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Deviations from Covered Interest Parity in the Emerging Markets After the 2008 Global Financial Crisis

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Abstract

In this paper, we examine deviations from covered interest parity (CIP) for six emerging market economies using daily data following the global financial crisis. After documenting large and persistent discrepancies between January 2010 and July 2018, we show the significant role of local factors in explaining sustained deviations from CIP. Specifically, we present evidence that the main drivers of explaining CIP deviations are cost of illiquidity and interest differentials. Our findings suggest that the impact of credit risk on CIP deviations in emerging market economies may take two forms. In low-carry currencies, the well-known mechanism for credit risk operates so that the increase in credit risk exacerbates CIP deviations. Conversely, in high-carry currencies, the high usage of FX swaps makes swap rates react more than domestic rates, which causes CIP to decrease. Finally, global factors play no prominent role in predicting CIP deviations.

JEL Classifications: G15; F31

Keywords: Covered interest parity; FX swap; Emerging Markets; Financial Crisis

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Non-Technical Summary

In this paper, we examine the CIP deviations for Hungarian forint, Mexican peso, Polish zloty, Russian rouble, South African rand, and Turkish lira during the post financial crisis period. We show that persistent CIP deviations exist for nearly all of these currencies. However, the scale of the deviations varies by currency and time. FX liquidity is clearly the most important indicator in explaining CIP deviations. Lower liquidity in emerging economies causes higher liquidity premia, which widens CIP deviations. Credit risk also significantly affects CIP deviations. Contrary to previous research, our findings suggest that increased credit risks, particularly in high carry-trade currencies, lessen CIP deviations. We argued that this association results from the changing nature of carry-trade activities. Increased use of FX derivatives instruments for carry-trade activities makes investors more sensitive to FX swap rates than domestic money market rates. Therefore, when a country's credit risk increases, investors demand higher premia for their investments in the form of FX derivatives. These investor behaviors affect FX swap rates to react more than domestic rates and narrow CIP deviations. Moreover, nominal interest rate differences between an emerging economy currency and the U.S. dollar also affect CIP deviations. That is, when such a difference widens, there is more FX swap demand to sell the high-interest currency and buy the low-interest rate currency. This in turn reduces CIP deviations. Finally, three global factors (the VIX index, U.S. dollar index and euro CIP deviations) are not consistently significant drivers of CIP deviations in the six analyzed currencies.

After the global financial crisis, emerging economy central banks have faced mounting difficulties in implementing independent monetary policies due to the dominance of the policies of advanced market central banks. CIP deviations may also influence the transmission mechanisms of these central banks by creating financial frictions. Although the policy implications of the CIP are still relatively unexplored in advanced

economies, emerging countries with larger CIP deviations than advanced ones should be more cautious when implementing monetary policy.

We show that the CIP deviations have persisted and varies considerably over time and across countries. One policy implication of our analysis is that it is very important for economic agents and policy makers to understand who is doing the arbitrage and which instruments are used in the derivative markets. Based on our results, we also propose that an in-depth understanding of FX liquidity is particularly important in the emerging markets. FX liquidity patterns are different than the other asset markets. As emphasized by Karnaukh et al. (2015), FX markets have limited transparency and are highly leveraged. Thus, monitoring fundamental sources of FX liquidity (demand or supply driven sources) helps explaining variation in currency liquidities and its effect on the CIP deviations.

1 Introduction

The global financial crisis followed by the European sovereign debt crisis had enormous impacts on international financial markets, particularly on covered interest parity (CIP)[1] , which is ordinarily anchored in riskless arbitrage during tranquil periods. Since 2008, CIP deviations have become a regular feature of advanced economies and hence a subject of research scrutiny (Borio et al., 2016; Du et al., 2017; Avdjiev et al., 2019). However, despite its far more importance than advanced economies, the CIP deviations associated with emerging market currencies are relatively understudied. The violation of CIP in the emerging economies suggests dampening monetary autonomy, i.e., conducting effective monetary policies and limiting the ability of financial intermediation among these countries. Emerging countries are known to be more dependent on the US dollar liquidity (Baba and Packer, 2009; Rose and and Spiegel, 2012). A failure of CIP deviation, which indicates financial friction in foreign exchange and money markets, would raise financial stability concerns by impairing the monetary transmission mechanism (Cerutti et al., 2021).

Moreover, actions of major central banks in the global financial crisis and afterwards have made it harder than ever to implement effective monetary policies for emerging markets. The financial trilemma - that financial integration and exchange rate stability mean a loss of monetary autonomy - has recently been challenged. Rey (2013) argues that even flexible exchange rates in the emerging economies cannot assure monetary autonomy without capital controls. That is, violation of CIP has made it even more challenging for emerging market central bankers to pursue effective monetary policies. In this paper, we focus on the deviations from the CIP condition in the six emerging economies: Hungary Mexico, Poland, Russia, Turkey and South Africa, using daily data from January 2010-December 2018. During the post-crisis period, many other emerging economies did deploy capital controls.[2] As shown by Sener et al. (2012), implementing

[1]The parity suggests that interest rate differentials among currencies should be reflected in FX rates.

[2]Jinjarak et al. (2013) document the cases of capital controls in several emerging economies, such as Thailand, Korea, Peru, Indonesia and Brazil, since the beginning of the global financial crisis in 2008.

arbitrage activities in the case of pure CIP is not possible under capital controls. Thus, we argue that our sample is consistent with the assumptions of covered interest parity.

Earlier studies on the validity of CIP following the collapse of Bretton Woods in 1973 show that CIP generally holds in advanced countries (Frenkel and Levich, 1975; Taylor, 1987; Fletcher and Taylor, 1996; Akram et al., 2008). Later research considers the empirical validity of CIP for major currencies during the 2007-2008 global financial crisis (GFC). It demonstrates that the increasing credit and liquidity risks of non-US financial institutions were mainly responsible for the significant deviations from CIP in developed countries (Baba and Parker, 2009a, 2009b; Coffey et al., 2009; Fong et al., 2010; Mancini-Griffoli and Ranaldo, 2010). More recently, researchers have investigated the persistent deviation from parity without accompanying market anomalies during the post-GFC period. For example, Avdjev et al. (2019) argue that there is a triangular relationship between the value of the US dollar, CIP deviations and cross-border bank lending in which the domestic currency's increasing strength against the dollar dampens CIP deviations. Du et al. (2018) show that monetary policy shocks and balance sheet costs are both responsible for those CIP deviations that cannot be explained by transaction costs or credit risks. Fukuda and Tanaka (2017), and Bräuning and Puria (2017) argue that countries having higher nominal interest rates have lower or positive CIP deviations while Borio et al. (2016) and Sushko et al. (2016) show that the hedging demand of non-financial firms and tighter limits to arbitrage both affect CIP deviations, particularly in the long run. These latter two studies suggest that credit and liquidity risks are the main drivers of short-term CIP deviations and have no relationship with longer maturities.

Few studies have analyzed CIP deviations in emerging economies due to the relative absence of deep financial markets. From their examination of deviations from CIP in advanced and emerging market economies between 2003 and 2006, Skinner and Mason (2011) showed that there is no deviation from CIP in the short run (three-month horizon) for Brazil, Russia and Chile after taking into account transactions costs. In the long run (five-year horizon), however, there is evidence of significant deviations because of the high credit risk embedded in emerging markets. Focusing on the South Korean market between 2007 and 2009, Baba and Shim (2014) showed that the major determinants of CIP deviations are global uncertainty in the short run and credit risk in the long run. However, no studies have yet examined post-crisis violations of CIP in emerging economies, where deviations are on average many times greater than in advanced economies.[3]

In this paper, we examine violation of CIP in six diverse emerging economies and show that CIP deviations occur for nearly all these currencies. This increased following the European sovereign debt crisis before reducing after 2014. On average, CIP deviations for the Turkish lira, Hungarian forint and Russian rouble hovered around or above 100 basis points (bps) at the three-month horizon whereas the Mexican peso and Polish zloty remained below 100bps. This demonstrates that borrowing at a synthetic rate using FX swaps is cheaper than borrowing directly in the local currency. The South African rand exhibited the only negative and lowest CIP deviation (nearly -4 bps).

We demonstrate that local factors have more impact on CIP deviations than global ones, with global factors having a a rather heterogeneous effect across the six countries. FX liquidity is a main factor that is significantly and positively associated with CIP deviations for all currencies for all periods. Lower liquidity in emerging market currencies causes a liquidity premium, which in turn drives CIP deviations. Credit risk is also significantly related to CIP deviations, although its impact is unexpected in a sense that increase in the CDS lowers the CIP deviation. We argue that the changing nature of carry trade activities is the main reason for this. The National Bank of Poland (2016) reports that non-resident investors use FX swaps more than domestic money market instruments to implement carry trade activities. In other words, FX swaps are used more for the carry activities than the hedging purposes. Investors have long position in domestic currency when they use FX swaps for carry trade unlike the hedging purpose

[3] Du et al. (2018) reported 20 basis point (bps) deviations from parity for G10 countries during 2010-2016. Using data from our six emerging economies over the same period, we find that CIP deviations are, on average, almost five time (91.5 bps) more than those of G10 countries.

where they have the short position in the domestic currency. Therefore as BIS (2015) documents that investors who heavily use FX swaps for carry trade activities become more sensitive to FX swap rates than local interest rates. Thus, we conclude that the apparent negative relationship occurs because when credit risk of a high carry currency increases, investors demand higher interest rates for FX swap rates.

We also show that another significant factor driving CIP deviations is nominal interest rate differences. When the nominal interest rate between the local currency and the U.S. dollar increases, CIP deviation decreases due to growing demand for the high interest currency. This causes more currency hedging demand to buy the low interest currency and sell the high interest currency. The subsequent rise in FX swap demand increase the forward premium beyond the CIP-implied value.

While there is growing evidence regarding CIP deviation in advanced countries, their policy implications remain undiscussed (see Du et al., 2018; Cerutti et al., 2021). Our study shows that liquidity (measured wth currency bid-ask spreads) is a key factor behind CIP deviations in emerging economies. Liquidity mostly impacts CIP deviations in advanced economies suggesting that financial development matters. Yet, this is precisely where emerging markets fall short despite their share in the world economy. Improving financial development may therefore help emerging economies to decrease their CIP deviations and implement more effective monetary policies.

The paper is organized as follows. Section 2 reviews the empirical implement of CIP deviations. Section 3 discusses the data and methodology. Section 4 presents the results of the regression analyses and discusses potential explanations of CIP deviations. Section 5 focuses on the changing power of credit risk to explain times-series variations in CIP deviations. Section 6 reports robustness exercises, specifically subdividing the sample period and using deposit rates instead of LIBOR rates to measure CIP deviations. Section 7 concludes.

