis points)

Note: \*,\*\* and \*\*\* indicate that the test statistic is significant at the 10%, 5% and 1% level, respectively.

Sources: Bloomberg and Bank of Canada calculations

		Panel 1: Difference in means with unequal variances					
		Horizon					
Pair	Attribute	30-day			90-day		
		pre-SNB	post-SNB	Difference	pre-SNB	post-SNB	Difference
EURCHF: euro basis	# Observations	641	118		641	118	
	Basis	-37.82	-117.14	-79.32***	-13.32	-25.65	-12.34***
	Spot spread	3.57	11.06	7.49***	3.57	11.06	7.49***
	Forward spread	4.06	12.09	8.03***	4.60	13.19	8.59***
USDCHF: dollar basis	# Observations	641	118		641	118	
	Basis	-34.70	-84.70	-50.00***	-2.96	-1.39	1.57
	Spot spread	4.31	10.12	5.81***	4.31	10.12	5.81***
	Forward spread	4.83	11.35	6.52***	5.24	12.48	7.24***

		Panel 2: Variance ratio test					
		Horizon					
Pair	Attribute	30-day			90-day		
		Standard deviation		Ratio of variances	Standard deviation		Ratio of variances
		pre-SNB	post-SNB		pre-SNB	post-SNB	
EURCHF: euro basis	# Observations	641	118		641	118	
	Basis	38.28	156.94	16.81***	14.35	52.20	13.23***
	Spot spread	3.02	13.91	21.24***	3.02	13.91	21.24***
	Forward spread	3.06	14.08	21.14***	3.09	14.30	21.46***
USDCHF: dollar basis	# Observations	641	118		641	118	
	Basis	44.24	135.10	9.33***	16.95	45.26	7.13***
	Spot spread	3.67	11.82	10.35***	3.67	11.82	10.35***
	Forward spread	3.74	11.98	10.25***	3.85	12.47	10.50***



Table 2: CIP deviations surrounding SNB policy events (basis points)

Note: \*,\*\* and \*\*\* indicate that the test statistic is significant at the 10%, 5% and 1% level, respectively.

Sources: Bloomberg and Bank of Canada calculations

Pair	Difference in means with unequal variances					
	Horizon					
	30-day			90-day		
	pre-negative rates	post-negative rates	Difference	pre-negative rates	post-negative rates	Difference
USDCHF: dollar basis (absolute value)	23.76	39.31	15.54	11.18	15.06	3.88
EURCHF: euro basis (absolute value)	11.37	41.70	30.33*	5.23	14.10	8.87**
	pre-floor removal	post-floor removal	Difference	pre-floor removal	post-floor removal	Difference
USDCHF: dollar basis (absolute value)	11.88	230.34	218.46***	18.69	74.80	56.11**
EURCHF: euro basis (absolute value)	28.33	170.31	141.98**	11.72	42.69	30.97**

Note: "Pre-negative rates" and "post-negative rates" refer to the 10 days before and after the SNB instituted negative deposit rates on December 18, 2014. "Pre-floor removal" and "post-floor removal" refer to the 10 days before and after the SNB abandoned its minimum exchange rate policy on January 15, 2015.

Table 3: CIP deviations during the pre- and post-SNB period - EURUSD and EURGBP (basis points)

Note: \*,\*\* and \*\*\* indicate that the test statistic is significant at the 10%, 5% and 1% level, respectively.

Sources: Bloomberg and Bank of Canada calculations

		Panel 1: Difference in means with unequal variances					
		Horizon					
Pair	Attribute	30-day			90-day		
		pre-SNB	post-SNB	Difference	pre-SNB	post-SNB	Difference
EURUSD: dollar basis	# Observations	641	118		641	118	
	Basis	-0.44	8.68	9.12***	8.81	16.19	7.38***
	Spot spread	0.93	1.08	0.15***	0.93	1.08	0.15***
	Forward spread	1.09	1.33	0.24***	1.17	1.35	0.18***
EURGBP: pound basis	# Observations	641	118		641	118	
	Basis	-42.01	-70.61	-28.6***	-6.35	-12.39	-6.04***
	Spot spread	3.69	7.00	3.31***	3.69	7.00	3.31***
	Forward spread	3.98	7.47	3.49***	4.26	7.77	3.51***

		Panel 2: Variance ratio test					
		Horizon					
Pair	Attribute	30-day			90-day		
		Standard deviation		Ratio of variances	Standard deviation		Ratio of variances
		pre-SNB	post-SNB		pre-SNB	post-SNB	
EURUSD: dollar basis	# Observations	641	118		641	118	
	Basis	9.25	6.57	0.51	8.22	3.45	0.2
	Spot spread	0.44	0.41	0.87	0.44	0.41	0.87
	Forward spread	0.47	0.43	0.84	0.48	0.42	0.75
EURGBP: pound basis	# Observations	641	118		641	118	
	Basis	35.93	79.75	4.93***	12.54	26.60	4.50***
	Spot spread	2.98	6.62	4.94***	2.98	6.62	4.94***
	Forward spread	3.03	6.65	4.82***	3.02	6.62	4.83***

Chart 1a: Spread between EURCHF swap-implied euro rate and EURIBOR (basis points, 30-day horizon, 10-day moving average)

Sources: Bloomberg and Bank of Canada calculations



Chart 1b: Spread between USDCHF swap-implied dollar rate and USD LIBOR (basis points, 30-day horizon, 10-day moving average)

Sources: Bloomberg and Bank of Canada calculations



Chart 2: Spread between CHF OIS and CHF LIBOR (basis points, 30-day horizon)

