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Bank foreign currency funding and currency markets: the case of Mexico post GFC*

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Abstract: This paper examines the impact of foreign currency hedging demand on the foreign exchange market. First, the paper documents deviations from covered interest parity (CIP) for Mexico after the global financial crisis (GFC), and then it evaluates the effect of two variables in a regression-based analysis: (i) the FX funding gap of domestic bank balance sheets and (ii) external foreign currency hedging demand. The main result is that both variables directly influenced CIP deviations in Mexico, and it was robust to including arbitrage funding and foreign exchange transaction costs in the regression. These results suggest hedging demand can be an important factor in emerging economies' foreign exchange forward markets, even at short maturities. One of the implications is that banks' ability to manage the currency mismatch is affected by global shocks in the foreign currency market.

Keywords: foreign currency hedging, financial stability, capital flows, currency mismatch, covered interest parity (CIP)
JEL Classification: F3, G2, F65, G15, G18

Resumen: Este documento examina el impacto de la demanda por cobertura en moneda extranjera sobre el mercado cambiario. Primero, el análisis documenta las desviaciones de la paridad cubierta de tasas de interés (PCT) para México después de la crisis financiera global (CFG); y evalúa el efecto de dos variables en el análisis de regresión: (i) la brecha del financiamiento en divisas en los balances de los bancos mexicanos y (ii) la demanda del exterior por la cobertura en moneda extranjera. El resultado principal es que ambas afectaron directamente las desviaciones de la PCT en México, lo cual fue robusto a incluir en la regresión los costos de fondeo de arbitraje y los de transacción de divisas. Estos resultados sugieren que la demanda por cobertura puede ser un factor importante en los mercados de futuros de divisas en economías emergentes, incluso en vencimientos de corto plazo. Una de las implicaciones es que la capacidad de los bancos para administrar el desajuste de divisas en sus balances puede verse afectada por choques globales en el mercado cambiario.
Palabras Clave: cobertura de moneda extranjera, estabilidad financiera, flujos de capital, desajuste de moneda, paridad cubierta de tasas de interés (PCT)

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1 Introduction

Foreign exchange funding in the banking sector is a key financial stability concern for financially open economies. The value of foreign currency denominated exposures will be subject to exchange rate movements. Large fluctuations can dramatically change the relative value of a bank's domestic and foreign liabilities and assets. For example, if a bank funds itself primarily through foreign currency and then lends in domestic currency, a large depreciation of the domestic currency reduces the value of the bank's assets and revenues from those assets, while increasing the cost of its liabilities. Thus managing the balance sheet in the context of global capital mobility, requires additional risk management targets.

Many countries have macro-prudential regulations requiring banks to manage their foreign currency balance sheets conservatively.[1] Foreign currency regulations curtail the size of an individual bank's currency mismatch with the aim of reducing risks from their FX funding gap. To comply with these government regulations as well as internal risk management protocols, banks turn to the foreign exchange markets to close their FX funding gaps. In particular, the more developed are the foreign exchange markets, the more easily banks are able to manage vulnerabilities due to foreign currency exposures.

Fundamental to a well-functioning, liquid FX market is an operational relation known as covered interest parity: interest rates denominated in different currencies should equalize, once exchange rate differences are accounted for. Pre-crisis, empirical research provided evidence that covered interest parity generally held: deviations did not last long as arbitrage transactions closed the differential.[2] However recent research has documented meaningful and persistent deviations from CIP in developed economies during and after the global financial crisis.[3] Avdjiev et al. (2017) analyze the ten most liquid currencies (besides the US dollar) and find non-zero deviations over their sample period of 2007-2015. Borio et al. (2016b) document persistent CIP deviations post crisis for nine developed economy currencies. Du et al. (2018) demonstrate that even after markets had normalized in the crisis aftermath, deviations from CIP persist in a number of interest rate spreads.

Various explanations for these documented persistent CIP deviations have been proposed. A central factor is the structural re-pricing of risk after the global financial crisis. Regulatory changes have imposed higher capital requirements, and market forces have increased the cost of capital for financial intermediaries, in particular for regulated banks. Furthermore, banks experience heterogeneous marginal funding costs because of the impact of different regulatory requirements for systemically important institutions. More stringent capital re-

[1]Domestic regulations on currency mismatch have been in place in Mexico since the early 1990s. Banks are required to hedge their dollar assets according to the following rule: $|A_{USD} - L_{USD}| < 15\% * T1Capital$, where Tier 1 capital is high quality bank equity. And, banks must hold enough liquid foreign currency assets.

[2]See Akram et al. (2008).

[3]See Avdjiev et al. (2017), Borio et al. (2016a,b), Du et al. (2018).

quirements increase the cost of deploying the balance sheet, and bail-in resolution regimes increase the costs to bank creditors in the event of trouble, leading to higher pricing for debt financing.[4] These large banks are also key potential arbitrageurs. Thus, their increased costs can deter arbitrage, leading to CIP deviations persisting.[5] Also, the extended period of low or negative interest rates in several major developed economies, the search for yield, and the role of the US dollar (and also some evidence for the Euro) as a funding currency have been highlighted as drivers of CIP deviations.[6]

Implicit in the studies of developed market currencies, is that these currencies trade freely internationally (an absence of capital controls) and financial markets are well developed with minimal frictions or segmentation. For example, for CIP arbitrage to occur, not only are liquid spot and forward foreign exchange markets desirable, but also risk-free securities in the foreign country of the desired maturity, and real time price information to minimize execution risk. Thus, the institutional features of the countries' financial systems are relevant. Studying an emerging economy brings into focus this issue. And, Mexico provides an ideal setting to study CIP deviations in an emerging economy. The Mexican peso is a highly liquid currency. The peso entered the international payment system in 2008 and according to data from the BIS triennial central bank survey on foreign exchange turnover, USD43bn of Mexican pesos trade daily in the spot market on average and USD54bn in foreign exchange derivatives. The Mexican peso is consistently in the top 15 by amount of turnover, and of EM currencies, is second only to China in the most recent survey. (See Table 1.)

Also the Mexican government securities market is well developed. Outstanding local currency risk-free government securities with maturities 12 months and under, known as cetes, are valued at around USD360bn, 32% of GDP. This compares to a local currency bond market valued at around 47% of GDP for Australia.(See Table 1.)

Foreign funding in emerging economies is also of interest because emerging economies, in the neo-classical sense, are capital scarce. Theory predicts capital inflows due to a structurally higher interest rate in an emerging economy versus a developed economy. Thus vulnerabilities arising from dependence on external funding are particularly critical for emerging economies. Currency mismatches and the financial sector's ability to manage this risk, has long been an issue for policymakers in those emerging economies that have been able to access global markets. Since banks are usually an important conduit of these flows, the FX balance sheet of domestic banks can be a source of vulnerability.[7]

Motivated by this, the paper examines the role of exogenous, business-model driven for-

[4]See Duffie (2017).

[5]See Boyarchenko et al. (2018), Rime et al. (2017).

[6]See Avdjiev et al. (2017), Ivashina et al. (2015).