2 Empirical Implementation

The transaction-cost adjusted deviation from covered interest parity can be written as in Du et al. (2018):[4]

$$\text{CIP deviation:}\exp(nr^{b}_{t,t+n}) - \frac{F^{a}_{t,t+n}}{S^{b}_{t,t+n}}\exp(nr^{*,a}_{t,t+n}) \;>\; 0 \quad \text{or}$$
$$\text{CIP deviation:}\exp(nr^{a}_{t,t+n}) - \frac{F^{b}_{t,t+n}}{S^{a}_{t,t+n}}\exp(nr^{*,b}_{t,t+n}) \;>\; 0$$

where a and b denote ask and bid rates respectively. $r_{t,t+n}$ and $r^{*}_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar, respectively. S_t is the spot rate and F_t is the forward rate.

In the literature (e.g. Akram et al., 2008; Buraschi et al., 2015), the dominant strategy to investigate whether CIP holds, is to calculate the transaction cost-adjusted (bid-ask spreads) deviations. Although recent evidence show that transaction costs are not enough to explain CIP deviations (see e.g., Du et al., 2018), in theory, to take advantage of CIP deviations, an investor has to conduct more than one transaction. Therefore, transaction costs may affect the profitability of currency trading strategy of an investor. CIP comprises four variables: spot exchange rate, forward exchange rate, domestic interest rate and foreign interest rate, that are often not fully synchronized. Following the first paper by Taylor (1987) that uses hand-collected, high-frequency data, there are many papers that study CIP deviations using high-frequency data, especially for the currencies of advanced economies (e.g., see Akram et al., 2008; Fong et al., 2010; Rime et al., 2016). Nonetheless, there are also several other important papers that use low-frequency (daily) data by ignoring the synchronization issue (e.g., see Du et al., 2018; Fukuda and Tanaka, 2017; Avdjiev et al., 2016; Allen et al., 2017). New studies mostly use low frequency data rather than the high frequency data. This is resulted from the findings of previous studies (Coffey et at. (2009), Mancini-Griffoli and Ranaldo (2010))

[4]As reported in Appendix Table A.1, currency markets in emerging economies have grown considerably since the GFC. Yet, they are still small relative to the markets in the advanced economies and hence market size matters for transaction costs (see e.g. Munro and Wooldridge, 2011).

which suggest that CIP deviations from the high frequency and low frequency data do not matter much and getting high frequency data have some difficulties. Moreover, nearly all studies use low frequency data when implementing regression analysis. In this paper, we use daily data to measure CIP deviations due to limited access to high frequency data for the currencies of emerging market economies (see also Karnaukh et al., 2015).[5]

For the benchmark analysis, we use interbank interest rates for each country and USD LIBID (interbank bid rate) for U.S. interest rates.[6] Although the indicative nature of interbank interest rates has been criticized during and after the global financial crisis in 2008-2009, in line with recent studies (e.g. Mancini-Griffoli and Ranaldo, 2010; McAndrews, 2009; Cerutti et al., 2021), we use LIBOR (interbank offer rate) but also use interbank deposit rates as an alternative interest rate to measure CIP deviations of emerging market currencies. As emphasized by Sushko et al. (2016), finding similar CIP deviations for different interest rates suggest that these deviations do not result from the conditions in underlying money markets but from frictions in FX swap markets.

Figure 1 presents the three-month CIP deviations for six countries from January 4, 2010 to July 30, 2018, suggests clear CIP deviations for nearly all six currencies. The deviations from CIP clearly increase during 2011 and 2012 for Hungarian forint, Turkish lira and Russian rouble (during the European debt crisis) before declining after 2014. Except the South African rand (ZAR), all currencies have positive CIP deviations, indicating that direct borrowing in the local currency is costlier than borrowing at a synthetic rate using FX swaps. Thus, an arbitrageur could borrow U.S. dollars from the

[5]Coffey et al. (2009) find similar results using hourly (high-frequency) and daily (low-frequency) data for the euro-USD exchange rate. Similarly, we compare (three-month and six-month) CIP deviations using both hourly and daily data for Turkey, Mexico, South Africa and Poland between August 27, 2013 and July 30, 2018 due to data availability. As seen in Appendix, Table A.2, the correlations between hourly and daily CIP deviations with respect to different tenors and currencies are very high and also not statistically different from each other for all currencies and tenors.

[6]LIBID (interbank bid rate) is used for considering the transaction costs in the interest rates. On the other hand, after doing the calculations using LIBOR (interbank offer rate), the difference was negligible.

money market before entering an FX swap deal to buy local currency. With this local currency, this arbitrageur would invest in the local currency money market to earn its interest rate. After the swap contract expires, local currencies are converted to dollars to pay back the dollar-denominated debt and thereby earn a profit. According to Figure 1, the Russian rouble (RUB) is more volatile than other currencies, particularly in 2015.

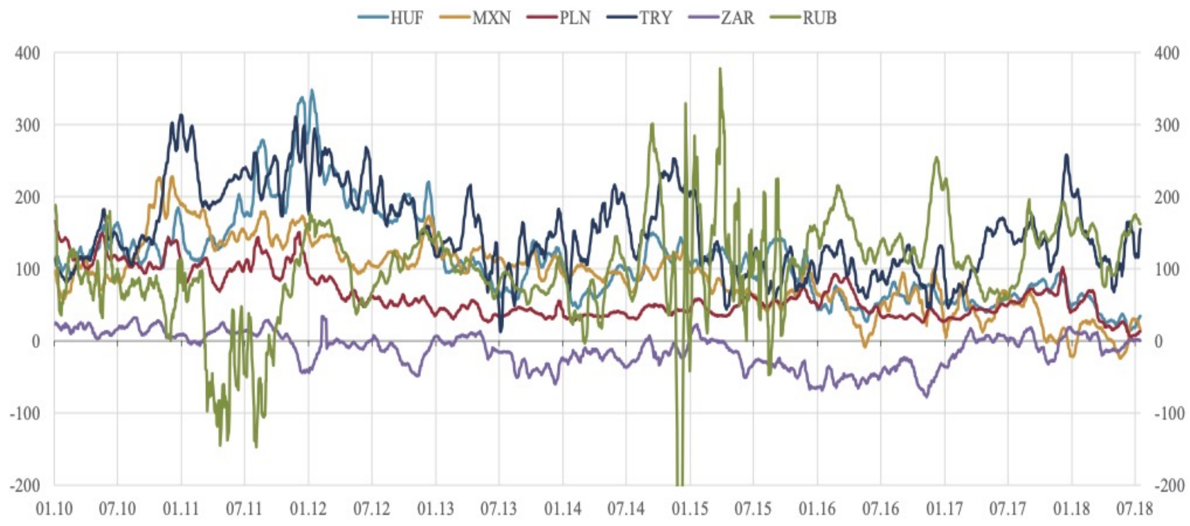

Figure 1: CIP Deviations (3 month LIBOR based, 10 day moving average, basis point)

During the second half of the 2014, Russia, whose economy is highly dependent on oil prices slipped into a recession by the decreasing oil prices and international sanctions.

Table 1 reports the descriptive statistics for the three-month CIP deviations. In the full sample, the Turkish lira, on average, has the greatest deviation (151 bps) whereas the South African rand has the only positive and lowest (-4 bps) deviation. The Hungarian forint follows the Turkish lira with a 113 bps deviation. Although the Russian rouble and Mexican peso have similar deviations (99 bps and 90 bps respectively), the rouble has the largest volatility of the sampled currencies. We divide our sample into two sub-periods to assess whether CIP deviations are similar under different periods. The first sub-sample covers 4 January 2010 to 31 December 2013, which includes the European debt crisis, the tapering announcement and the first reduction of the quantitative easing program. The second sub-sample is between 4 January 2014 and 30 July 2018, which we can call the post-European debt crisis period. Moreover, there is a trend change in DXY index and EURUSD CIP deviations beginning from 2014. Therefore, we start the second sub-sample in January 2014. The deviations are found to be higher in the first sub-period. Mean CIP deviation in the first sub-sample is 105 bps whereas it is 69 bps in the second sample. All CIP deviations except for the Russian rouble decrease in the second sub-period.

According to the 2016 BIS Triennial Central Bank Survey, FX swaps are the major

Table 1: Summary Statistics for 3-month CIP Deviations in basis point

	Full Sample	Sub-Samples	
	Jan 2010-July 2018	Jan 2010-Dec 2013	Jan 2014-July 2018
Hungarian Forint	113.11 (62.45)	156.63 (61.10)	76.01 (33.04)
Mexican Peso	90.11 (49.93)	127.76 (35.09)	57.26 (35.75)
Polish Zloty	64.94 (33.85)	85.78 (36.15)	46.75 (17.22)
Russian Rouble	98.75 (112.02)	73.86 (84.63)	120.53 (127.44)
Turkish Lira	151.08 (62.88)	178.56 (64.15)	127.09 (50.81)
South African Rand	-4.25 (26.12)	5.32 (24.53)	-12.60 (24.56)
Average	85.62 (57.83)	104.65 (51.17)	69.17 (48.14)

Notes: The table presents the mean and standard deviations (in parenthesis) of LIBOR based 3-month CIP deviations. CIP deviations are calculated as follows:

$$\text{CIP Deviations} = \exp(nr^a_{t,t+n}) - \frac{F^b_{t,t+n}}{S^a_{t+n}} \exp(nr^{*,b}_{t,t+n})$$

where a and b denote ask and bid rates respectively. $r_{t,t+n}$ and $r^*_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and US dollar respectively. S_t is the spot rate and F_t is the forward rate.

instruments in emerging markets rather cross-currency swaps. The former is usually used up to a one-year maturity whereas the latter is employed for maturities longer than a year. As reported in Table 2, except for Turkey and South Africa, the share of currency swaps is less than two percent of the total volume of FX and currency swaps among the sample countries. The shares of currency swaps in Turkey and South Africa in total volume are less than 10% and 15% respectively. Thus, FX swap transactions

Table 2: Daily Averages of FX and Currency Swap Transactions

Currency	FX Swaps	Currency Swaps
		((Million U.S. dollars)
Hungarian Forint (HUF)	7,994	105
Mexican Peso (MXN)	35,730	206
Polish Zloty (PLN)	18,042	375
Russian Rouble (RUB)	27,063	546
Turkish Lira (TRY)	39,645	4,162
South African Rand (ZAR)	23,542	3,541

Notes: The data is from BIS Triennial Central Bank Survey, April 2016. Table 2 shows the daily average volume of FX swap and currency swap transactions for that currency.

are more liquid than the currency swaps that we focus on FX swaps in calculating CIP deviations. These contracts have several tenors up to one year.