Sources: Bloomberg and Bank of Canada calculations

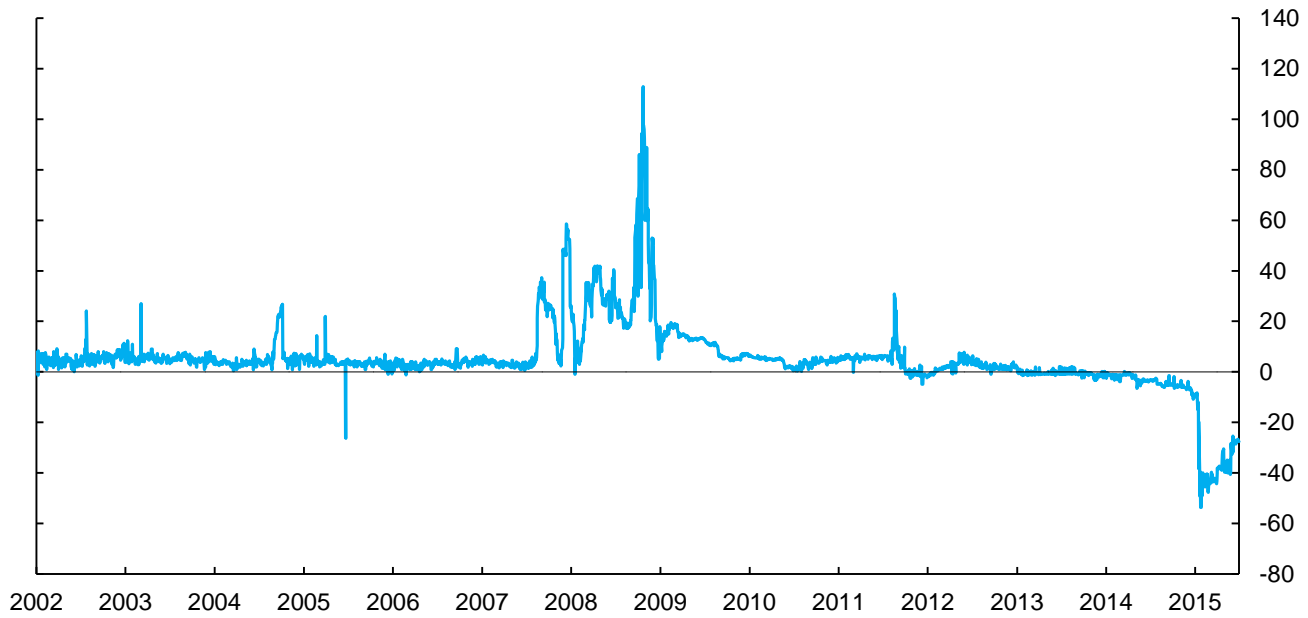


Chart 3a: Decomposition of spread between EURCHF swap-implied euro rate and EURIBOR (basis points, 30-day horizon, 10-day moving average) (2002 – 2015)

Sources: Bloomberg and Bank of Canada calculations

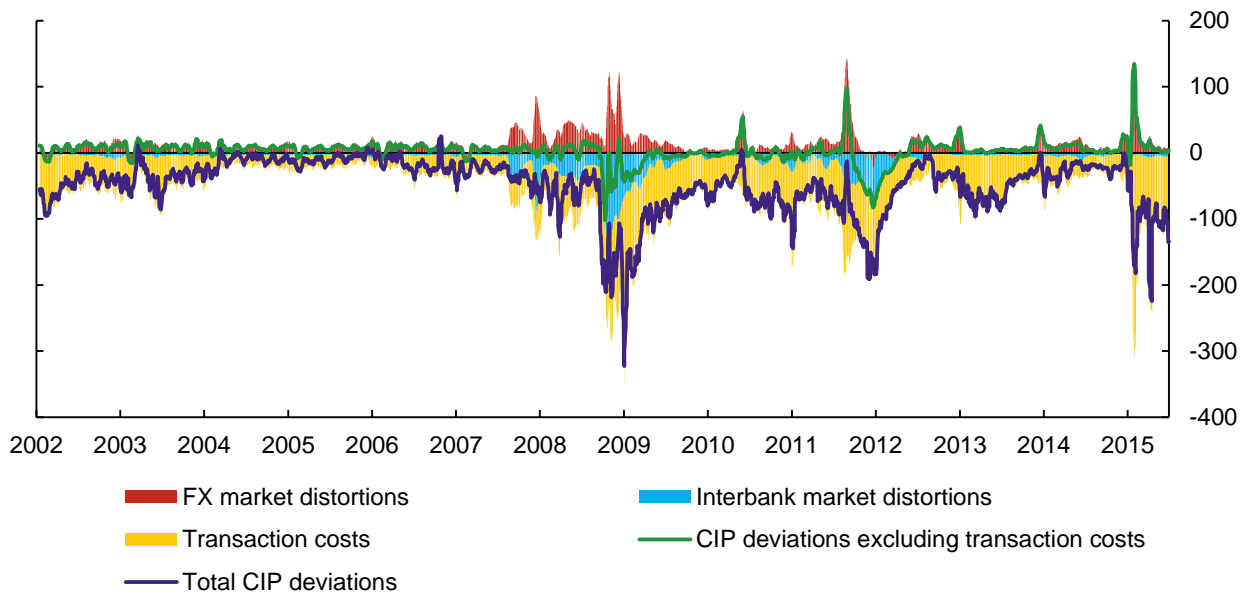


Chart 3b: Decomposition of spread between EURCHF swap-implied euro rate and EURIBOR (basis points, 30-day horizon, 10-day moving average) (2013 – 2015)

Sources: Bloomberg and Bank of Canada calculations

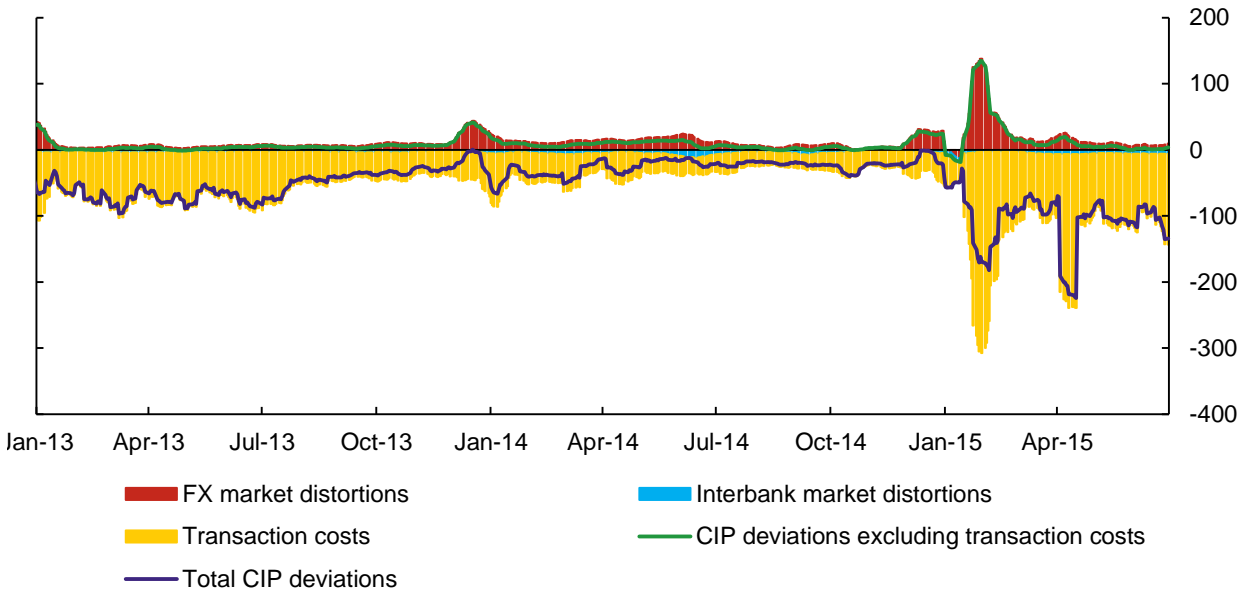


Chart 4a: Decomposition of spread between USDCHF swap-implied dollar rate and USD LIBOR (basis points, 30-day horizon, 10-day moving average) (2002 – 2015)