[7]Domestic regulations on currency mismatch have been in place in Mexico since the early 1990s. Banks are required to hedge their dollar assets according to the following rule: $|A_{USD} - L_{USD}| < 15\% * T1Capital$, where Tier 1 capital is high quality bank equity. And, banks must hold enough liquid foreign currency assets.

Table 1: Mexican peso vs. major markets

	OTC Foreign Exchange Daily Turnover		Domestic Currency Gov. Bonds	
	(USD bn)	% nominal GDP	(USD bn)	% nominal GDP
USD	4,438	23.82	17,252	88.97
EUR	1,591	13.32	9,431	74.80
JPY	1,096	22.14	9,427	193.49
GBP	649	24.39	2,669	101.69
AUD	348	27.51	647	46.90
CNY	202	1.80	4,026	33.51
MXN	**97**	**9.00**	**362**	**31.5**
SGD	91	29.38	86	26.55
TRY	73	8.46	147	17.30
RUB	58	4.53	125	8.18
INR	58	2.55	832	31.87
BRL	51	2.84	1,557	75.77
ZAR	49	16.57	156	44.66

Daily turnover includes cash and derivatives markets. USD, GBP, EUR general government total debt securities reported, issuance is primarily in domestic currency. For the rest of the countries, general government domestic debt securities are reported.
Source: Triennial Central Bank Survey, IMF, BIS.

eign currency hedging demand in the foreign exchange market, the key market where banks manage their foreign currency funding gap. The paper focuses on the period post crisis, when the USD/MXN currency basis was persistently negative. From the Mexican commercial bank perspective, if foreign denominated assets are greater than foreign denominated liabilities, banks need to raise dollar denominated liabilities to close the gap. To do this, banks can sell US dollars forward, which increases supply in the forward market. This puts downwards pressure on the forward exchange rate, fostering deviations from covered interest parity and arbitrage opportunities. From the counterparty perspective, foreign entities, mostly international financial institutions, wish to hedge the foreign currency risk of an investment in Mexican domestic currency bonds, or investments in other emerging economies with less liquid currencies. Therefore they want to buy US dollars forward, which should have the opposite effect on CIP deviation from that of the domestic banks' hedging demand. Thus hypothetically the banks hedging needs are met by these foreign counterparties, and any remaining CIP deviation will be arbitraged.

To answer whether these two sources of exogenous hedging demand affect the forward market in this way (Mexican banks widening CIP deviations, Foreigners narrowing), the paper first documents substantial and persistent deviations from covered interest parity for tenures of 1, 3, 6 and 12 months for an emerging economy.[8] Having documented the CIP

[8]I find that Mexico's CIP deviations are comparable to developed market currencies, for example Japanese yen. This is somewhat different to the conclusions in Frankel and Poonwala (2009) which finds that the for-

deviations, regulatory filings are used to construct a balance sheet for the Mexican banking system and calculate the system foreign currency funding gap. This data is combined with data on foreign currency derivatives transactions to construct the banking system's net FX derivatives positions by counterparty.

The first question I ask, is could Mexican bank hedging demand be a proximate driver for the CIP deviation.[9] Mexican regulation requires domestic banks to reduce currency mismatch risks by complying with the rule that the gap between foreign currency liabilities and assets (in either direction) must be less than 15% of Tier 1 capital (high-quality bank equity). Inspecting the daily reporting data required by the Mexican central bank, banks in Mexico seem to be conservative and stay far from this constraint. Thus, I construct the foreign currency balance sheet of the banking system, and observe the FX funding gap between core assets and core liabilities. The paper investigates the relation between this proxy for domestic bank FX hedging demand and the CIP deviations.

Next, I ask if foreign hedging demand, measured by the FX derivatives transacted with foreign counterparties, has an impact on the CIP deviation.[10]

To answer the research questions, the currency hedging demand measures (domestic and foreign) are each included in an econometric model of covered interest parity under limits to arbitrage, following the approach used in Borio et al. (2016b). Results show that each factor directly influenced the CIP deviations, measured as the differential between the forward market implied rate and the observed risk free rate. Even when relative arbitrage funding costs, and foreign exchange bid/ask spreads are also accounted for in the regression model. Results including the interaction effect between the hedging variables and the arbitrageur balance sheet constraint variables provide mixed evidence that arbitrageur balance sheet costs are a factor in the Mexican peso market.

These results from the Mexican case suggest exogenous hedging needs can be a more significant factor in foreign exchange forward markets than has so far been documented in the literature on CIP deviations, and an important factor even at shorter maturities. One implication is that the ability of Mexican domestic banks to manage their FX funding gap is influenced by foreign hedging demand.

This paper adds to the literature on CIP deviations after the Global Financial Crisis by analyzing the case of an emerging market, with the unique advantage of using regulatory

ward premium (another way to measure CIP deviations) in emerging economy currencies is smaller than for developed. The difference may stem from the different sample periods.

[9] There are many factors that could be driving Mexican peso - US dollar hedging activity. Oil price changes, trade frictions, central bank interventions and of course US monetary policy normalization. This paper is focused not on what drives hedging activity, but rather asking do shocks to FX hedging demand, and in particular via domestic banks, impact CIP deviations.

[10] There may be some part of these foreign counterparty FX derivatives transactions that are endogenous to the CIP deviation. To address this issue, I instrument for foreign hedging demand. See Section 4 for further detail.

filings data and FX derivatives transactions data. Furthermore, the FX derivatives data is split by counterparty and therefore the impact of actual foreign hedging transactions, rather than proxies, can be evaluated. Prior research on CIP deviations in Mexico include Carstens (1985), Khor and Rojas-Suarez (1991) and Hernandez (2014). Of these, Hernandez (2014) is the most current, analyzing the period 2003 - mid-2012 and focusing on funding liquidity shocks during the crisis. The paper estimates a VECM to assess the role of US and European funding liquidity in CIP deviations for 1-month sovereign securities (US Treasury bills vs Mexican Cetes). Similar to the argument in Borio et al. (2016b) and Khor and Rojas-Suarez (1991), if CIP holds, there should be a cointegrating relationship between the domestic and foreign interest rate. Borio et al. (2016b) find this is true for Japanese yen - US dollar at the 2-year maturity for the post-crisis period, only when exogenous hedging demand is included in the model. Hernandez (2014) finds one cointegrating relationship exists for the 1-month maturity for Mexican peso - US dollar basis but only when the funding liquidity measures are included, providing evidence that funding liquidity is a factor in short-run Mexican CIP deviations.

2 Covered Interest Parity

Covered interest parity (CIP) is a no-arbitrage condition that states interest rates denominated in different currencies should be equal, once currency risk has been covered.

$$(1 + r_{t,m})S_t = (1 + r^*_{t,m})F_{t,m}$$

The domestic interest rate for maturity m and time t, $r_{t,m}$, and the foreign interest rate, $r^*_{t,m}$, equate when adjusted by the currency components. These are the exchange of domestic for foreign currency at the spot exchange rate (S_t) and the exchange of foreign for domestic currency at a later date at the forward exchange rate ($F_{t,m}$). The spot exchange rate, and interest rates are priced in more liquid markets than the forward market.[11] Thus one can rewrite the above relation as

$$F_{t,m} = S_t \frac{(1 + r_{t,m} + b)}{(1 + r^*_{t,m})}$$

and under covered interest parity, the cross-currency basis $b = 0$.