Bräuning and Puria (2017) emphasize that there is no stable relationship between maturity and CIP deviations. They show that CIP deviations increase with maturity only in recent years. During the global financial crisis and the European sovereign crisis, deviations are higher for short maturities. Fong et al. (2010) show that CIP deviations increase with maturity using one-week, one-month and three-month contracts. As seen in Table 3, we find no clear-cut relationship between CIP deviations and maturity from examining CIP deviations calculated from five tenors (i.e., one-week, one-month, three-month, six-month, and 12-month). Increasing CIP deviations with maturity is found only in the Russian rouble whereas deviations decrease with maturity for the Hungarian forint. Deviations follow no pattern for the Mexican peso, Polish zloty and Turkish lira. Although the average deviations of one-week maturity do not differ from the other maturities, they are much more volatile than for other maturities for each currency, which is consistent with Du et al. (2018)

Although we calculate the deviations from CIP using the U.S. dollar as the reference rate, the euro is another currency used in FX swap transactions, particularly in Hun-

Table 3: CIP Deviations with Different Maturities (basis point, Jan 2010 - July 2018

	HUF	MXN	PLN	RUB	TRY	ZAR
1 week	113.63 (90.7)	–	–	56.50 (613.1)	131.62 (92.7)	–
1-month	114.08 (65.0)	52.10 (64.9)	60.10 (30.9)	73.32 (138.6)	142.99 (66.0)	-6.70 (37.9)
3-month	113.11 (62.5)	90.11 (49.9)	64.94 (33.9)	98.78 (112.0)	151.08 (62.9)	-4.25 (26.1)
6-month	109.77 (68.6)	61.63 (44.9)	63.93 (39.7)	102.52 (141.2)	141.61 (64.0)	17.67 (23.0)
12-month	95.72 (76.0)	–	53.08 (44.5)	–	103.09 (67.1)	13.05 (23.8)

Notes: The table presents the mean and standard deviations (in parenthesis) of LIBOR based different tenors of CIP deviations in basis point for six emerging markets currencies. CIP deviations are calculated as follows:

$$\text{CIP} = \exp(nr^{a}_{t,t+n}) - \frac{F^{b}_{t,t+n}}{S^{a}_{t+n}} \exp(nr^{*,b}_{t,t+n})$$

where a and b denote ask and bid rates respectively. $r_{t,t+n}$ and $r^{*}_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar respectively. S_t is the spot rate and F_t is the forward rate.

Table 4: CIP Deviations Based on US dollar and Euro (3 months, basis point)

Currency	U.S. Dollar	Euro	Difference
Hungarian Forint (HUF)	113.11	86.98	26.13
Mexican Peso (MXN)	90.11	65.80	25.31
Polish Zloty (PLN)	64.94	38.71	26.23
Russian Rouble (RUB)	98.78	76.45	22.33
Turkish Lira (TRY)	151.08	127.85	23.22
South African Rand (ZAR)	-4.25	-30.42	26.17

Notes: The table presents the mean of USD LIBOR based three-month CIP deviations, EUR LIBOR based three-month CIP deviations and the difference of two deviations in basis point for six emerging markets currencies during Jan 2010 to July 2018.

gary, Poland, Russia and Turkey. In their seminal paper, Buraschi et al. (2015) show that, during the 2008-2009 global financial crisis, there is a significant pricing anomaly between Eurobonds denominated U.S. dollars and the euro for Turkey, Brazil and Mexico. Thus, we document euro-based CIP deviations to understand whether they differ from U.S. dollar-based deviations between January 2010 and July 2018.

As seen in Table 4, U.S. dollar-based deviations are, on average, less than euro-based deviations. Although CIP deviations vary significantly in size across currencies, the difference between U.S. dollar- and euro-based deviations are nearly the same for almost all currencies. Yet, there is a clear CIP deviation in euro-based calculations in the post-European debt crisis period. Figure 2 shows the difference between U.S. dollar- and euro-based deviations for our sample currencies and EURUSD CIP deviation itself.

The difference between U.S. dollar-based CIP deviations and euro-based CIP deviations are captured by the EURUSD CIP deviations. Unlike Buraschi et al. (2015), we do not observe any anomaly among emerging market currencies, coming from the base currencies in the post-European debt crisis period.

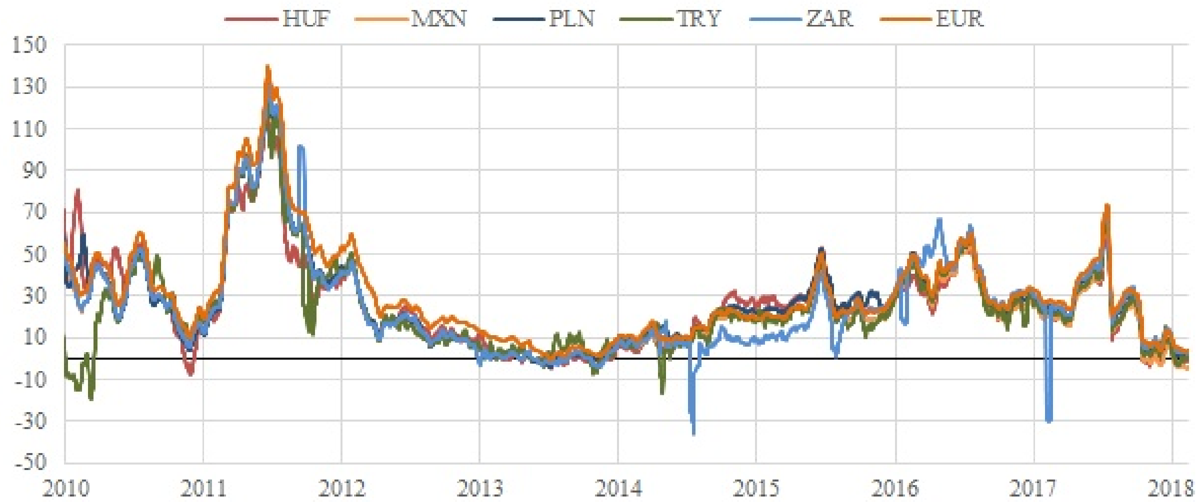

Figure 2: Differences between Euro based and US dollar based CIP Deviations vs CIP Deviation in EURUSD (3 month, 10 day moving average, basis point). For the sake of presentation clarity, we do not report CIP deviations for Russian Rouble.

3 Data and Methodology

The estimations are at daily frequency over the sample period from January 4, 2010 to July 30, 2018, subject to data availability. Our dependent variable is three-month CIP deviations, which is the most widely used maturity measure in the literature. Baran and Witzany (2017) underline that short-end spreads are affected more by LIBOR rates and credit/liquidity premiums whereas supply and demand conditions are more pronounced in the long run. In our empirical model for deviations from short-term CIP, we have no structural factor. Since there is no formal theory to explain the deviations in CIP, we use possible explanatory variables from the literature. We include three variables for local factors: credit risk, liquidity risk and countries' nominal interest rate differences; and three variables for global factors: VIX index, U.S. dollar index and 3-month EURUSD CIP deviations (see Appendix Table A.3 for detailed descriptions of the variables).

We use sovereign five-year CDS spreads from Bloomberg[7] as the premium attached

[7] Although there are studies that use bank CDSs instead of sovereign CDSs, not all countries in our sample have CDS data for banks. Moreover, as shown by Shim and Shin (2018), sovereign and bank CDSs are very highly correlated.

to credit risk in the sample countries. As emphasized by Longstaff et al. (2011), the sovereign CDS market is more liquid than the corresponding sovereign bond market and hence captures more accurate estimates of credit spreads. Baba and Parker (2009a) and Baba and Shim (2011) provide evidence that credit risk plays an important role in explaining CIP deviations associated with the currencies of advanced economies during the global crisis period. However, in the papers covering the post-crisis period, the association of credit risk with CIP deviations is found to be mostly insignificant (see e.g., Du et al., 2018).

Interest rate credit risk premia in emerging economies are much higher than those for U.S. dollar interest rates. It might be natural to expect that the higher level of perceived credit risk in the emerging economies would cause CIP deviations to differ in favor of the U.S. dollar. However, in this paper, we emphasize that there might be an opposite relation between credit risk and CIP deviations depending on the carry trade activities in the emerging economies. We argue that if carry trade activities are large in volume and FX swaps are used in these activities, a different association between CDS spreads and CIP deviations might be observed. FX swap transactions are mainly used for two purposes: hedging and carry trade, both of which have different mechanisms depending on the purpose of their usage.

As we explained in Figure 3, when FX swap transactions are implemented due to the hedging purposes, foreign banks receive domestic currency at the first leg and in return give foreign currency. This makes foreign banks short on domestic currency and long on foreign currency. Therefore, foreign banks receive foreign interest rate and pay domestic interest rate. On the other hand, when FX swap is used as a carry trade purpose, foreign banks provide domestic currency and in return receive domestic interest rate which create a long position in domestic currency and a short position in foreign currency. Therefore, when hedging activity is strong, an increase in the credit risk of a domestic country may lead to an increase in domestic interest rate but may not affect so much the FX swap rate since foreign banks receive foreign interest rate. Or, when carry trade activity is strong, since foreign banks are long on the domestic

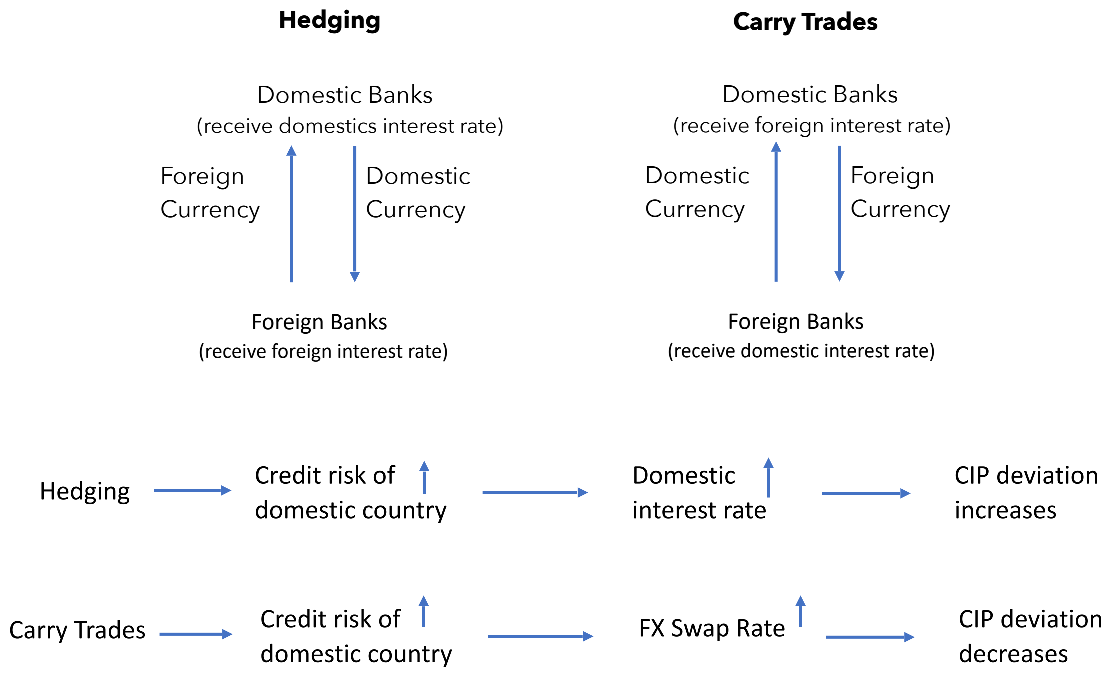

Figure 3: Mechanisms of FX swap according to purpose of usage

currency and receive domestic interest rate, an increase in credit risk would lead FX swap rates to increase since foreign banks ask higher interest rate due to increase in sovereign credit risk (Dos Santo et al., 2016). Under these circumstances, domestic interest rates also increase; however, if FX swaps are widely used, the reaction of the FX swap rates to the increase in the credit risk would be higher than the increase in the domestic interest rates which causes CIP deviation to decrease.