Sources: Bloomberg and Bank of Canada calculations

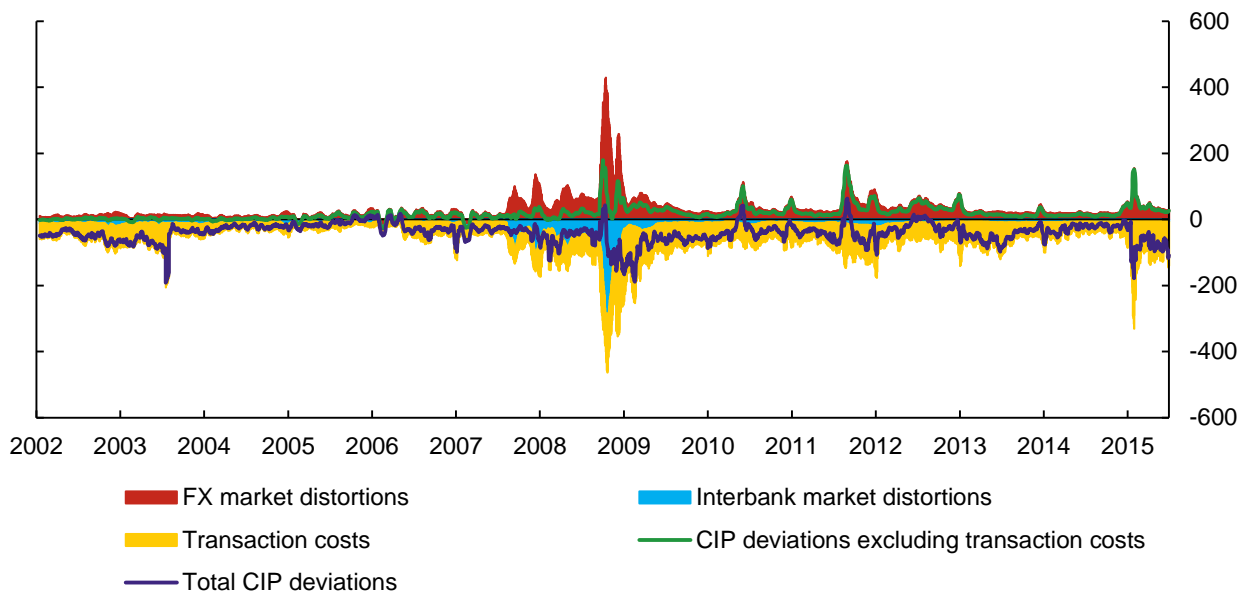


Chart 4b: Decomposition of spread between USDCHF swap-implied dollar rate and USD LIBOR (basis points, 30-day horizon, 10-day moving average) (2013 – 2015)

Sources: Bloomberg and Bank of Canada calculations

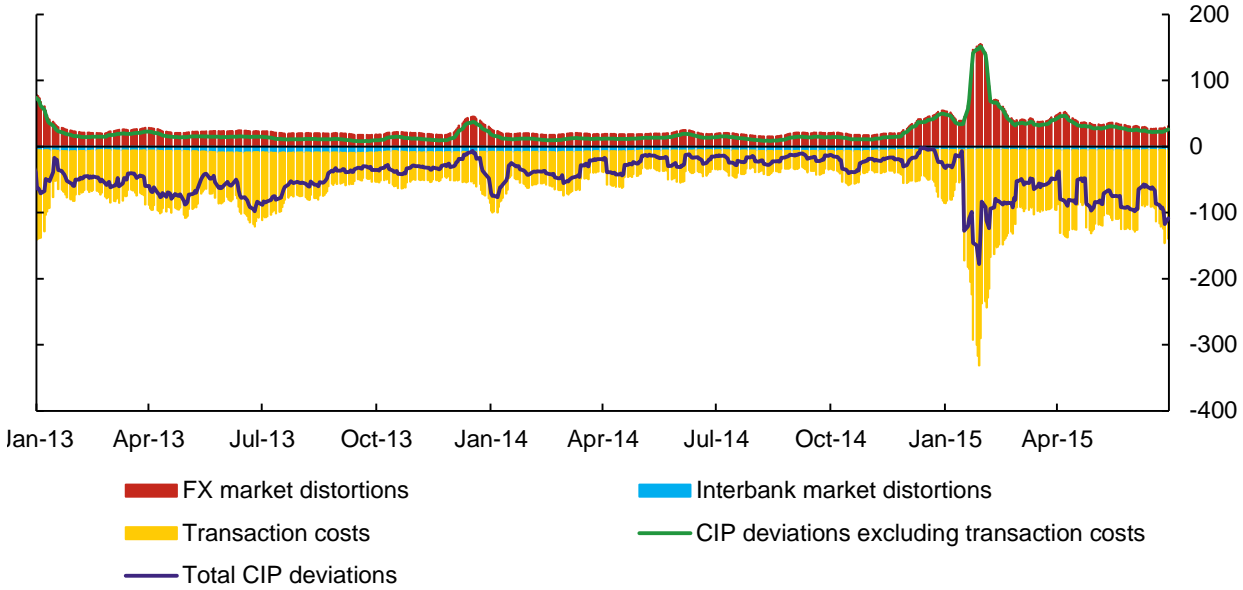


Chart 5a: Decomposition of spread between EURUSD swap-implied dollar rate and USD LIBOR (basis points, 30-day horizon, 10-day moving average) (2002 – 2015)