Theoretically the parity condition rests on the argument that any deviations would be arbitraged away, until there are no arbitrage opportunities. For example, taking the case of the Mexican peso and US dollar, when the cross-currency basis is negative $b < 0$,

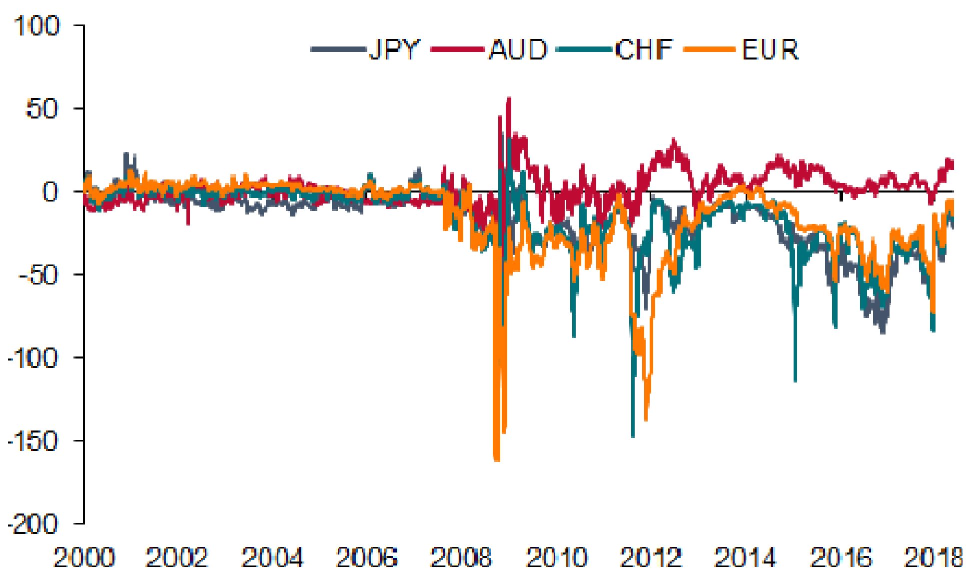
[11] A forward is a contract to exchange two currencies at a future date and price, agreed at time t. It is usually collateralized which is why default on the forward contract can induce market risk.

$$\frac{F_{t,m}}{S_t}(1 + r^*_{t,m}) > (1 + r_{t,m} + b)$$

an arbitrageur (based outside of Mexico) would borrow US dollars at the cost $r_{t,m}$, swap these for Mexican peso at the spot market exchange rate S_t,[12] buy $S_t MXN$ worth of cetes at $r^*_{t,m}$. This will thus earn $(1 + r^*_{t,m})S_t MXN$. The arbitrageur covers the exchange rate risk by buying from a dealer a forward contract $F_{t,m}$. The arbitrageur at maturity thus receives $(1 + r^*_{t,m})\frac{S_t}{F_{t,m}}USD$, and repays $(1 + r_{t,m})USD$. Arbitrage will continue as long as this is profitable, pushing returns in the two currencies closer to parity.[13]

CIP deviations can be measured in various ways, derived from the above equation. Using observed prices in the spot and forward markets, one can back out the implied domestic interest rate in the forward market and compare this to the observed interest rate on a zero-risk domestic government security. The cross-currency US dollar basis, for 3-month tenor, for four developed market currencies is plotted in Figure 1. After the global financial crisis, the Japanese yen and Euro bases have been consistently negative, whereas the Australian dollar basis has been positive. These are four of the 10 currencies that have been studied in the recent literature.

Figure 1: CIP deviations for 4 developed economy currencies, basis points



CIP deviations measured as the Forward market implied interest rate minus the interest rate on a government security. Source: Bloomberg, Banco de México.

For the USD/MXN exchange rate,[14] as seen in Figure 2, the differential between the for-

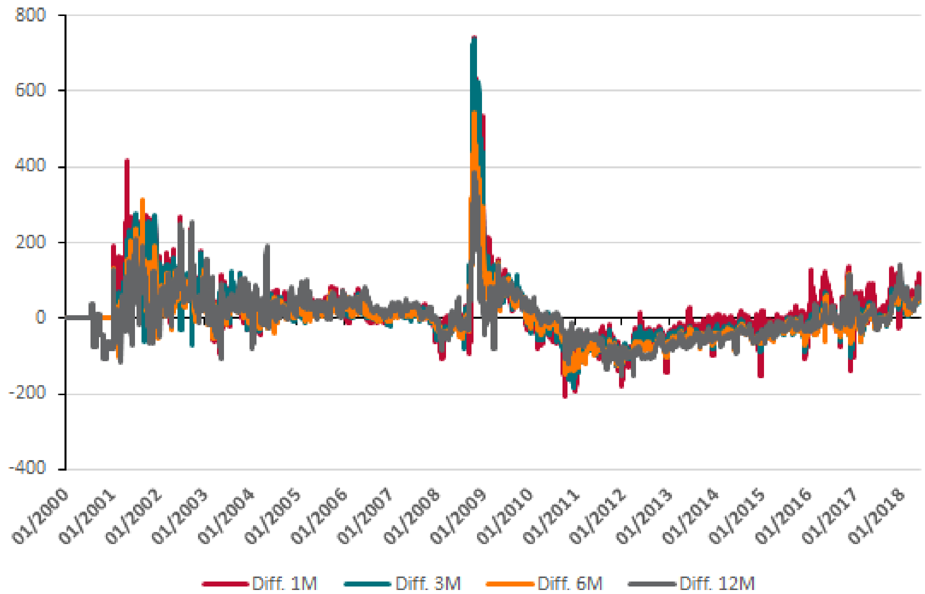
[12]Where the spot exchange rate is defined as MXN/USD, in other words, the number of US dollars per 1 Mexican peso.

[13]How close to parity the returns will be, is the subject of research dating back to the earlier part of the 20th century as discussed in Levich (2017). Estimates from the 1960s of how wide the CIP deviation needed to be to induce arbitrage ranged from 0.25% to 0.06%. Current anecdotal estimates are around 40-60 basis points.

[14]Note where 1 US dollar = x Mexican pesos.

ward market implied rate and the observed risk free rate post crisis was persistently negative from 2010 until around 2016. The spread for different maturities tend to move together, although there are periods early in the sample where the 12-month and 6-month seem to move in opposite directions to the shorter maturities.

Figure 2: CIP deviations for USD/MXN for 1, 3, 6, and 12 month maturities, basis points



CIP deviations measured as the cross currency basis with the US dollar, the Forward market implied interest rate minus the interest rate on a government security. Source: Bloomberg, Banco de México.