Liquidity is another important factor that can be related to CIP deviations. In addition to the seminal paper by Mancini et al. (2013) in which a new liquidity measure is developed particularly tailored to the FX market,[8] several other papers such as Brunnermeier et al. (2009) and Burnside (2009) show the importance of liquidity in the FX market. Given that the emerging countries have lower liquidity than advanced economies, low FX liquidity is hypothesized to widen CIP deviations among emerging countries. We proxy FX liquidity using bid-ask spreads, which is the most commonly used measure (see e.g. Banti and Phylaktis, 2015). We calculate the bid-ask spread

[8] In the new liquidity measure, Mancini et al. (2013) uses "ultra" high frequency data for the following currency pairs: AUD/USD, EUR/GBP, GBP/USD and USD/CAD.

by taking the difference between the daily series of the ask and bid prices divided by the mid prices. In this way, our liquidity measure provides a standardized average of the bid-ask spreads of forward and spot rates. A wider bid-ask spread (increase in FX liquidity coefficient) thus indicates lower liquidity.

CIP deviations decrease with the nominal interest rate differential between the foreign currency and U.S. dollar when the gap between two interest rates increases in favor of the former (Du et al., 2017; Avdjiev et al., 2019). When the foreign currency interest rate rises compared to the U.S. dollar interest rate, demand for foreign currency increases, which in turn causes currency hedging demand to increase through selling foreign currency and buying U.S. dollars in the swap market. Because these hedging contracts have a cost for financial intermediaries, CIP deviation becomes less positive to justify the high balance sheet costs associated with the larger positions. As in Avdjiev et al. (2019), we use 10-year government bond yields for nominal interest rates.

We introduce VIX index[9] as a global factor to explain CIP deviations in the currencies of emerging economies. The VIX index, the implied volatility of S&P 500 Index options, captures global risk sentiment (Cerutti et al., 2021). VIX rises when uncertainty and volatility in the global economy rises. Skinner and Mason (2011) find that an increase in the VIX index increases CIP deviations since it increases the possibility of governments' defaulting. Moreover, Baba and Shim (2014) show that an increase in VIX causes investors to diminish their positions, particularly in emerging economies, which can bolster CIP deviations.[10]

Our second global factor is U.S. dollar index (DXY)[11] which compares the value of

[9]All variables enter in first differences (see Table 5 for unit root tests) but for the VIX, we report only first difference for the sake of space but also examine in log-level or first difference and log-level together as in Avdjiev et al. (2019).

[10]As an alternative to the VIX index, we employed the Economic Policy Uncertainty Index (Baker et al., 2016). To save space, we do not report the results which are similar to our findings with VIX index.

[11]Since DXY measures the value of the U.S. dollar against a basket of six currencies (euro, Swiss franc, Japanese yen, Canadian dollar, British pound and Swedish krona), we also use the Wall Street Journal Dollar Index, which includes 16 currencies, as an alternative to the U.S. dollar index. However, this does

the U.S. dollar against its major trading partners. Avdjiev et al. (2019) and Cerutti et al. (2021) claim that there is a positive relationship between the U.S. dollar index and deviations from CIP. When the U.S. dollar strengths, CIP deviations widen in advanced economies, suggesting that synthetic local funding using FX swaps is outweighed by direct funding of local currencies. From their examination of the real implications of the U.S. dollar on emerging economies using data for 1970-2014, Druck et al. (2018) show that real GDP growth in emerging economies slows when the U.S. dollar appreciates despite the positive impulse of U.S. growth, and vice versa. Hence, we hypothesize that the strength of the U.S. dollar is positively associated with CIP deviations in emerging economies.

Our third global factor is three-month LIBOR-based CIP deviations of the euro. We use this variable to capture the effect of other global factors than the VIX and U.S. dollar that can affect CIP deviations in emerging economies. Du et al. (2018) show that CIP deviations in advanced economies move together. Hence, we include this third global variable to determine whether there is any communality between CIP deviations in emerging economies and advanced economies.

In our estimations, we use Nelson's (1991) exponential GARCH (EGARCH) model. The advantage of EGARCH(1,1) over other types of GARCH models is its log-form specification of conditional variance. This avoids the need to force the variance equation to take a non-negative constraint. Panorska et al. (1995) underline that financial times series often exhibit fat-tail properties, which necessitates the use of a t-distribution in GARCH models. Therefore, consistent with Baba and Shim (2014), we rely on the Student t-distribution as a conditional distribution in our regressions. As shown in Table 5, the standard unit root tests suggest that CIP deviations are stationary at different significance levels. The results for other variables are mixed, particularly in the first sub-period, January 2010 to July 2013. We therefore use all variables in first-difference form throughout our analysis, as in Baba and Shim (2014).[12]

not change our results.

[12]We check the correlations between differenced local and global factors, and find that they are not high. To save space, these results are not reported but are available on request.

Table 5: Augmented Dickey-Fuller Test

	Jan 2010-July 2018		Jan 2010-Dec 2013		Jan 2014-July2018	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
CIP Deviations						
HUF	-2.624*	-15.849***	-2.705*	-14.396***	-2.736*	-11.138***
MXN	-2.633*	-16.321***	-2.996**	-16.884***	-2.868**	-11.651***
PLN	-3.238**	-18.394***	-2.766*	-14.647***	-3.281**	-11.185***
RUB	-5.143***	-13.599***	-2.781*	-14.967***	-8.580***	-16.057***
TRY	-4.235***	-18.068***	-3.049**	-13.222***	-3.807***	-12.718***
ZAR	-4.237***	-14.937***	-3.007**	-13.532***	-3.095**	-12.694***
Determinants						
DXY	-1.262	-47.222***	-2.303	-31.581***	-2.036	-35.029***
VIX	-6.008***	-22.522***	-3.214**	-22.910***	-6.427***	-27.218***
EURUSD-CIP	-2.708*	-16.755***	-1.454	-30.875***	-3.272**	-11.946***
CDS-HUF	-1.296	-42.401***	-1.768	-28.488***	-2.520	-26.727***
CDS-MXN	-3.282**	-26.150***	-2.988**	-17.737***	-2.310	-22.437***
CDS-PLN	-1.887	-42.357***	-1.665	-28.388***	-2.596*	-36.278***
CDS-RUB	-2.220	-30.431***	-3.092**	-18.611***	-1.445	-23.13 ***
CDS-TRY	-2.997**	-43.105***	-2.237	-18.528***	-2.316	-31.551***
CDS-ZAR	-3.063**	-42.830***	-2.972**	-19.581***	-1.869	-26.492***
LIQ-HUF	-3.919***	-17.273***	-4.217***	-16.089***	-4.161***	-13.666***
LIQ-MXN	-4.511***	-18.873***	-5.497***	-15.469***	-4.262***	-14.442***
LIQ-PLN	-4.777***	-17.389***	-3.916***	-14.777***	-5.384***	-13.466***
LIQ-RUB	-6.891***	-19.712***	-4.336***	-18.067***	-5.282***	-22.339***
LIQ-TRY	-4.242***	-17.410***	-2.854*	-15.567***	-8.585***	-14.455***
LIQ-ZAR	-5.749***	-17.224***	-4.443***	-16.003***	-4.995***	-13.968***
$(i^{huf}-i^{us})$	-1.005	-44.404***	-1.271	-30.024***	-1.794	-33.299***
$(i^{mxn}-i^{us})$	-2.765*	-30.806***	-3.242**	-33.971***	-1.860	-26.012***
$(i^{pln}-i^{us})$	-1.101	-48.814***	-0.973	-32.246***	-2.044	-37.321***
$(i^{rub}-i^{us})$	-1.940	-42.682***	-2.141	-32.242***	-1.562	-29.521***
$(i^{try}-i^{us})$	1.230	-46.734***	-1.860	-30.143***	1.416	-35.449***
$(i^{zar}-i^{us})$	-2.850*	-35.983***	-3.410**	-33.250***	-2.343	-27.631***

Notes: HUF, MXN, PLN, RUB, TRY and ZAR denote the 3-month LIBOR based CIP deviations of the currencies respectively; Hungarian forint, Mexican peso, Polish zloty, Russian rouble, Turkish lira and South African rand. DXY is the Dollar index, VIX is the implied volatility of S&P 500 Index , EURUSD CIP is the 3 month LIBOR based CIP deviations of Euro, CDS is the 5-year credit default swap spread of countries, LIQ is the average of normalized bid-ask spread of the 3 month forward and spot rates of currencies, $(i\text{-}i^{us})$ is the nominal 10 year government bond yield differences of the respective country and United States. Lag length is determined by the Schwarz Information criterion. ***, ** and * indicate significance at the 1%, 5% and %10 respectively.

4 Empirical Results

Table 6 reports the estimation results for the time-series and panel estimation for Jan 4, 2010 to July 30, 2018. The panel regression results show that all local factors (i.e. credit risk (measure by CDS spreads), FX liquidity (measured by bid-ask spread) and nominal interest rate differences) are significantly related to CIP deviations. The sign of the CDS coefficient is negative, which indicates that CIP deviations decrease when a country's credit risk increases. This negative association is contrary to the given early evidence that credit risk is found to be positively associated with CIP deviations in the sample of emerging economies (see Skinner and Mason, 2011).

We find that at the individual currency level, there is a heterogeneity in the association between credit risk and CIP deviation. Sovereign CDS spreads for Mexico, Russia, Turkey and South Africa were negatively and significantly related to CIP deviations whereas Hungary and Poland were positively but not significantly related to CIP deviations. Since currencies with negative CDS coefficients are so-called highest-yield carry currencies, the negative association of credit risk on CIP deviations is in line with our expectations. As we explain in section 3 (see also Figure 3), the changing nature of carry-trade activities in the post-crisis period among some of the emerging economies and given the wide use of FX swaps in these countries for the carry trade causes a negative relationship between the CIP deviation and CDS.

Direct evidence on carry trade activities requires the detailed data on individual investor positions, which are rarely available. Thus, when we order the average LIBOR rates of currencies as a proxy for the incentives for carry-trade activities, countries with the highest LIBOR rates have negative signs for the CDS coefficients.[13] BIS (2015) documents that FX derivatives tools have become more popular for implementing carry-trade activities, especially in emerging economies. The ease of implementation of FX

[13] We also used the interest rate difference between two currencies adjusted for implied volatility as a proxy to measure the incentive for carry-trade activities. This produced similar results for high-yielding currencies.