Sources: Bloomberg and Bank of Canada calculations

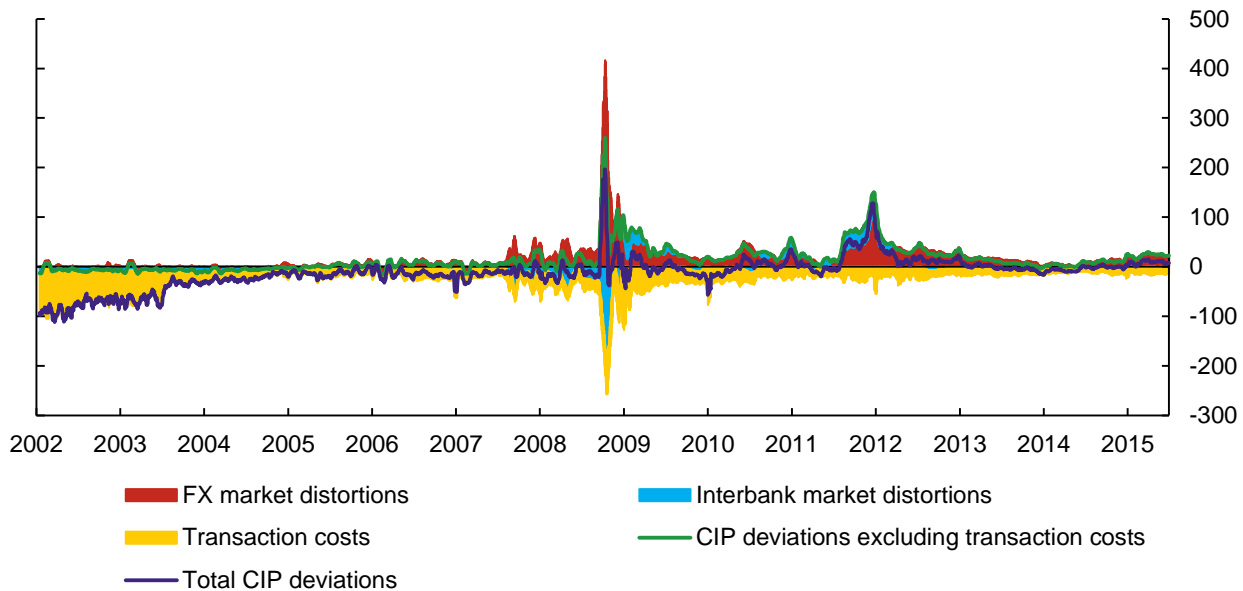


Chart 5b: Decomposition of spread between EURUSD swap-implied dollar rate and USD LIBOR (basis points, 30-day horizon, 10-day moving average) (2007 – 2010)

Sources: Bloomberg and Bank of Canada calculations

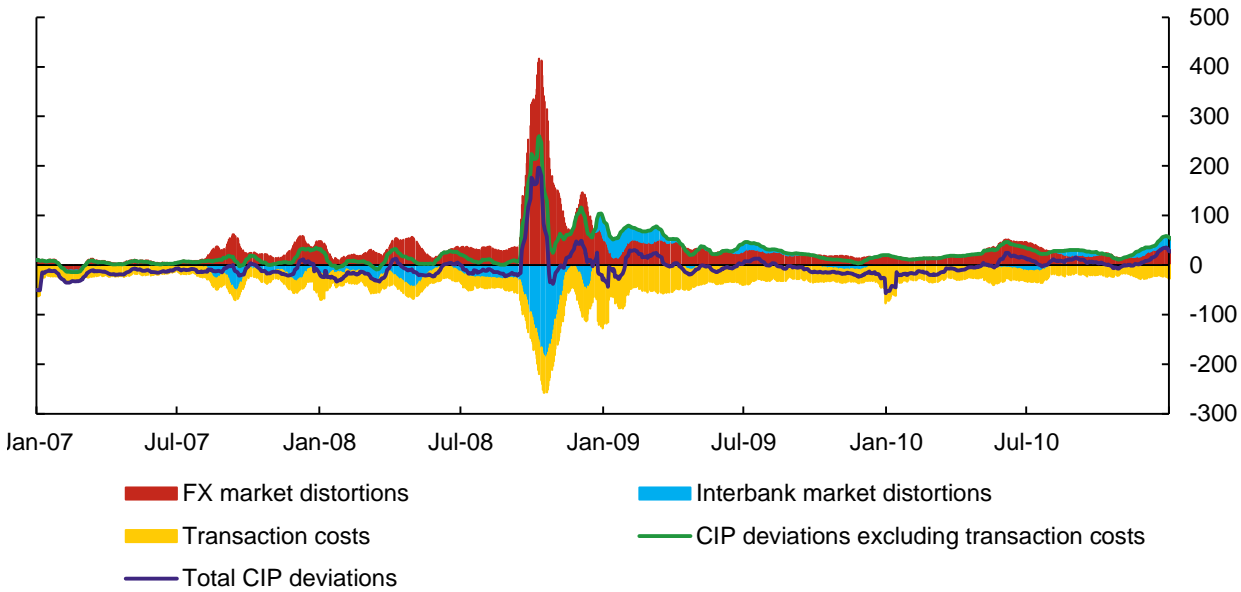


Chart 6: Spread between interbank and OIS rates (basis points, 30-day horizon)

Sources: Bloomberg and Bank of Canada calculations

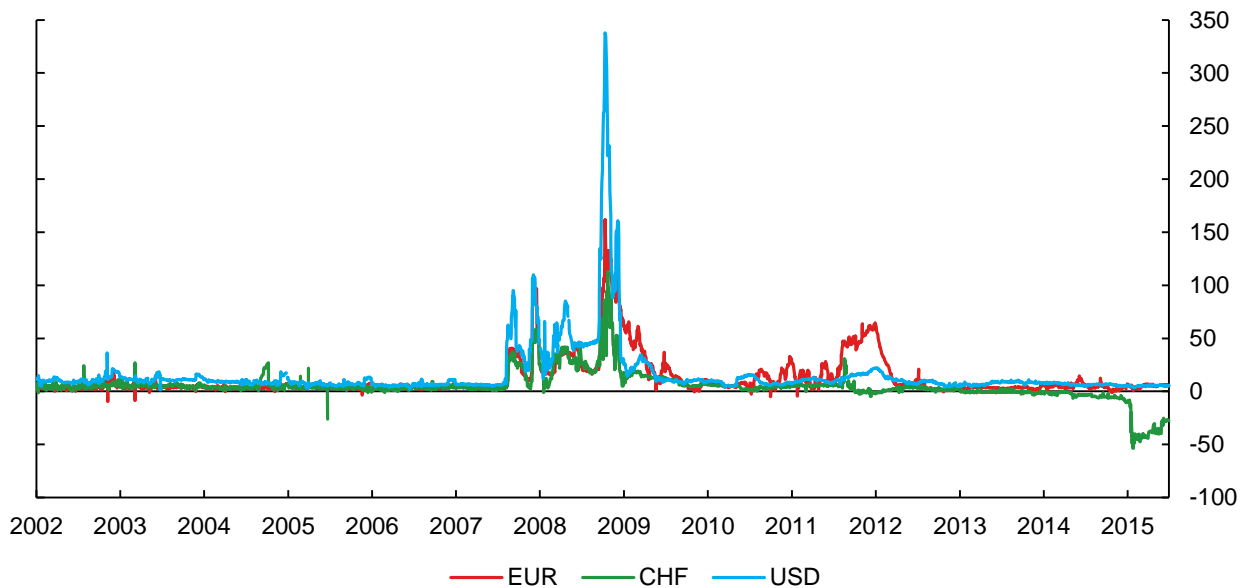


Chart 7: Spread between interbank rates and sovereign bill rates (basis points, 90-day horizon)