2.1 Determinants of CIP deviations

Small deviations from covered interest parity have been explained by bid/ask spreads in the foreign currency markets.[15] At shorter maturities this spread may be a proxy for transaction costs, at longer maturities it may account for market liquidity. In addition to transaction costs, funding costs for would-be arbitrageurs have been emphasized.[16] For example, financial firms such as hedge funds may use repo markets to fund their arbitrage activities in foreign markets. Thus as modeled in Borio et al. (2016b), tighter relative repo funding conditions may deter arbitrage and prevent the interest rate differential from closing.

However, other less easily quantifiable factors post crisis may be affecting economic agents participation and behavior, and consequently interest parity conditions. Compliance with banking regulations implemented after the global financial crisis increases the cost of

[15]For example see Akram et al. (2008).

[16]See Boyarchenko et al. (2018), Duffie (2017), Rime et al. (2017). In addition, Hernandez (2014) studies the Mexican case in particular and shows how US and European funding liquidity conditions relate to the Mexican peso-US dollar foreign exchange markets.

deploying the balance sheet and may prompt some players to exit certain activities altogether. Internal risk management procedures, including concentration limits, liquidity management, and trading protocols, may have also evolved, altering the covered interest parity relation.

The literature has emphasized two types of measurable risks as constraints on arbitrage activity: counterparty risk and market risk. Counterparty risk in the interbank market escalated rapidly during the Global Financial Crisis. In particular, this led to US dollar funding constraints as highlighted in Ivashina et al. (2015). As such, counterparty risk has become part of the arbitrage trade assessment. However since the crisis, the magnitude of this risk factor has decreased markedly as banks have taken measures to strengthen their balance sheets. Also regulators have encouraged standardizable contracts to move to central clearing, facilitating a shift from currency forwards which are over the counter, to futures, which are centrally cleared and require margin to be posted. A common measure of counterparty risk in the interbank market is the spread between LIBOR equivalent and the Overnight Indexed Swap. Market risk affects the value of foreign exchange collateral via unexpected exchange rate movements. Mark to market practices and supervisory pressure have highlighted market risk for FX collateral. In general, higher volatility can signal higher levels of uncertainty and expected risk. Both these factors affect currency contracts and pricing has evolved to reflect these risks. Also, if a counterparty defaults on a collateralized forward contract, the collateral will be valued at the current market price. Thus counterparty and market risk interact.

In an era of financial globalization, and capital flows in an environment of low developed economy interest rates, cross-currency flows are inducing foreign currency hedging demand. Related to this paper's focus, Borio et al. (2016b) show that shocks to exogenous FX hedging demand—from three main sectors: banks, institutional investors (like pension funds), and corporates—drive CIP deviations. They provide time series econometric evidence that hedging demand has an effect in the US dollar-Japanese yen foreign exchange markets at the 3-month and 2-year maturity. At the shorter tenor, hedging demand only has an effect when interacted with arbitrageur balance sheet constraint variables (including counterparty and market risk). In contrast, hedging demand directly affects the CIP deviation at the longer maturity.

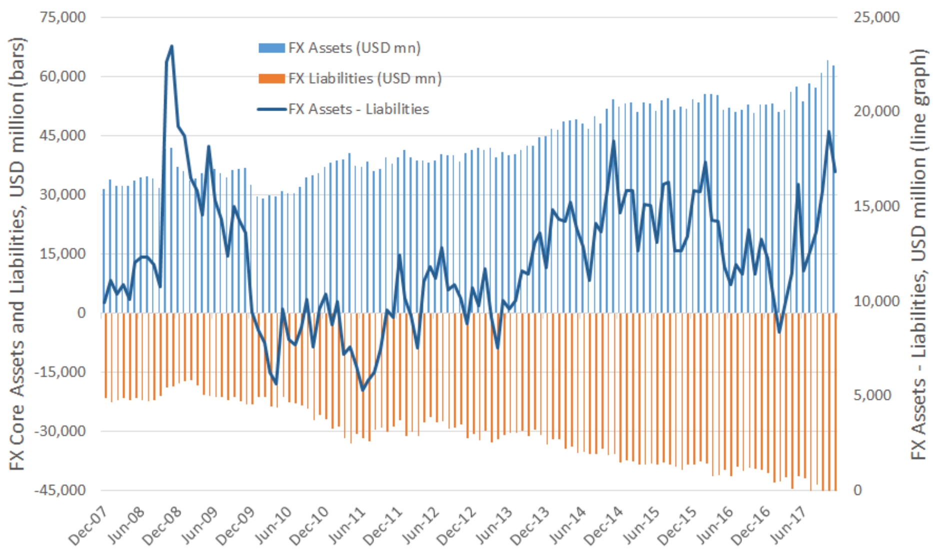
This paper will focus on hedging demand in the US dollar-Mexican peso foreign exchange markets at relatively short maturities, up to 1 year, and the econometric model will include controls for the variables highlighted in the literature.[17] The two sources of business model driven hedging demand under analysis are 1. domestic bank demand driven by balance sheet currency mismatch, and 2. foreign demand, driven by international capital flows into peso denominated assets.

[17]Future work will examine the peso market at the longer end. Other research on longer term hedging demand and foreign debt positions includes Klingler and Sundaresan (2018) and Borio et al. (2017).

3 Data and Initial Analysis

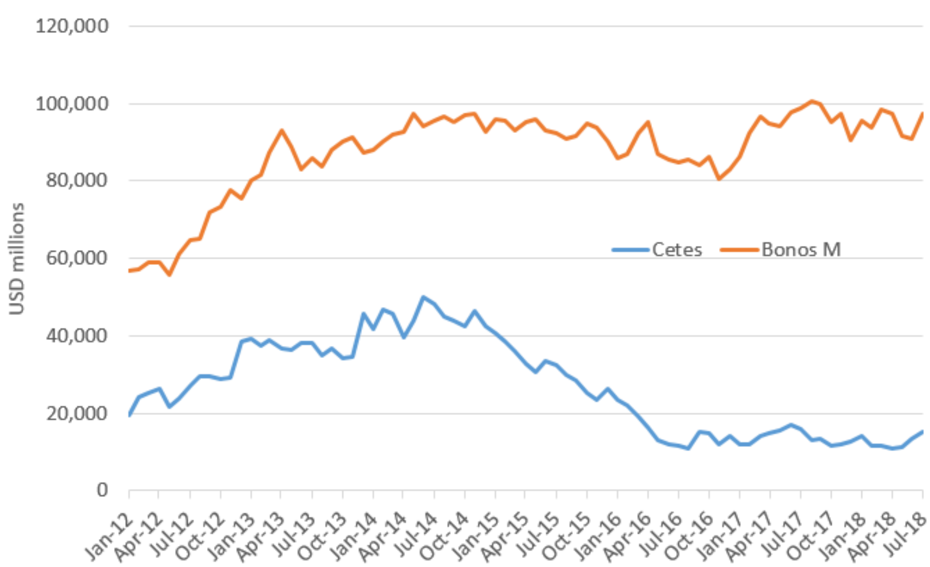
With respect to bank hedging demand, Figure 3 shows the foreign currency denominated balance sheet of the Mexican banking system. Note that foreign currency core assets (blue) are greater than foreign currency core liabilities (orange). The gap (blue line) varies from around USD7bn to USD20bn over the period of interest. Data is the value at the end of each month, unless noted otherwise.