Table 6: Full Sample Regression (3-month LIBOR rate, January 2010 to July 2018)

	Time Series Regressions						
	Hungary (HUF)	Mexico (MXN)	Poland (PLN)	Russia (RUB)	Turkey (TRY)	South Africa (ZAR)	Panel
	Dependent Variable: D(CIP) $= D(\exp(nr_{t,t+n}) - F_{t,t+n}/S_{t+n}\exp(nr^*_{t,t+n}))$						
Constant	0.194	-0.697***	0.107	-1.333***	-1.310***	-0.812***	-0.032
	(0.153)	(0.183)	(0.085)	(0.378)	(0.380)	(0.213)	(0.221)
D(CDS)	0.035	-0.130***	0.033	-0.536***	-0.427***	-0.139***	-0.570***
	(0.028)	(0.047)	(0.027)	(0.070)	(0.072)	(0.042)	(0.070)
D(LIQ)	0.214 ***	0.781 ***	0.472 ***	1.359 *	5.293 ***	2.663 ***	4.737 ***
	(0.077)	(0.093)	(0.041)	(0.725)	(0.267)	(0.104)	(0.393)
D(i-i^{us})	-1.658	-7.338**	1.813	-31.100***	-29.324***	-14.540***	-24.951***
	(2.219)	(2.869)	(1.614)	(5.688)	(3.343)	(2.603)	(4.537)
D(VIX)	0.187 *	0.304 **	0.005	-1.052	0.326	0.264 ***	0.427
	(0.106)	(0.121)	(0.060)	(0.295)	(0.252)	(0.125)	(0.272)
D(EURUSD CIP)	0.154 ***	0.060	0.199 ***	0.059	0.030	0.059	0.319 **
	(0.049)	(0.060)	(0.032)	(0.131)	(0.132)	(0.081)	(0.139)
D(DXY)	-0.135	-0.447	1.077 ***	-1.634	-0.502	1.066 **	1.028
	(0.399)	(0.474)	(0.218)	(1.067)	(0.989)	(0.531)	(1.025)
	Variance Equation						
γ_0	-0.090***	3.389 ***	-0.106***	0.007	4.616 ***	0.617 ***	
	(0.025)	(0.350)	(0.022)	(0.048)	(0.433)	(0.138)	
γ_1	0.226 ***	0.617 ***	0.283 ***	0.630 ***	0.652 ***	0.482 ***	
	(0.024)	(0.059)	(0.025)	(0.066)	(0.072)	(0.036)	
γ_2	0.079 ***	-0.247***	0.035	-0.157***	-0.269***	-0.191***	
	(0.020)	(0.041)	(0.021)	(0.037)	(0.046)	(0.033)	
γ_3	0.982 ***	0.173 ***	0.969 ***	0.951 ***	0.181 ***	0.796 ***	
	(0.005)	(0.072)	(0.006)	(0.006)	(0.068)	(0.030)	
Student t	5.415 ***	4.994 ***	5.182 ***	2.700 ***	4.056 ***	8.067 ***	
R-squared	0.022	0.013	0.066	0.030	0.097	0.150	0.047
N	2235	2235	2235	2235	2110	2235	13285

Notes: In this table, we report coefficients both from EGARCH(1,1) model and panel model for CIP deviations. For individual currency estimates mean equation is as follows:

$$\text{D(CIP)} = \alpha_0 + \alpha_1\text{D(CDS)} + \alpha_2\text{D(LIQ)} + \alpha_3\text{D(i-i}^{\text{us}}) + \alpha_4\text{D(VIX)} + \alpha_5\text{D(EURUSD-CIP)} + \alpha_6\text{D(DXY)} + \epsilon$$

where $\epsilon \sim N(0,\sigma^2)$ and thus, variance equation is as follows:

$$\ln(\sigma^2) = \gamma_0 + \gamma_1\ln(\sigma^2_{-1}) + \gamma_2\epsilon_{-1} + \gamma_3(|\epsilon_{-1}/\sigma_{-1}| - \sqrt{2/\pi})$$

where $r_{t,t+n}$ and $r^*_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar, respectively. S_t and F_t are spot and forward rate, respectively. CDS is the 5-year credit default swap spread of countries, LIQ is the average of normalized bid-ask spread of the 3 month forward and spot rates of currencies, i-i^{us} is the nominal 10 year government bond yield differences of the respective country and United States. VIX is the implied volatility of S&P 500 Index , EURUSD CIP is the 3 month LIBOR based CIP deviations of Euro, DXY is the Dollar index. Numbers in parentheses are standard errors. In panel data, standard errors are robust to conditional heteroscedasticity and cross-sectional and serial correlation as in Driscoll and Kraay (1998). ***, ** and * denote 1%, 5% and 10% significance levels, respectively. N denotes number of observations.

Figure 4: FX swap (foreign currency to Turkish lira (TL)) positions of non-residents with Turkish banks (billions U.S. dollar). Source: Turkey's Banking Regulation and Supervision Agency.

derivatives and their low default risk properties are the main reasons for investors to shift their carry-trade investments from fixed income markets to FX derivatives markets (Lustig et al., 2011). In our sample countries, four currencies (Mexican peso, Russian rouble, South African rand, Turkish lira) belong to the high carry countries and the usage of FX swaps is high in those currencies. Since the FX swaps are done in OTC, it is difficult to reach the volume of the FX swap transactions. Yet, surprisingly, Banking Regulation and Supervision Agency in Turkey (BRSA) publishes data about the FX swap positions of domestic banks with non-residents in Turkey on monthly basis.

Using BRSA data, we compile FX swap positions (in billions USD) of non-residents between January 2010 and July 2018 (Figure 4). The amount that foreigners give the Turkish lira (TL) and receive the US dollars at the first leg is always higher than the amount that foreigners receive the Turkish lira (TL) and give the US dollar. Considering that the former is used for the carry trade activities and the latter is used for hedging purposes, it is clear that the amount of carry trade activities are higher than the amount used for hedging during the sample period in Turkey. Therefore, when credit risk of Turkey increases, one should expect that FX swap rates would increase more than the domestic interest rates and hence the CIP deviation would diminish. We believe that credit risk affects CIP deviations in two ways. In low-carry currencies, the well-known mechanism for credit risk works so that an increase in credit risk increases CIP deviations. Conversely, in high-carry currencies, FX swaps rates seem to react more than domestic interest rates, which reduces CIP deviations.

We find that FX liquidity is significantly and positively associated with CIP deviations in the single country and the panel regressions. Our findings suggest that a decrease in FX liquidity (the higher the liquidity coefficient) widens CIP deviations. In the single country regressions, we find a similar association, such that liquidity has strongly significant positive effects on CIP deviations in all six emerging economies.

Nominal interest rate differences have negative and significant coefficients in the panel regression, which implies that CIP deviation decreases when the interest rate differential between the sample countries' currencies and the U.S. dollar widens. Except for Poland, the single country regressions revealed significant negative associations between nominal interest rates and CIP deviations. Bräuning and Ivashina (2017) argue that an increase in the differences of interest rates raises demand for FX swaps from the lower rate currency to the higher one. This in turn increases the forward premium beyond its CIP-implied value. This finding underlines that nominal interest rates are important drivers of CIP deviations.

Global factors, on the other hand, seem to have a smaller impact on CIP deviations than local factors. The VIX coefficient is found to be significant for the CIP deviations in the Hungarian forint, Mexican peso and South African rand. Studies of advanced economies provide conflicting evidence about the effect of VIX during the post financial crisis period. For example, Avdjiev et al. (2019) find no significant impact of VIX on CIP deviations whereas Cerutti et al. (2021) show that VIX is an important driver of CIP deviations, particularly in low-interest currencies. Our findings seem to fall between these two studies.

We find a significant positive relationship between three-month EURUSD CIP deviation and local currency CIP deviations in the panel regression. In the single-country regressions, we find similar significant relationship, only for the Hungarian forint and

Polish zloty. Hungary and Poland have been European Union members since 2004 and have financial and trade ties with Eurozone countries. Therefore, factors that affect EURUSD CIP deviations seem to contribute to the CIP deviations in these countries.

The panel regression shows no effect of U.S. dollar strength (DXY). CIP deviations are only positively associated with the value of the U.S. dollar for the Polish zloty and, to a lesser extent, the South African rand. Cerutti et al. (2021) and Avdjiev et al. (2019) argue that the financial channel of exchange rates dominates the net exports channel. Consequently, depreciation of a domestic currency widens CIP deviation in advanced economies. In most emerging economies, however, this mechanism does not work as it does in advanced economies. Other factors, particularly domestic ones, have more influence on EME currency CIP deviations.

4.1 Implied Volatility of the Currencies, Credit Risk and CIP Deviations

To further understand the mechanism behind the effect of credit risk on CIP deviations, we add the three-month implied volatility of the currencies to our basic model. The relationship between implied volatility and a country's credit risk is well-documented in the literature (e.g. see Della Corte et al., 2016; Hui and Fong, 2015; Carr and Wu, 2007). The two variables often move in tandem, whereby an increase in sovereign risk is accompanied by higher foreign exchange (FX) volatility. Empirical studies also show that implied volatility, as a measure of market risk, explains CIP deviations (Coffey et al., 2009; Mancini-Griffoli and Ranaldo, 2010; Park, 2015; Sushko et al., 2016). Both credit risk and implied volatility appear to amplify CIP deviations in advanced economies.

Table 7 reports the estimation results of a model with implied volatility as a proxy for FX market risk. Our findings are generally in line with our previous results. That is, the sign of the credit risk and implied volatility are the same for all currencies, being positive in low-carry currencies (Hungarian forint and Polish zloty) and negative for high-carry currencies (Mexican peso, Russian rouble, South African rand and Turkish lira). As explained in section 3, greater usage of FX swaps in carry-trade activities makes investors more sensitive to FX swap interest rates than domestic rates. Therefore, an increase in implied volatility and/or credit risk reduces CIP deviations since investors demand a greater return for the higher risk.

4.2 Time Varying Measure of Credit Risk and CIP Deviations

Although credit risk is central to CIP deviations across advanced economy currencies during the global financial crisis, we find a significant but negative association between credit risk and CIP deviation among emerging economies, except for those in Europe. We investigate the effect of credit risk further by estimating with a 500-day window.[14] In this way, we explore the time-varying importance of credit risk in explaining CIP deviations.

Figure 5 plots the estimated coefficient of each currency's five-year CDS spread over the whole sample period. The coefficients are mostly consistent with our previous findings. In particular, the five-year CDS spreads coefficient is significantly and negatively associated with CIP deviations in the Russian rouble and Turkish lira. For most of the period, it is also negative for the South African rand and Mexican peso. For the Polish zloty, our rolling-window regressions show a significant and positive relation between CDS spreads and CIP deviations before 2014, although the relation turns negative afterwards. The Hungarian forint is the only currency with no association between CDS spreads and CIP deviations. Based on these results, we suggest that he impact of credit risk on CIP deviations must be interpreted cautiously, especially when carry-trade activities are frequent.

[14] We also used a 250-day window. However, this did not change the results much. To save space, these are not reported here but can be shared on request.