Sources: Bloomberg and Bank of Canada calculations

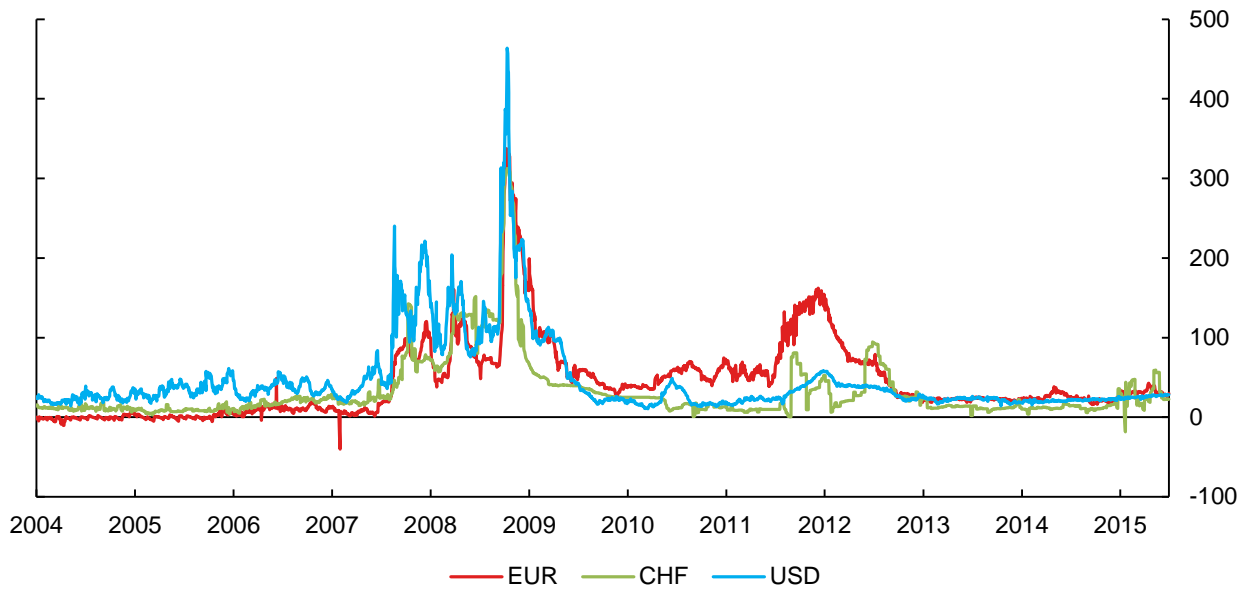


Chart 8: Option-adjusted spread between corporate bonds and government bonds (basis points, 1–3 year horizon)

Source: Bank of America Merrill Lynch

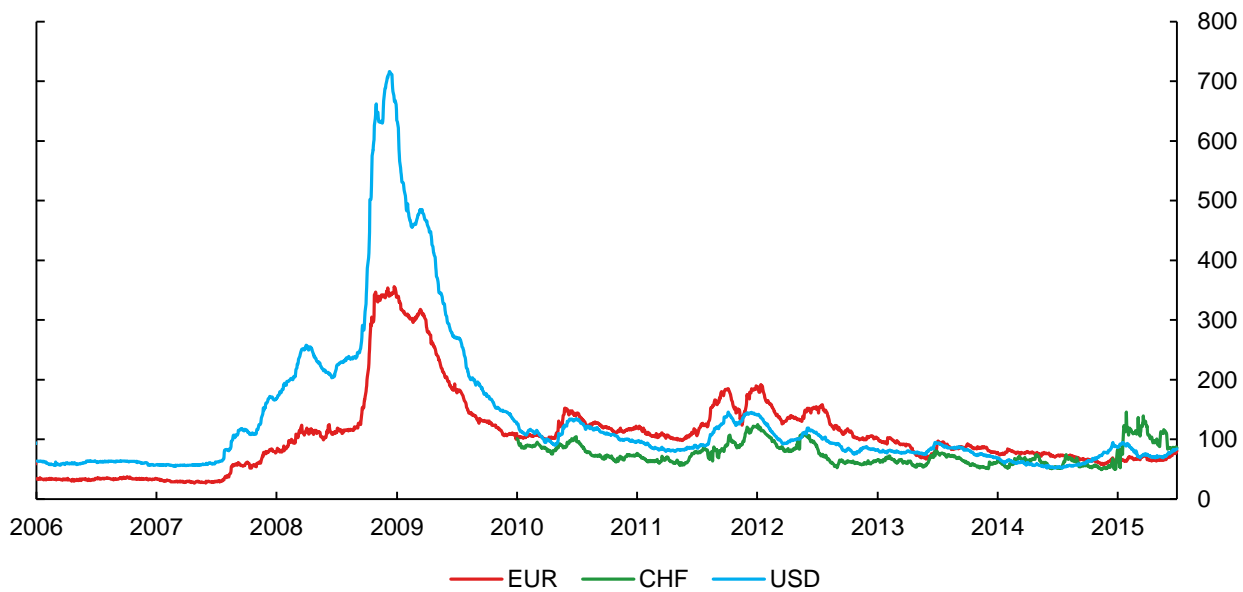




Chart 9: Total allotment of Swiss National Bank U.S.-dollar auctions (\$ millions)