Figure 3: FX balance sheet of commercial banks in Mexico (USD millions, month-end)



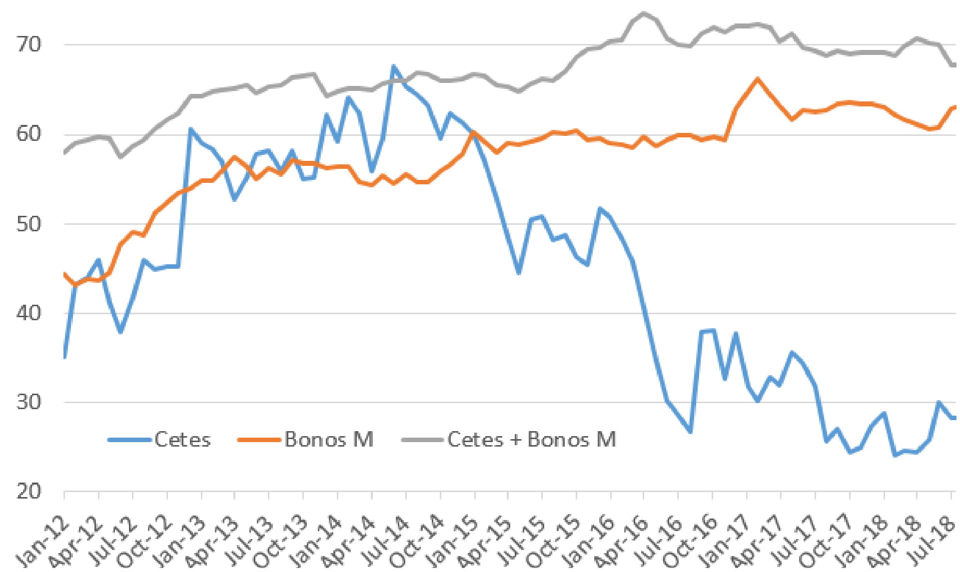
System wide balance sheet constructed using individual bank level data.
Source: Comisión Nacional Bancaria y de Valores (CNBV), Banco de México.

Figure 4: Foreign holdings of Mexican local currency bonds, USD millions, month-end



Total foreign holdings of Mexican local currency bonds. Source: Banco de México.

Figure 5: Foreign holdings of Mexican local currency bonds, % of total, month-end



Total foreign holdings as a percent of total outstanding. Source: Banco de México.

With respect to hedging demand for non-Mexican investors, Figure 4 charts the month-end foreign holdings of Mexican local currency bonds of up to 1-year maturity (cetes), and for longer maturities (bonos). One can see that foreign holdings of peso denominated bonds overall have been rising, although shorter maturities (cetes) rose from 2012 and began declining in 2015. Foreigners continue to hold a large portion of outstanding local currency bonds, totalling around 70%, see Figure 5. Using supervisory data on derivatives transactions, actual hedging behavior is observed via foreign exchange derivatives contracts by counterparty. Figure 6 plots the Mexican banking system's net derivatives transactions involving foreign exchange, by counterparty.

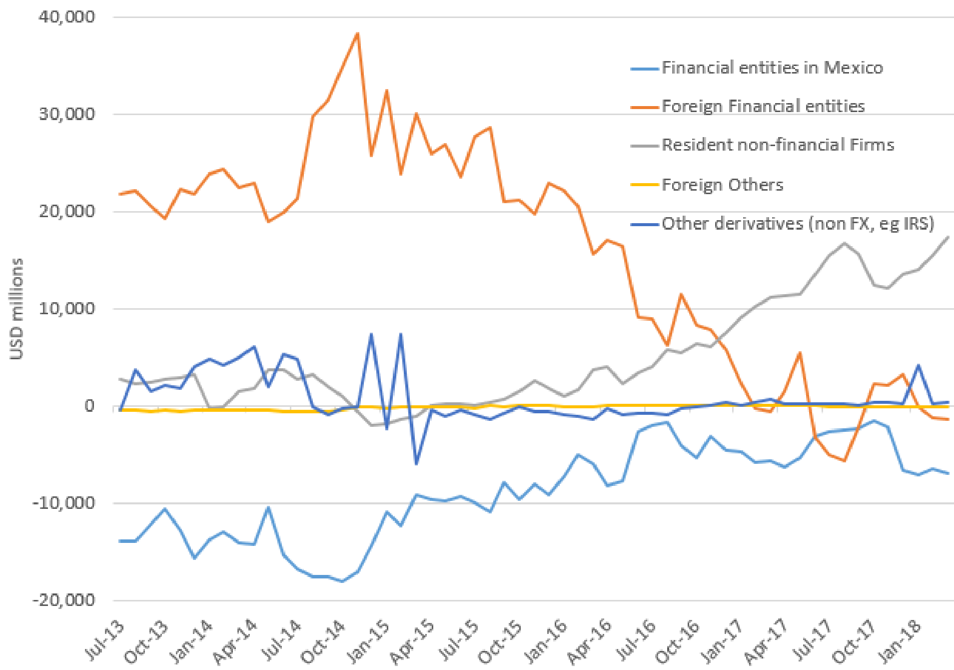
3.1 CIP Deviations Data

The sample period for the regression analysis covers July 2013 to November 2017. CIP deviations are calculated using Bloomberg data. Using principal component analysis on the CIP deviations[18](negative of the basis) for the four different cetes maturities, Figure 7 shows that the first principal component (explaining 86% of the joint variation in the bases) is persistently different from 0.[19]

[18]The negative of the basis (the Mexican peso risk free rate (cetes) minus the forward market implied interest rate) was used for ease of comparison with the bank balance sheet FX funding gap in Figure 9.

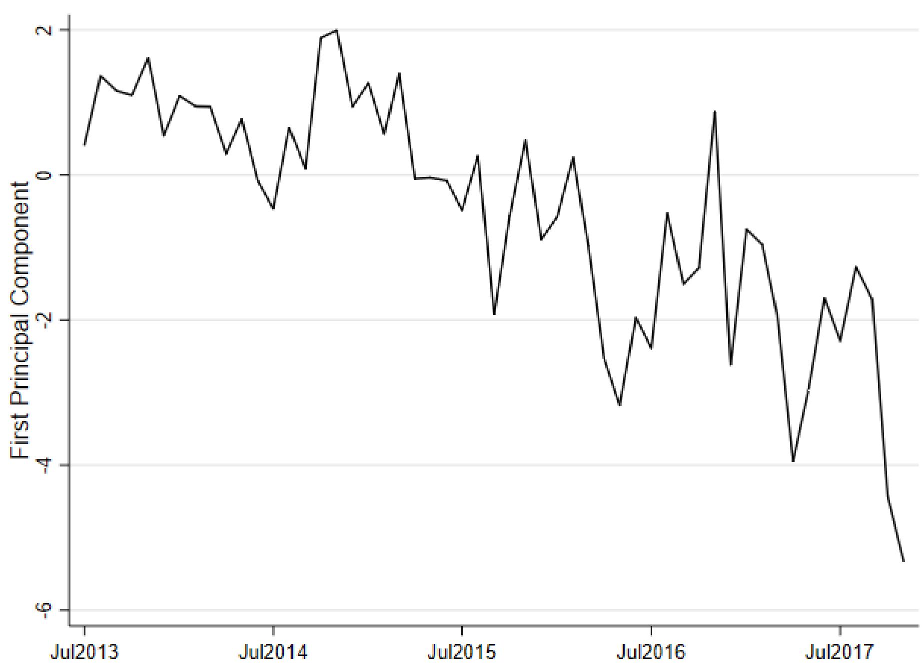
[19]The overall Kaiser-Meyer-Olkin measure of sampling adequacy scored 0.7070, slightly higher than the score when using daily data.