Table 7: Full Sample Regression with Implied Volatility (3-month LIBOR rate, Jan 2010 to July 2018)

	Time Series Regressions						
	Hungary (HUF)	Mexico (MXN)	Poland (PLN)	Russia (RUB)	Turkey (TRY)	South Africa (ZAR)	Panel
	Dependent Variable: D(CIP) $= D(\exp(nr_{t,t+n}) - F_{t,t+n}/S_{t+n}\ \exp(nr^*_{t,t+n}))$						
Constant	0.178	-0.678***	0.102	-1.435***	-1.321***	-0.784***	-0.112
	(0.153)	(0.182)	(0.085)	(0.377)	(0.378)	(0.214)	(0.189)
D(CDS)	0.053 *	-0.070	0.017	-0.498***	-0.287***	-0.094**	-0.581***
	(0.029)	(0.051)	(0.028)	(0.073)	(0.079)	(0.044)	(0.072)
D(LIQ)	0.223 ***	0.761 ***	0.474 ***	1.350 *	5.532 ***	2.672 ***	4.737 ***
	(0.077)	(0.092)	(0.041)	(0.738)	(0.269)	(0.103)	(0.393)
D(i-i$^{\text{us}}$)	-1.265	-6.568**	1.193	-29.233***	-26.640***	-12.774***	-25.389***
	(2.248)	(2.904)	(1.646)	(5.766)	(1.122)	(2.721)	(4.623)
D(VIX)	0.213 **	0.345 ***	-0.009	-0.998***	0.387	0.270 **	0.416
	(0.107)	(0.128)	(0.061)	(0.298)	(0.246)	(0.126)	(0.274)
D(EURUSD CIP)	0.172 ***	0.096	0.192 ***	0.056	0.059	0.088	0.311 **
	(0.05)	(0.061)	(0.033)	(0.130)	(0.133)	(0.078)	(0.139)
D(DXY)	-0.017	-0.424	1.02 ***	-1.499	-0.382	1.083 **	1.003
	(0.405)	(0.473)	(0.219)	(1.07)	(0.988)	(0.532)	(1.027)
D(IMPVOL)	-0.840	-1.839**	0.709 **	-2.816**	-5.841***	-1.956***	0.659
	(0.621)	(0.475)	(0.344)	(1.287)	(3.351)	(0.682)	(1.050)
	Variance Equation						
γ_0	-0.090***	3.563 ***	-0.106***	0.008	4.733 ***	0.627 ***	
	(0.025)	(0.342)	(0.022)	(0.048)	(0.433)	(0.141)	
γ_1	0.226 ***	0.618 ***	0.281 ***	0.633 ***	0.643 ***	0.474 ***	
	(0.024)	(0.059)	(0.025)	(0.066)	(0.072)	(0.036)	
γ_2	0.078 ***	-0.240***	0.036*	-0.157***	-0.255***	-0.187***	
	(0.021)	(0.041)	(0.022)	(0.037)	(0.047)	(0.033)	
γ_3	0.983 ***	0.136 ***	0.970 ***	0.951 ***	0.164 ***	0.796 ***	
	(0.005)	(0.071)	(0.006)	(0.006)	(0.07)	(0.031)	
Student t	5.409 ***	4.846 ***	5.143 ***	2.689 ***	3.961 ***	7.992 ***	
R-squared	0.025	0.016	0.067	0.029	0.101	0.155	0.047
N	2235	2235	2235	2235	2110	2235	13285

Notes: In this table, we report coefficients both from EGARCH(1,1) model and panel model for CIP deviations. For individual currency estimates mean equation is as follows:

$$\text{D(CIP)} = \alpha_0 + \alpha_1\text{D(CDS)} + \alpha_2\text{D(LIQ)} + \alpha_3\text{D(i-i}^{\text{us}}) + \alpha_4\text{D(VIX)} + \alpha_5\text{D(EURUSD CIP)} + \alpha_6\text{D(DXY)} + \epsilon$$

where $\epsilon \sim N(0, \sigma^2)$ and thus, variance equation is as follows:

$$\ln(\sigma^2) = \gamma_0 + \gamma_1 \ln(\sigma^2_{-1}) + \gamma_2\epsilon_{-1} + \gamma_3(|\epsilon_{-1}/\sigma_{-1}| - \sqrt{2/\pi})$$

where $r_{t,t+n}$ and $r^*_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar, respectively. S_t and F_t are spot and forward rate, respectively. CDS is the 5-year credit default swap spread of countries, LIQ is the average of normalized bid-ask spread of the 3 month forward and spot rates of currencies, i-i$^{\text{us}}$ is the nominal 10 year government bond yield differences of the respective country and United States. VIX is the implied volatility of S&P 500 Index , EURUSD CIP is the 3 month LIBOR based CIP deviations of Euro, DXY is the Dollar index and IMPVOL is the 3-month implied volatility of the currencies. Numbers in parentheses are standard errors. In panel data, standard errors are robust to conditional heteroscedasticity and cross-sectional and serial correlation as in Driscoll and Kraay (1998). ***, ** and * denote 1%, 5% and 10% significance levels, respectively. N denotes number of observations.

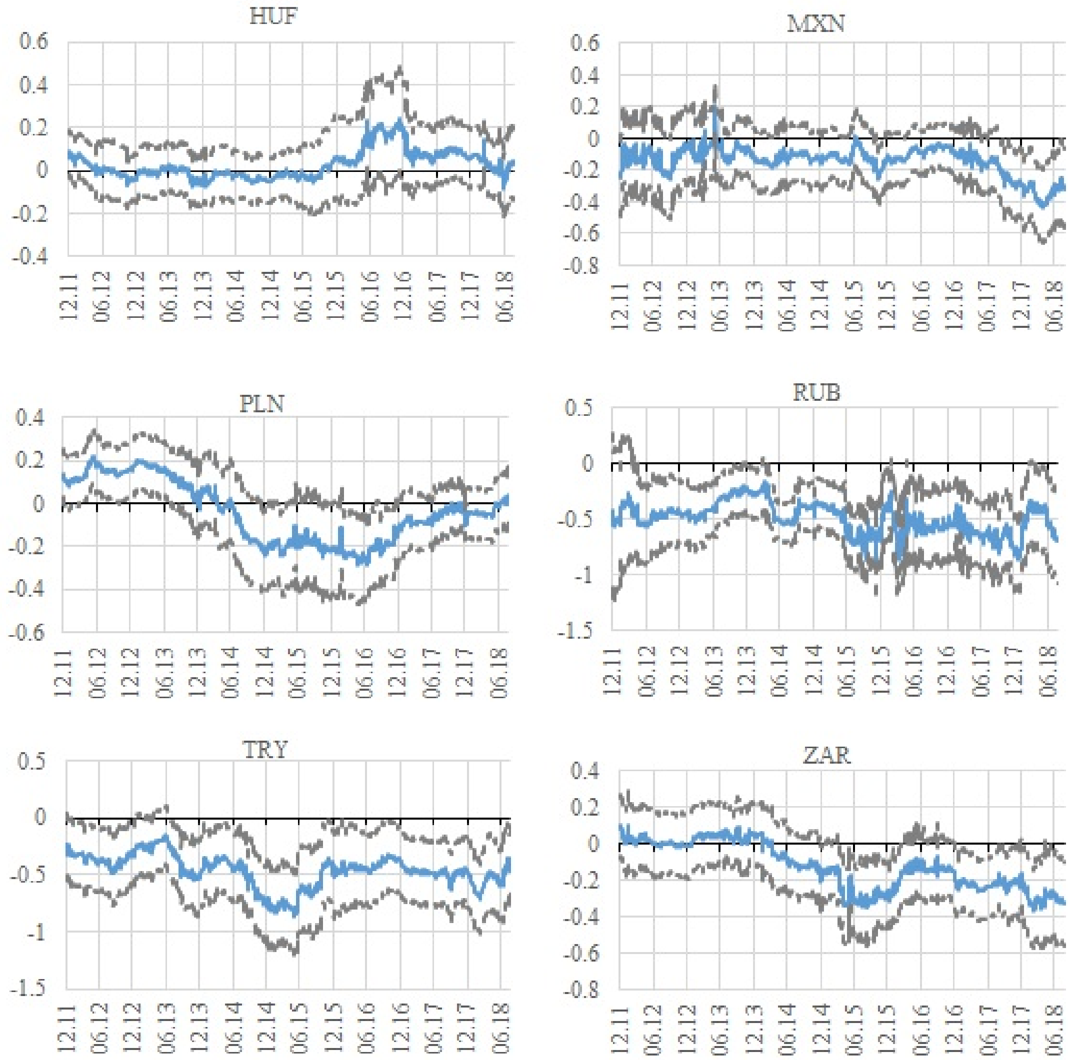

Figure 5: Estimated CDS coefficients from 500-day rolling regression (3 month LIBOR based CIP deviations and 95 percent confidence bands)

5 Robustness Checks

To examine whether the dynamics of CIP deviations are similar in different periods, we divide the whole sample into two sub-periods: January 2010 to December 2013 and January 2014 to July 2018. We report the estimated coefficients in Table 8. Overall, we find similar outcomes to the panel regression except for the insignificant impact of EURUSD CIP deviations in the sub-sample regressions.

For the individual currencies, there are some interesting results. For example, the Polish zloty has different signs for the credit risk in the two sub-samples. While there is no significant effect of credit risk on CIP deviations for the Polish zloty for the full sample, it has a significant positive effect on CIP deviations in the first sub-sample and a significant negative effect in the second sub-sample. We argue that the former trend is due to the European debt crisis whereas the latter is due to increased usage of FX swaps in non-residents' carry-trade activities (National Bank of Poland, 2016, pp.10). Moreover, the impact of credit risk on the Mexican peso and South African rand differs between the sub-samples, in that it is only significant in the first sub-sample for the Mexican peso and in the second sub-sample for the South African rand.

In the sub-samples, liquidity risk remains the most important factor driving CIP deviations in individual currencies. The Hungarian forint and Russian rouble are not significant in the second sub-period compared to the first. The impact of nominal interest rate differences on CIP deviations in each sub-sample is the same for all currencies. Although VIX is an important factor in CIP deviations for the Hungarian forint, Mexican peso and South African rand in the full sample, it is only significant in the first sub-sample for the forint and peso and in the second sub-sample for the South African rand.