Source: Swiss National Bank

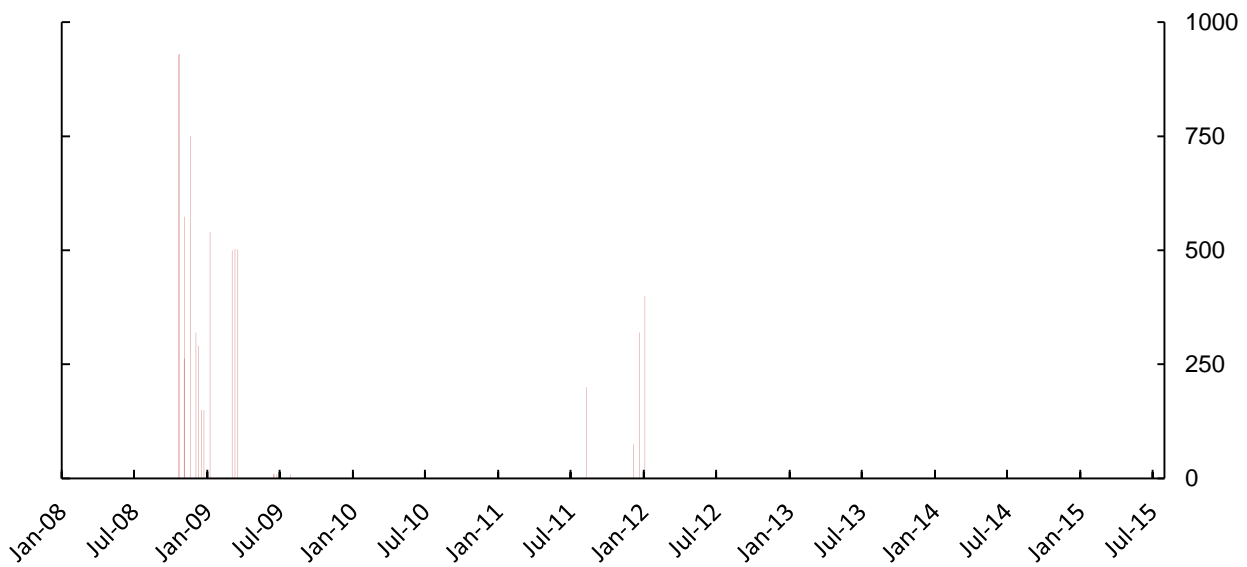


Chart 10: Proxies for risk-neutral distribution of EURCHF returns (% implied volatility units, 30-day horizon)

Source: Bloomberg

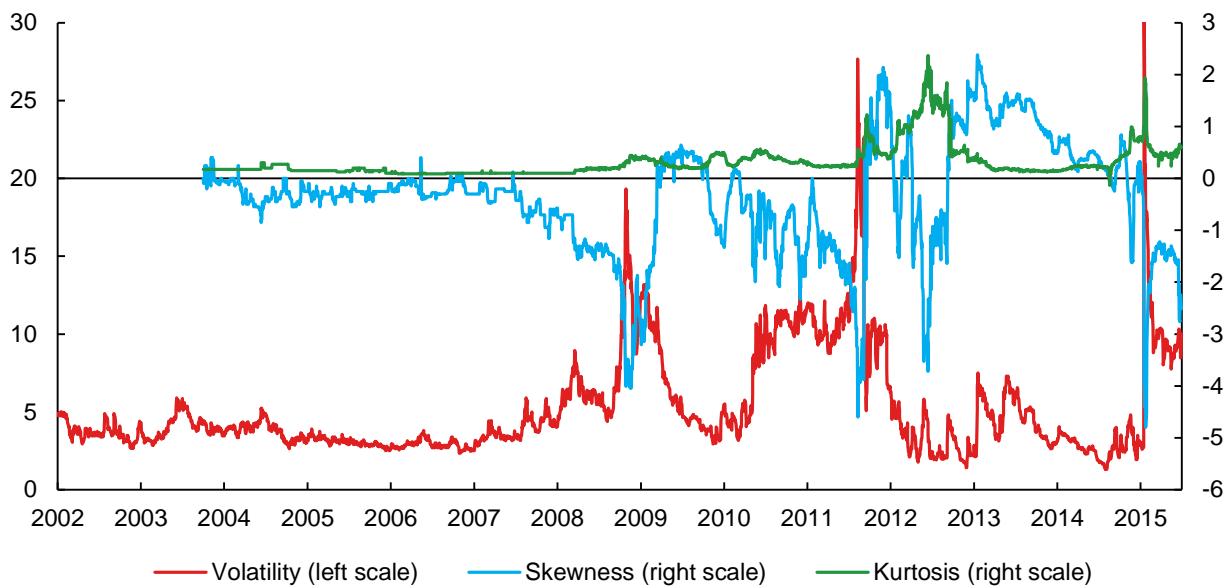


Chart 11: Proxies for risk-neutral distribution of USDCHF returns (% implied volatility units, 30-day horizon)

Source: Bloomberg

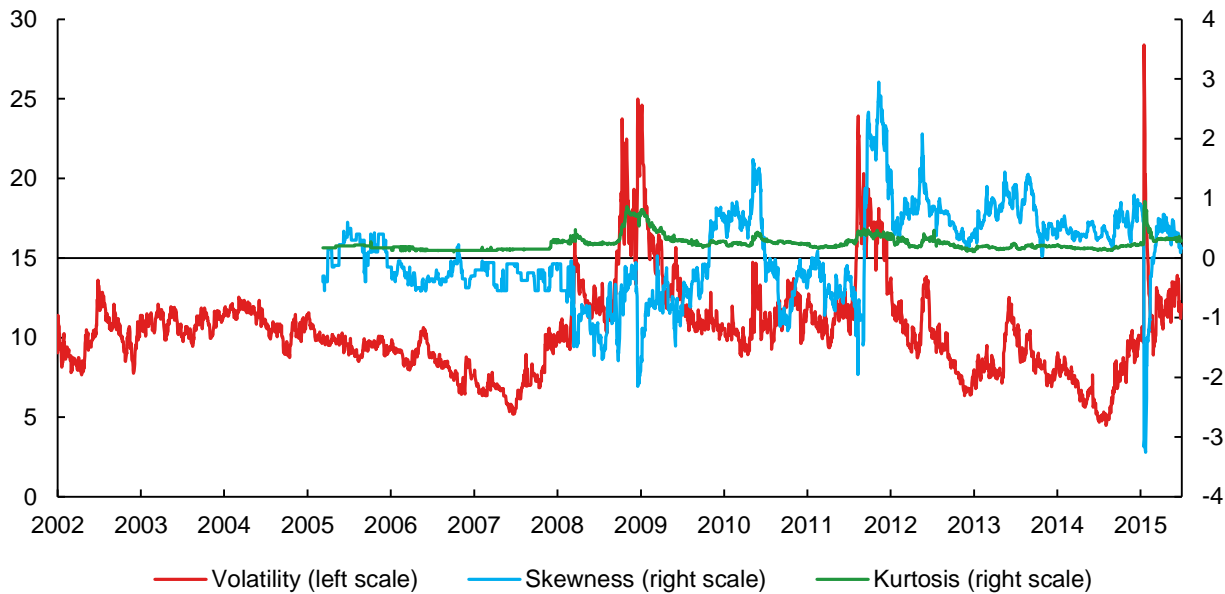


Chart 12a: Net dealer positions in USDCHF futures and spread between USDCHF swap-implied dollar rate and CHF LIBOR (weekly data)