Figure 6: Mexican banking system's foreign exchange derivatives, counterparty, month-end



System wide balance sheet constructed using individual bank level data.
Source: Comisión Nacional Bancaria y de Valores (CNBV), Banco de México.

Figure 7: 1st principal component of CIP deviations for 1, 3, 6, and 12 month maturities



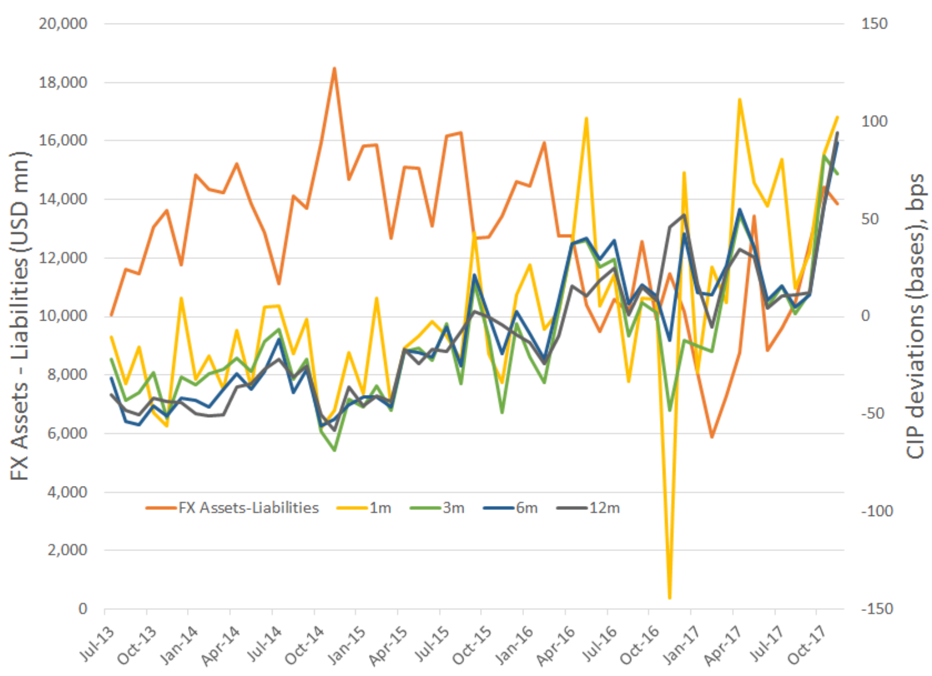
The plot uses the negative of the principal component of the bases.
Source: Bloomberg, Banco de México.

3.2 Bank Hedging Demand

Domestic regulations on currency mismatch have been in place in Mexico since the early 1990s. Banks are required to hedge their dollar assets according to the following rule: $|A_{USD} - L_{USD}| < 15\% * T1Capital$. And, banks must hold enough liquid foreign currency assets.[20] However, from inspecting Mexican regulatory data on daily positions, banks are far from this constraint and thus seem to manage foreign currency funding more conservatively than the regulation threshold.

I assume that management of the foreign funding gap is the dominant hedging motive for banks in Mexico and use foreign currency core assets net of core liabilities as a proxy for Mexican bank demand for US dollar hedging. Using bank filing data from the banking authority Comisión Nacional Bancaria y de Valores (CNBV), monthly balance sheet data has been compiled for the Mexican banking system as a whole for the period July 2013 to November 2017. Figure 8 plots the banking sector foreign funding gap and the four Mexican peso - US dollar bases.

Figure 8: CIP deviations (bases) vs. bank FX funding gap (USD bn)

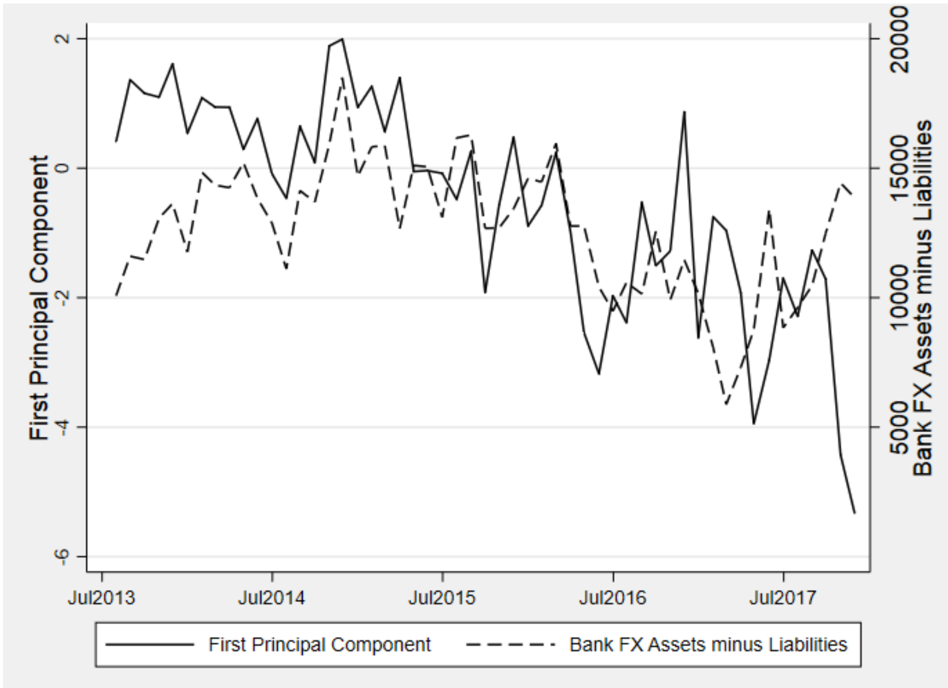


The plot compares the dynamics of the bases to the bank hedging demand variable.
Source: Bloomberg, Comisión Nacional Bancaria y de Valores (CNBV), Banco de México.

Using the first principle component, Figure 9 plots the Mexican banking system balance sheet currency mismatch with the first principal component of the four different spreads plotted as the negative of the bases.

[20] Liquid assets include FX deposits, US Treasuries, Central Bank deposits, and highly rated short-term securities (which are preferred because of their non-zero yield).

Figure 9: PC of CIP deviations versus Mexican banking system currency mismatch



The plot uses the negative of the principal component of the bases.
Source: Bloomberg, Comisión Nacional Bancaria y de Valores (CNBV), Banco de México.