In the sub-samples, liquidity risk remains the most important factor driving CIP deviations in individual currencies. The Hungarian forint and Russian rouble are not significant in the second sub-period compared to the first. The impact of nominal inter-

Table 8: Sub-Samples Regression (3-month LIBOR rate, January 2010 - December 2013, January 2014 to July 2018)

	Time Series Regressions													
	Hungary (HUF)		Mexico (MXN)		Poland (PLN)		Russia (RUB)		Turkey (TRY)		South Africa (ZAR)		Panel	
	2010-2013	2014-2018	2010-2013	2014-2018	2010-2013	2014-2018	2010-2013	2014-2018	2010-2013	2014-2018	2010-2013	2014-2018	2010-2013	2014-2018
	Dependent Variable: D(CIP) $= D(\exp(nr_{t,t+n}) - F_{t,t+n}/S_{t+n}\ \exp(nr^*_{t,t+n}))$													
Constant	0.003 **	0.192	-0.439*	-0.877***	-0.377*	0.186 **	-1.310***	-1.289**	-0.224	-2.196***	-0.674**	-0.940***	-0.030	-0.030
	(0.326)	(0.161)	(0.263)	(0.257)	(0.211)	(0.085)	(0.498)	(0.569)	(0.506)	(0.542)	(0.301)	(0.305)	(0.264)	(0.264)
D(CDS)	-0.002	0.063	-0.173**	-0.061	0.087 **	-0.085*	-0.429***	-0.699***	-0.415***	-0.380***	0.012	-0.274***	-0.129*	-0.984***
	(0.038)	(0.053)	(0.075)	(0.063)	(0.044)	(0.045)	(0.097)	(0.100)	(0.107)	(0.108)	(0.059)	(0.058)	(0.077)	(0.115)
D(LIQ)	1.407 ***	0.020	0.398 *	0.952 ***	1.290 ***	0.305 ***	1.389 *	1.882	4.042 ***	5.425 ***	3.266 ***	2.547 ***	2.449 ***	5.592 ***
	(0.178)	(0.081)	(0.218)	(0.107)	(0.103)	(0.042)	(0.845)	(1.232)	(0.405)	(0.321)	(0.265)	(0.117)	(0.470)	(0.569)
D(i-i$^{\text{us}}$)	-2.373	-2.952	-5.948*	-11.710**	0.471	1.898	-26.563***	-33.828*	-21.797***	-29.967**	-13.512***	-14.385***	-16.016***	-31.267***
	(3.232)	(3.032)	(3.513)	(4.834)	(3.485)	(1.686)	(9.131)	(7.407)	(5.617)	(4.571)	(3.862)	(3.642)	(5.272)	(7.021)
D(VIX)	0.611 ***	-0.058	0.428 **	0.276	-0.081	0.047	-1.090**	-0.913**	0.336	-0.024	0.082	0.551 ***	0.048	0.723
	(0.212)	(0.122)	(0.172)	(0.176)	(0.138)	(0.061)	(0.489)	(0.387)	(0.337)	(0.363)	(0.180)	(0.188)	(0.315)	(0.447)
D(EURUSD CIP)	0.169 *	0.151 ***	0.013	0.183 ***	0.404 ***	0.117 ***	-0.001	0.035	-0.029	0.139	0.105	-0.102	0.123	0.251
	(0.098)	(0.054)	(0.098)	(0.072)	(0.076)	(0.033)	(0.188)	(0.200)	(0.192)	(0.211)	(0.106)	(0.105)	(0.153)	(0.225)
D(DXY)	2.321 **	-0.864**	-1.604**	-0.212	1.873 ***	0.957 ***	-2.722*	-0.896	1.173	-1.726	-0.318	2.188 ***	-0.956	1.404
	(0.927)	(0.434)	(0.749)	(0.622)	(0.624)	(0.218)	(1.498)	(1.561)	(1.471)	(1.398)	(0.815)	(0.726)	(1.313)	(1.530)
	Variance Equation													
γ_0	3.785 ***	-0.099***	5.136 ***	2.702 ***	2.784 ***	-0.101**	-0.067	0.060	0.074	5.365 ***	0.858 ***	0.559 ***		
	(1.031)	(0.032)	(0.857)	(0.348)	(0.645)	(0.042)	(0.058)	(0.064)	(0.084)	(0.551)	(0.248)	(0.192)		
γ_1	0.415 ***	0.238 ***	0.413 ***	0.691 ***	0.488 ***	0.370 ***	0.538 ***	0.531 ***	0.245 ***	0.694 ***	0.515 ***	0.465 ***		
	(0.081)	(0.036)	(0.087)	(0.079)	(0.073)	(0.047)	(0.083)	(0.075)	(0.049)	(0.097)	(0.057)	(0.049)		
γ_2	0.039	0.120 ***	-0.039	-0.341***	-0.069	0.125 ***	-0.209***	-0.045	-0.066*	-0.325***	-0.163***	-0.214***		
	(0.056)	(0.031)	(0.057)	(0.056)	(0.059)	(0.033)	(0.053)	(0.048)	(0.037)	(0.063)	(0.050)	(0.046)		
γ_3	0.166	0.981 ***	-0.168	0.301 ***	0.238	0.937 ***	0.966 ***	0.951 ***	0.957 ***	0.071	0.738 ***	0.812 ***		
	(0.211)	(0.006)	(0.182)	(0.074)	(0.158)	(0.014)	(0.007)	(0.008)	(0.015)	(0.085)	(0.055)	(0.041)		
Student's t	6.010 ***	4.852 ***	4.097 ***	6.750 ***	5.403 ***	5.000 ***	2.738 ***	2.743 ***	4.826 ***	4.397 ***	6.678 ***	10.824***		
R-squared	0.058	0.013	0.009	0.027	0.089	0.082	0.013	0.045	0.125	0.072	0.089	0.216	0.014	0.012
Observations	1041	1194	1041	1194	1041	1194	1041	1194	916	1194	1041	1194	6121	7164

Notes: In this table, we report coefficients both from EGARCH(1,1) model and panel model for CIP deviations. For individual currency estimates mean equation is as follows:

$$\text{D(CIP)} = \alpha_0 + \alpha_1\text{D(CDS)} + \alpha_2\text{D(LIQ)} + \alpha_3\text{D(i-i}^{\text{us}}) + \alpha_4\text{D(VIX)} + \alpha_5\text{D(EURUSD CIP)} + \alpha_6\text{D(DXY)} + \epsilon$$

where $\epsilon \sim N(0, \sigma^2)$ and thus, variance equation is as follows:

$$\ln(\sigma^2) = \gamma_0 + \gamma_1 \ln(\sigma^2_{-1}) + \gamma_2\epsilon_{-1} + \gamma_3(|\epsilon_{-1}/\sigma_{-1}| - \sqrt{2/\pi})$$

where $r_{t,t+n}$ and $r^*_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar, respectively. S_t and F_t are spot and forward rate, respectively. CDS is the 5-year credit default swap spread of countries, LIQ is the average of normalized bid-ask spread of the 3 month forward and spot rates of currencies, i-i$^{\text{us}}$ is the nominal 10 year government bond yield differences of the respective country and United States. VIX is the implied volatility of S&P 500 Index, EURUSD CIP is the 3 month LIBOR based CIP deviations of Euro, DXY is the Dollar index. Numbers in parentheses are standard errors. In panel data, standard errors are robust to conditional heteroscedasticity and cross-sectional and serial correlation as in Driscoll and Kraay (1998). ***, ** and * denote 1%, 5% and 10% significance levels, respectively. N denotes number of observations.

est rate differences on CIP deviations in each sub-sample is the same for all currencies. Although VIX is an important factor in CIP deviations for the Hungarian forint, Mexican peso and South African rand in the full sample, it is only significant in the first sub-sample for the forint and peso and in the second sub-sample for the South African rand.

EURUSD CIP deviations in the sub-samples have similar effects on CIP deviations using full-sample data. Likewise, in both sub-periods, euro/dollar CIP deviations are still a significant driver of CIP deviations only for the Hungarian forint and Polish zloty. This time, we observe that the Mexican peso is related to EURUSD CIP deviations in the second sub-sample but not in the first.

The association between the U.S. dollar index and CIP deviations across the sub-samples is mixed. In the full sample, only the Polish zloty and South African rand are positively related to the U.S. dollar index, which remains a significant driver of CIP deviations in the Polish zloty in both sub-samples and the South African rand in the second sub-sample. The Hungarian forint, Mexican peso and Russian rouble have different associations. The coefficients of the U.S. dollar index for the Hungarian forint are significant in both periods but with a positive sign in the first sub-period and a negative in the second. For the Mexican peso and Russian rouble, the sign of the coefficient is negative and significant in the first sub-sample. These dissimilar patterns for the U.S. dollar index suggest that U.S. dollar index cannot be a common driver of CIP deviations in the emerging economies.

In the literature, using the LIBOR rate for measuring CIP deviations has been criticized due to the measurement problem. As another robustness check, we calculate CIP deviations with deposit rates available as bid/ask rates for the sample countries (Figure 6). Table 9 reports the estimated coefficients to explain CIP deviations measured with deposit rates. Similarly, we observe that local factors play important roles on CIP deviations in the emerging economies.

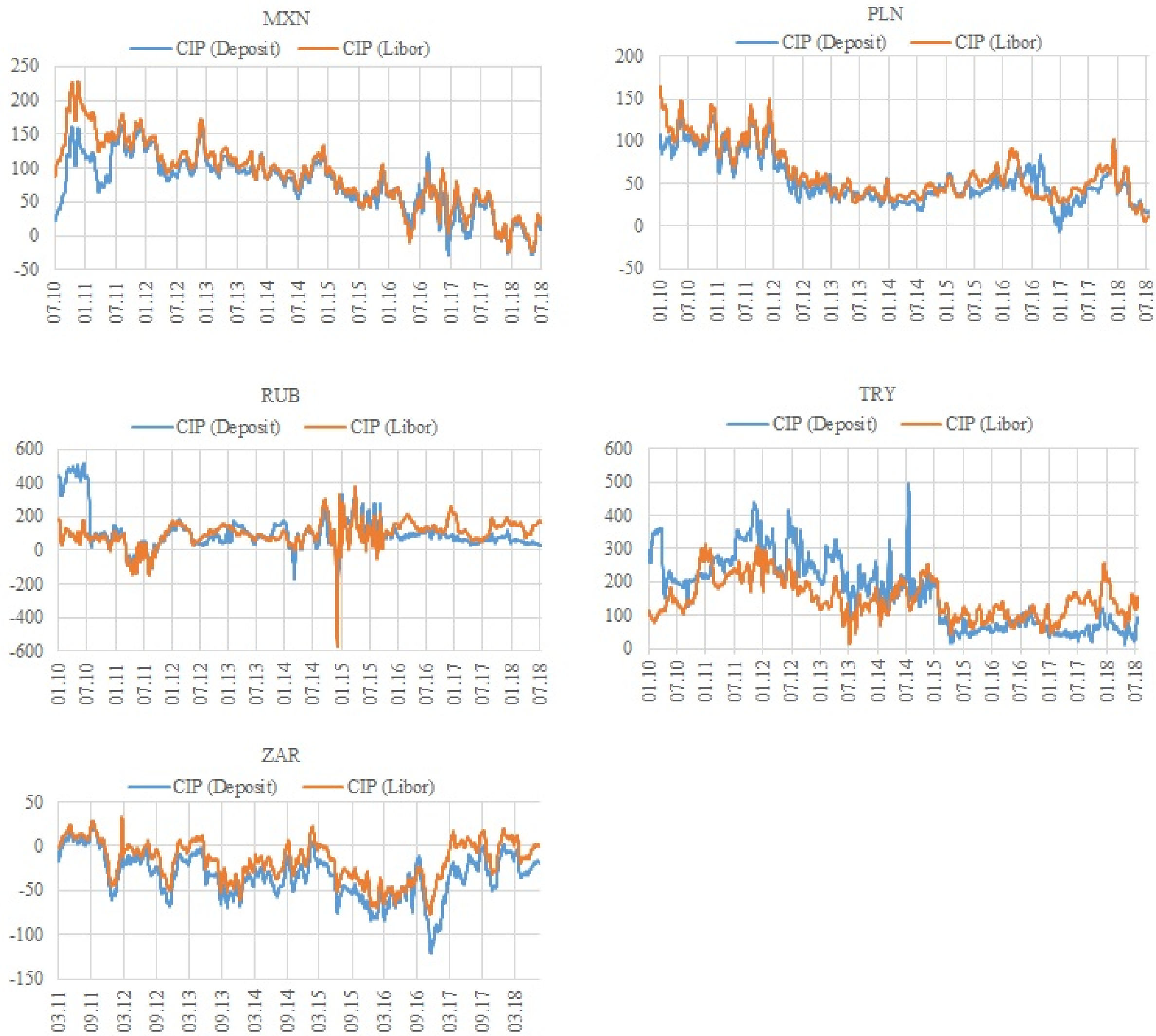

Figure 6: CIP Deviations (3 month, 10 day moving average, basis points) based on deposit rates and LIBOR