Sources: Bloomberg, U.S. Commodity Futures Trading Commission and Bank of Canada calculations

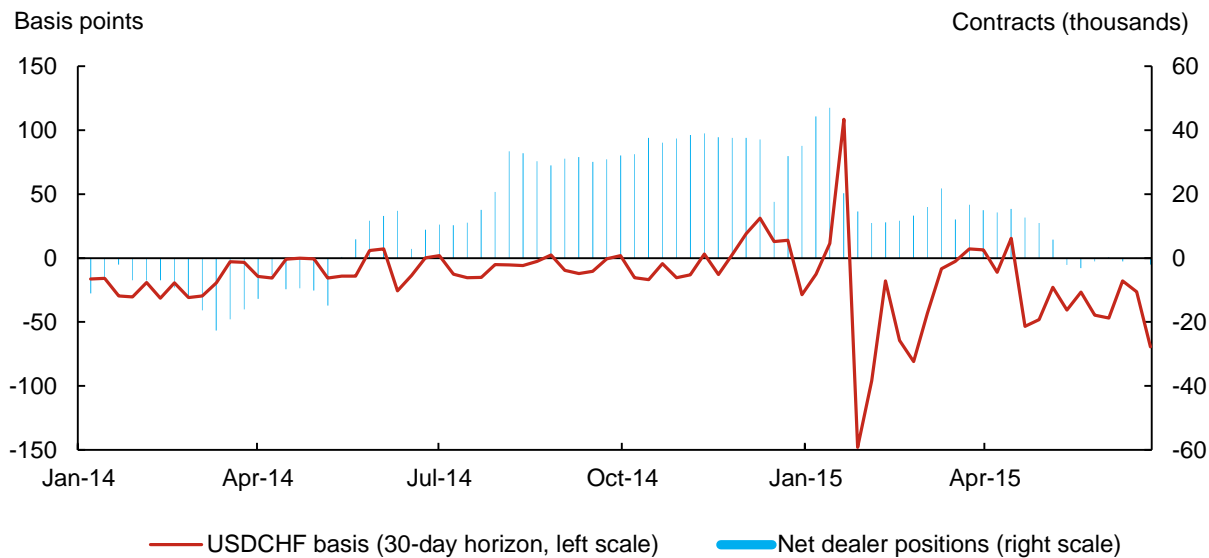


Chart 12b: Total dealer positions in USDCHF futures and spread between USDCHF swap-implied dollar rate and CHF LIBOR (weekly data)

Sources: Bloomberg, U.S. Commodity Futures Trading Commission and Bank of Canada calculations

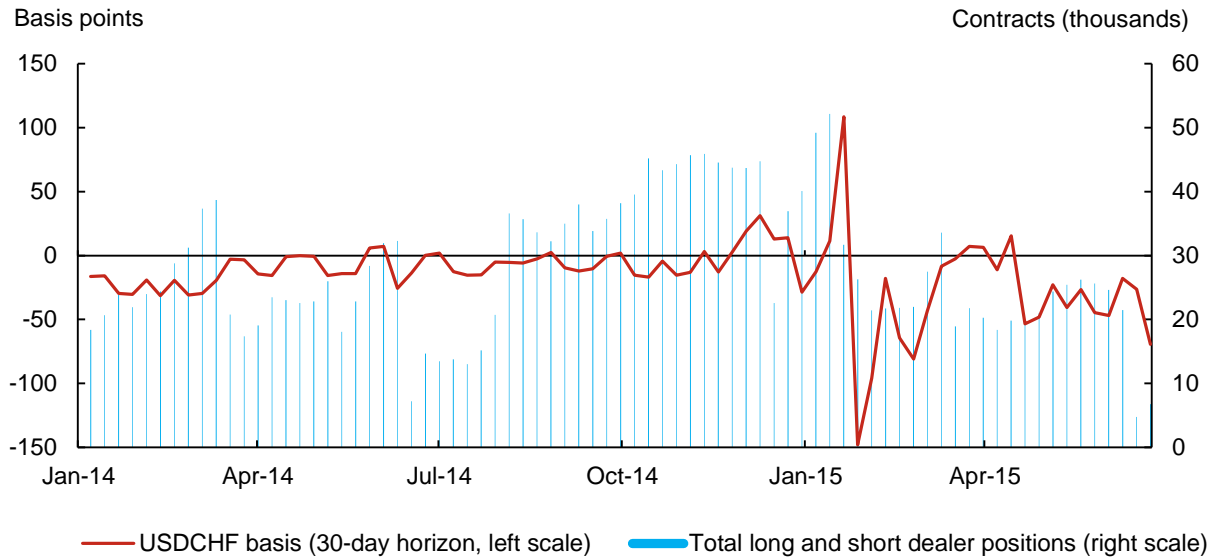


Chart 13: Spread between EURCHF swap-implied euro rate and EURIBOR (basis points, multiple horizons, 10-day moving average) (2002 – 2015)