3.3 Foreign Hedging Demand

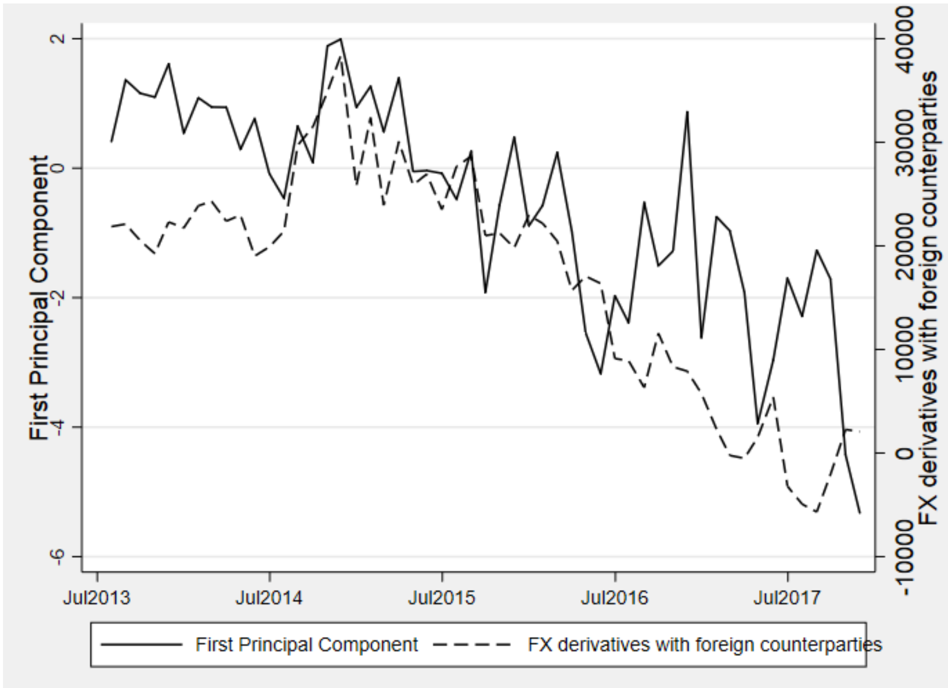
Search for yield by institutional investors has driven the development of new investment products and intermediation channels. Foreign investor appetite for local currency bond holdings rises as these domestic markets develop. Global asset management companies can offer mutual funds with diversified local currency fixed income portfolio opportunities. I assume that the dominant motive for these foreigners is to hedge some portion of their peso denominated investments.

Using daily derivatives transactions data from Banxico, I have compiled monthly net transactions data for the Mexican banking system for the period July 2013 to November 2017. I use the foreign counterparty foreign exchange derivatives transactions data as a measure for foreign FX hedging demand. The bulk of foreign counterparty foreign exchange derivatives transactions are with foreign financial entities.

Figure 10 plots the amount of FX derivatives with foreign counterparties (liabilities net of assets) against the first principal component of the four different spreads. The graph suggests a relationship between the hedging demand measure and the interest rate differentials.[21]

[21] See Table 8 in the Appendix for Summary Statistics for the sample period.

Figure 10: PC of CIP deviations versus foreign FX hedging



The plot uses the negative of the principal component of the bases.
Source: Bloomberg, Comisión Nacional Bancaria y de Valores (CNBV), Banco de México.

4 Regression Analysis

4.1 Exogenous Hedging Needs

To test whether the domestic banking sector's foreign currency funding gap and foreign hedging needs affect the deviations from covered interest parity, I estimate the following econometric model:

$$b_t = \alpha + \beta_1 FXBidAsk_t + \beta_2 RelRepo_t + \beta_3 \theta_t + \beta_4 \sigma_t + \beta_5 Hedge_t + \epsilon_t \quad (1)$$

The first two terms are proxies for transaction costs and relative funding conditions in US dollar and Mexican peso repo markets. Higher transaction costs and tighter funding conditions in US repo relative to Mexican repo are expected to deter arbitrage and widen the basis ($\beta_1 < 0$ and $\beta_2 < 0$).[22] Incorporating additional factors highlighted in the more recent literature, I include counterparty risk (θ) and market risk (σ) for foreign currency collateral. Both factors are expected to deter arbitrage (because they represent costs to deploying arbitrageur balance sheets) and prevent narrowing of the CIP deviation ($\beta_3 < 0$ and $\beta_4 < 0$). To proxy for counterparty risks in the interbank market, I use the spread between Mexican LIBOR (TIIE) and OIS. I use the options implied FX volatility to proxy for market risk. These are

[22] Mexican repo is only overnight, therefore I use the same relative repo measure for all four maturities.

proxies used in the literature.[23]

The final term, $Hedge$, is the proxy for either domestic bank hedging needs or foreign hedging needs. The hypothesis is that exogenous hedging demand (domestic and foreign) is a proximate determinant of the CIP deviations. The alternative is that on its own, this factor has no explanatory power. The sample comprises monthly data for July 2013 to November 2017.

There may be some part of these foreign counterparty FX derivatives transactions that are endogenous to the CIP deviation. To address this issue econometrically, I instrument for foreign hedging demand using appropriately lagged values of the FX derivatives transactions with foreigners variable. Table 9 in the Appendix demonstrates that the 3rd lagged value and beyond, satisfy the exclusion restriction requirement. Using the third lag alone, the regression model weakly passes endogeneity tests. Using more than two lags results in failing overidentification tests. Consequently, I use two lags, the 3rd and 4th lags, as instruments for the contemporaneous value. This specification passes the endogeneity test with p-values of 0.24 (the null is exogeneity).

Table 2: Hedging needs direct effect on 3-month CIP deviation

	Dependent variable: CIP deviations (basis, 3m)					
	(1)	(2)	(3)	(4)	(5)	(6)
Transaction Cost	-0.164*	-0.201*	-0.112	-0.166	-0.128	0.0715
	(0.0981)	(0.102)	(0.109)	(0.115)	(0.0962)	(0.114)
RelRepoFF	-0.122	-0.0118	-0.0961	-0.00667	-0.0430	-0.102
	(0.109)	(0.117)	(0.119)	(0.121)	(0.115)	(0.103)
Libor_OIS 3M		-0.248*		-0.225*	-0.225**	-0.150
		(0.130)		(0.133)	(0.111)	(0.122)
FX Implied Vol.			0.148	0.0871	-0.0634	-0.109
			(0.122)	(0.116)	(0.109)	(0.139)
Hedge, Dom. Bank					-0.344***	
					(0.125)	
Hedge, For. Fin.						0.771***
						(0.184)
Observations	53	53	53	53	53	49
Adjusted R^2	0.019	0.053	0.017	0.039	0.121	.
F	4.135	6.591	3.331	4.993	5.683	.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

Hegde, For. Fin. is instrumented by its 3rd and 4th lags, passing exogeneity tests.