Table 9: Full Sample Regression (3-month Deposit rate, January 2010 to July 2018)

	Time Series Regressions					
	Mexico (MXN)	Poland (PLN)	Russia (RUB)	Turkey (TRY)	South Africa (ZAR)	Panel
	Dependent Variable: D(CIP) $= D(\exp(nr_{t,t+n}) - F_{t,t+n}/S_{t+n}\exp(nr^*_{t,t+n}))$					
Constant	-0.509***	-0.087	-0.771	-0.999**	-0.504*	0.285
	(0.197)	(0.127)	(0.471)	(0.456)	(0.258)	(0.209)
D(CDS)	-0.049	0.032	-0.382***	-0.239**	-0.140***	-0.686***
	(0.05)	(0.042)	(0.097)	(0.096)	(0.051)	(0.112)
D(LIQ)	0.700 ***	0.732 ***	2.104 **	4.666 ***	2.651 ***	5.111 ***
	(0.11)	(0.062)	(0.961)	(0.292)	(0.131)	(0.554)
D(i-i^{us})	-4.257	-1.922	-10.983	-15.982***	-16.168***	-17.530***
	(3.016)	(2.444)	(6.977)	(4.217)	(3.317)	(6.916)
D(VIX)	0.108	0.074	-0.398	0.594 **	0.235	0.583
	(0.125)	(0.093)	(0.351)	(0.298)	(0.167)	(0.434)
D(EURUSD CIP)	0.083	0.562 ***	0.363 **	0.030	-0.003	0.221
	(0.064)	(0.057)	(0.18)	(0.171)	(0.094)	(0.216)
D(DXY)	-0.401	0.883 ***	-1.531	0.786	1.709 ***	1.455
	(0.505)	(0.335)	(1.352)	(1.265)	(0.67)	(1.349)
	Variance Equation					
γ_0	0.086	-0.037	0.093	2.761 ***	0.160 *	
	(0.061)	(0.04)	(0.059)	(0.453)	(0.084)	
γ_1	0.359 ***	0.515 ***	0.743 ***	1.458 **	0.399 ***	
	(0.037)	(0.049)	(0.149)	(0.616)	(0.036)	
γ_2	-0.128***	-0.048	-0.070	-0.276**	0.103 ***	
	(0.029)	(0.031)	(0.044)	(0.135)	(0.029)	
γ_3	0.931 ***	0.943 ***	0.950 ***	0.623 ***	0.910 ***	
	(0.013)	(0.008)	(0.006)	(0.036)	(0.017)	
Student t	4.327 ***	2.853 ***	2.308 ***	2.138 ***	6.938 ***	
R-squared	0.002	0.021	0.018	0.035	0.115	0.028
N	2087	2235	2235	2110	1926	10593

Notes: In this table, we report coefficients both from EGARCH(1,1) model and panel model for CIP deviations. Dependent variable is the deposit rate-based deviations from CIP. For individual currency estimates mean equation is as follows:

$$\text{D(CIP)} = \alpha_0 + \alpha_1\text{D(CDS)} + \alpha_2\text{D(LIQ)} + \alpha_3\text{D(i-i}^{\text{us}}) + \alpha_4\text{D(VIX)} + \alpha_5\text{D(EURUSD CIP)} + \alpha_6\text{D(DXY)} + \epsilon$$

where $\epsilon \sim N(0,\sigma^2)$ and thus, variance equation is as follows:

$$\ln(\sigma^2) = \gamma_0 + \gamma_1\ln(\sigma^2_{-1}) + \gamma_2\epsilon_{-1} + \gamma_3(|\epsilon_{-1}/\sigma_{-1}| - \sqrt{2/\pi})$$

where $r_{t,t+n}$ and $r^*_{t,t+n}$ denote the continuously compounded n-year interest rates at date t in local currency and U.S. dollar, respectively. S_t and F_t are spot and forward rate, respectively. CDS is the 5-year credit default swap spread of countries, LIQ is the average of normalized bid-ask spread of the 3 month forward and spot rates of currencies, i-i^{us} is the nominal 10 year government bond yield differences of the respective country and United States. VIX is the implied volatility of S&P 500 Index , EURUSD CIP is the 3 month LIBOR based CIP deviations of Euro and DXY is the Dollar index. Numbers in parentheses are standard errors. In panel data, standard errors are robust to conditional heteroscedasticity and cross-sectional and serial correlation as in Driscoll and Kraay (1998). ***, ** and * denote 1%, 5% and 10% significance levels, respectively. N denotes number of observations.

6 Conclusion

In this paper, we examine the CIP deviations for Hungarian forint, Mexican peso, Polish zloty, Russian rouble, South African rand, Turkish lira during the post financial crisis period. We show that persistent CIP deviations exist for nearly all of these currencies. However, the scale of the deviations varies by currency and time. FX liquidity is clearly the most important indicator in explaining CIP deviations. Lower liquidity in emerging economies causes higher liquidity premia, which widens CIP deviations.

Credit risk also significantly affects CIP deviations. Contrary to previous research, our findings suggest that increased credit risks, particularly in high carry-trade currencies, lessen CIP deviations. We argued that this association results from the changing nature of carry-trade activities. Increased use of FX derivatives instruments for carry-trade activities makes investors more sensitive to FX swap rates than domestic money market rates. Therefore, when a country's credit risk increases, investors demand higher premia for their investments in the form of FX derivatives. These investor behaviors affect FX swap rates to react more than domestic rates and narrow CIP deviations. Moreover, nominal interest rate differences between an emerging economy currency and the U.S. dollar also affect CIP deviations. That is, when such a difference widens, there is more FX swap demand to sell the high-interest currency and buy the low-interest rate currency. This in turn reduces CIP deviations. Finally, three global factors (the VIX index, U.S. dollar index and euro CIP deviations) are not consistently significant drivers of CIP deviations in the six analyzed currencies.

After the global financial crisis, emerging economy central banks have faced mounting difficulties in implementing independent monetary policies due to the dominance of the policies of advanced market central banks. CIP deviations may also influence the transmission mechanisms of these central banks by creating financial frictions. Although the policy implications of the CIP are still relatively unexplored in advanced economies, emerging countries with larger CIP deviations than advanced ones should be more cautious when implementing monetary policy.

In this paper, we show that the CIP deviations have persisted and varies considerably over time and across countries. One policy implication of our analysis is that it is very important for economic agents and policy makers to understand who is doing the arbitrage and which instruments are used in the derivative markets. Based on our results, we also propose that an in-depth understanding of FX liquidity is particularly important in the emerging markets. FX liquidity patterns are different than the other asset markets. As emphasized by Karnaukh et al. (2015), FX markets have limited transparency and are highly leveraged. Thus, monitoring fundamental sources of FX liquidity (demand or supply driven sources) helps explaining variation in currency liquidities and its effect on the CIP deviations.

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Appendices

Table A.1

OTC Foreign Exchange Turnover by Currency (Net daily averages in billions of USD)

	High Income Countries			Emerging Market Economies			
	2010	2016	%Δ		2010	2016	%Δ
U.S. dollar	3371	4438	31.6	Chinese Renminbi	34	202	489.8
Euro	1551	1591	2.5	Mexican Peso	50	97	94.4
Japanese Yen	754	1096	45.2	Korean Won	60	84	39.1
British Pound	512	649	26.8	Turkish Lira	29	73	148.6
Australian Dollar	301	348	15.6	Russian Rouble	36	58	62.0
Canadian Dollar	210	260	24.1	Indian Rupee	38	58	53.6
Swiss Franc	250	243	-2.8	Brazilian Real	27	51	86.3
Swedish Krona	87	112	29.1	South African Rand	29	49	71.9
New Zealand Dollar	63	104	64.5	Polish Zloty	32	35	10.4
Singapore Dollar	56	91	62.5	New Taiwan Dollar	19	32	68.9
Hong Kong Dollar	94	88	-6.7	Thai Baht	8	18	138.4
Norwegian Krone	52	85	61.4	Malaysian Ringgit	11	18	65.4
Danish Krone	23	42	84.3	Hungarian Forint	17	15	-10.8

Notes: Derivatives currencies (Leg 1) are from 2010 and 2016 BIS Triennal Survey. Emerging markets are classified according to International Monetary Fund classification. %Δ indicates percentage change.

Table A.2

Correlations of Hourly Data with Daily Data

	Currencies			
Tenor	Mexican Peso	Turkish Lira	South African Rand	Polish Zloty
3-month	0.97*	0.98*	0.97*	0.97*
6-month	0.98*	0.99*	0.97*	0.99*

Notes: Correlations of the high frequency (hourly) and daily 3-month and 6-month CIP deviations are calculated for the time period between Aug 27, 2013 and July 30, 2018. All the numbers with stars indicate that hourly data and daily data are statistically not different from each other at the 5% significance level.

Table A.3

Description of the Variables and Data Sources

Variable	Description	Source
D(CIP)	Three-month LIBOR based CIP deviations	Authors' calculations†
CDS	Five-year credit default risk spread of countries	Bloomberg
LIQ	Average of normalized bid-ask spread of the three-month forward and spot rates of currencies	Authors' calculations†
$i\text{-}i^{us}$	Nominal 10 year government bond yield difference sof the respective country and United States	Bloomberg
VIX	Implied Volatility of S&P 500 Index	Bloomberg
DXY	U.S. Dollar Index	Bloomberg
€-CIP	Three-month LIBOR based CIP deviations of Euro	Bloomberg
IMPVOL	Three-month implied volatility of the currencies	Bloomberg

Notes: D(CIP) is deviation from CIP. †The data used in authors' calculations are from Bloomberg

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