Sources: Bloomberg and Bank of Canada calculations

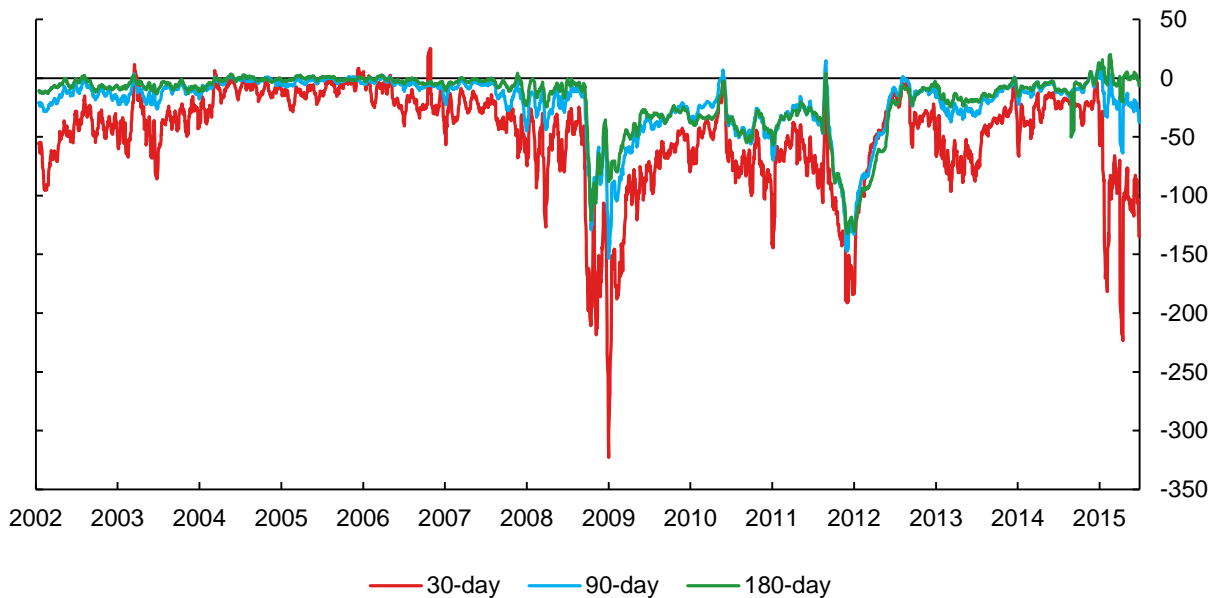


Chart 14: Spread between USDCHF swap-implied dollar rate and USD LIBOR (basis points, multiple horizons, 10-day moving average) (2002 – 2015)

Sources: Bloomberg and Bank of Canada calculations



Chart 15: Bond issuance patterns between the United States and the euro area

Sources: Bank of America Merrill Lynch, Bloomberg, Dealogic and Bank of Canada calculations

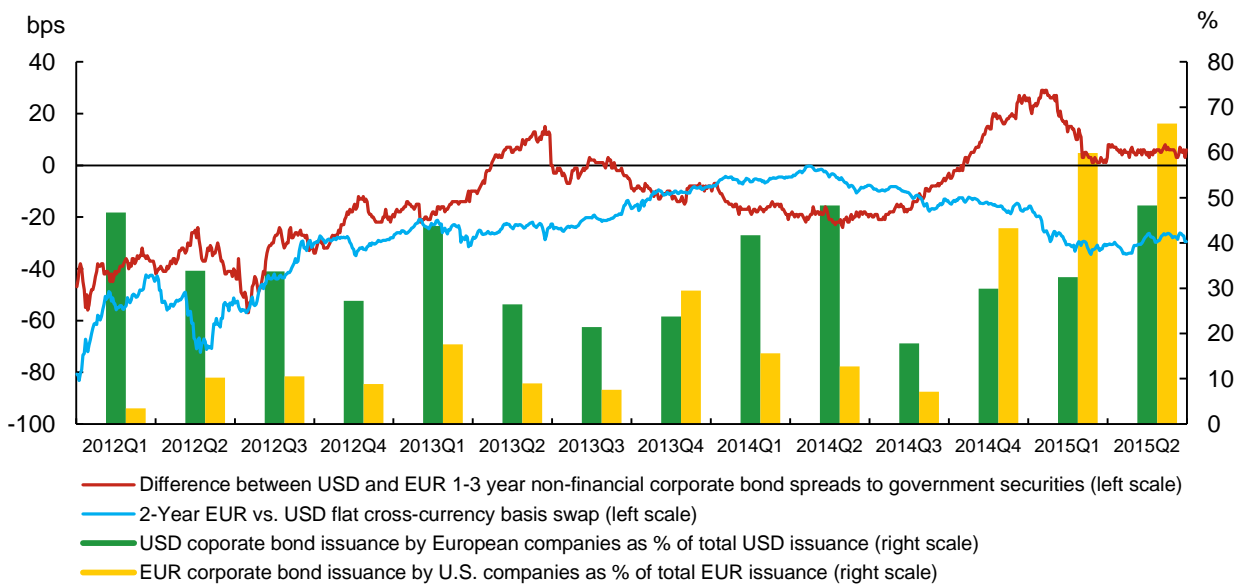
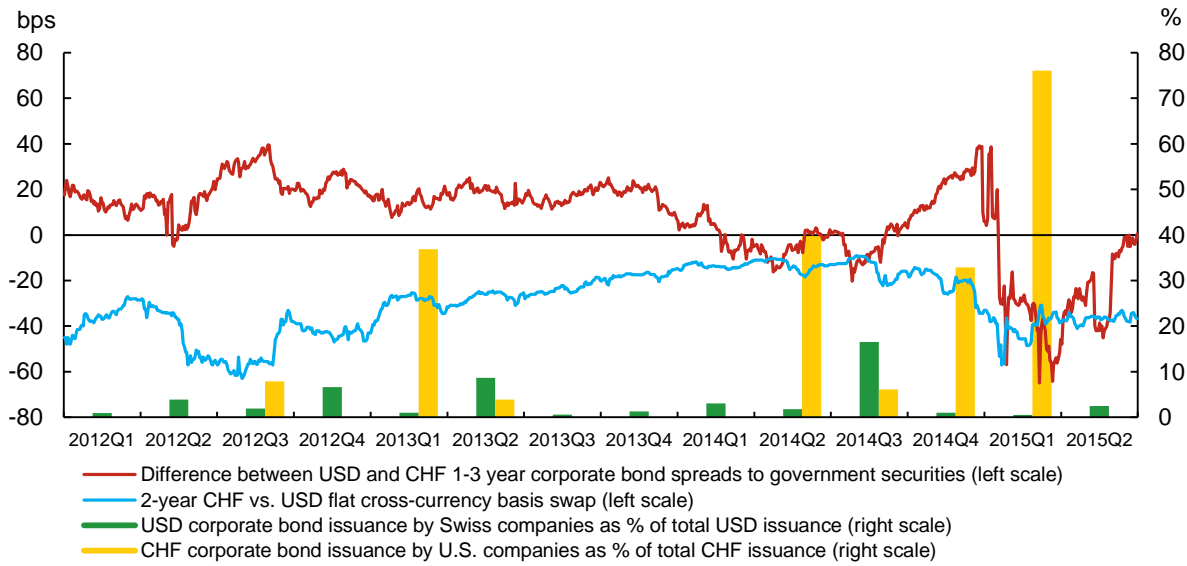


Chart 16: Bond issuance patterns between the United States and Switzerland

Sources: Bank of America Merrill Lynch, Bloomberg, Dealogic and Bank of Canada calculations



Notes: The USD corporate spreads exclude the financial sector while the CHF corporate spreads include all industries.