Table 2 reports the estimation results for the 3-month maturity, the tenor typically analysed in the literature on short-term CIP deviations. In column (1), the standard CIP deviations

[23] All variables have been standardized (0 mean and variance of 1) to allow for ease of interpretation of the coefficient estimates β. A 1 standard deviation change in the covariate X, induces a β times standard deviations change in the CIP deviation.

variables are included. Columns (2) - (6) include the additional regressors. The coefficient on the bid/ask spreads in the forward and spot FX markets (Transaction Cost) is correctly signed (higher transaction costs drive the (negative) basis wider) and statistically significant in two of the regression specifications. Counterparty risk (Libor-OIS, θ) is also correctly signed (higher counterparty risk, wider CIP deviation) and statistically significant in all the specifications.[24] In contrast, there is no evidence that relative repo funding or market risk (FX Implied Volatility, σ) on their own are key drivers of the 3-month CIP deviation. Both hedging variables have coefficient estimates with the correct signs (domestic USD hedging demand widens the negative basis, foreign peso hedging narrows the basis), and are statistically significant.

Table 3: Bank hedging needs direct effect on CIP deviations

	basis, 1m	basis, 3m	basis, 6m	basis, 12m
	(1)	(2)	(3)	(4)
Hedge, Dom. Bank	-0.308***	-0.344***	-0.308***	-0.136
	(0.108)	(0.125)	(0.110)	(0.0858)
Transaction Cost	-0.201*	-0.128	-0.211**	0.0664
	(0.113)	(0.0962)	(0.100)	(0.0943)
RelRepoFF	0.0163	-0.0430	-0.0694	0.0540
	(0.113)	(0.115)	(0.106)	(0.0635)
Libor_OIS	-0.0606	-0.225**	0.0280	-0.123
	(0.0828)	(0.111)	(0.161)	(0.0858)
FX Implied Vol.	-0.0759	-0.0634	0.196	-0.121
	(0.120)	(0.109)	(0.156)	(0.0988)
Observations	53	53	53	52
Adjusted R^2	0.041	0.121	0.242	0.023
F (5, 47)	2.193*	5.683*	12.43*	1.115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

a. The first difference is used for the 12month basis to correct a unit root.

Tables 3 and 4 report results for all four cetes maturities, showing the estimated direct effect of Mexican banking system or foreign hedging demand on covered interest parity deviations during this time period.

The coefficient estimates on the banking FX funding gap variable are statistically significant for three out of four of the maturities.The estimates range from -0.308 to -0.344. The interpretation is that domestic bank hedging needs (to create USD liabilities, i.e. hedge USD assets) widen the basis, a 1 standard deviation increase in domestic bank hedging needs

[24]Given that the dependent variable contains information from Mexican LIBOR (TIIE), I conduct the Durbin-Wu-Hausman augmented regression test to check whether endogeneity problems arise when using the TIIE-MXNOIS spread as a regressor. The test result shows no evidence of inconsistency: the p-value for the coefficient on the first equation residuals are all high: Table 2 Column (2) 0.55, Column (4) 0.58, Column (5) 0.58, Column (6) 0.48, thus rejecting the null of endogeneity.

Table 4: Foreign investor hedging needs direct effect on CIP deviations

	basis, 1m (1)	basis, 3m (2)	basis, 6m (3)	basis, 12m (4)
Hegde, For. Fin.	0.596***	0.771***	0.738***	0.0327
	(0.151)	(0.184)	(0.181)	(0.137)
Transaction Cost	-0.0865	0.0715	0.0287	0.0477
	(0.103)	(0.114)	(0.101)	(0.0988)
RelRepoFF	0.0380	-0.102	-0.0107	0.0600
	(0.110)	(0.103)	(0.0800)	(0.0591)
Libor_OIS	-0.0347	-0.150	-0.134	-0.143
	(0.0696)	(0.122)	(0.113)	(0.0949)
FX Implied Vol.	-0.107	-0.109	0.111	-0.105
	(0.127)	(0.139)	(0.118)	(0.113)
Observations	49	49	49	49
Root Mean Sqrd. Error	0.858	0.754	0.629	0.475

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

Hegde, For. Fin. is instrumented by its 3rd and 4th lags.

a. The first difference is used for the 12month basis to correct a unit root.

(around USD2.6bn), widens the 3-month CIP deviation by an estimated 0.344 of a standard deviation (about 11 basis points). Table 4 reports results showing estimates for the effect of foreign hedging demand. These are more precisely estimated and of greater magnitude, ranging from 0.596 to 0.771. Thus when the basis is negative, foreign hedging needs narrow the CIP deviation (make it more positive). A 1 standard deviation increase in foreign hedging transactions (around USD11.2bn), narrows the 3-month CIP deviation by an estimated 0.771 of a standard deviation (about 26 basis points)

Results for the three shorter maturities are broadly similar, both hedging variables have a statistically significant direct effect on the interest rate differential, with the foreign hedging effect stronger. However, for the 12-month maturity, the estimated effect of hedging needs are not statistically different from 0. This could be because Mexican LIBOR is not available at a 12-month tenure, and as such a direct measure of counterparty risk is not available. Instead the 6-month counterparty risk measure is used as a proxy in this regression. There may also be different dynamics that affect the 12-month maturity.[25]

With regards to the other covariates, the results are mixed. In the foreign hedging regression, Table 4, the additional covariates are not significant and only the estimated coefficient on counterparty risk is correctly signed for all four maturities. In the bank hedging regression, Table 3, estimates of the effect of bid/ask spreads in the forward and spot FX markets (Transaction Costs) have negative coefficients (as expected) and are statistically significant

[25] The first difference of the 12-month CIP deviation is used as the dependent variable, since stationarity tests showed the presence of a unit root.

for the 1 and 6 month maturities. Counterparty risk (LIBOR-OIS, θ) is correctly signed for 1, 3 and 12 month tenors, however the coefficient estimate is only statistically significant at the 3-month maturity.[26] Similarly, implied volatility (market risk, σ) has an estimated widening effect for 1, 3 and 12 month tenors, as expected, but this is not statistically significant. This suggests that variables that are important for developed market currency markets may not be the key factors in the peso market, and that the 12-month maturity has distinct dynamics from the shorter maturities.

The hedging demand result discussed above is different from Borio et al. (2016b) who find that for the short maturity (3 month) Japanese yen - US dollar CIP deviations, hedging demand affects the CIP deviation only when interacted with the balance sheet cost variables. The hedging demand variable directly affects the JPY/USD CIP deviation only at the 2-year maturity. For the Mexican peso, the above results show hedging needs have the direct effect at the shorter maturities.

4.2 Arbitrage Constraints Interaction with Hedging Needs

Tables 5 and 6 report estimation results for regressions that include interaction terms between the $Hedge$ variable and arbitrageur balance sheet cost variables (counterparty risk and market risk). Transaction costs and relative funding conditions have the expected signs, although they are not statistically significant. The estimated coefficients on the two hedging demand variables are signed as expected and remain statistically significant in all the regressions.

With respect to balance sheet variables, the estimated coefficients on counterparty risk (LIBOR-OIS) and market risk (FX Implied Volatility) are correctly signed in all the regressions. However the interaction terms with hedging demand have different importance for the two different hedge variables. For domestic bank hedging demand, counterparty risk is significant on its own, but has no amplifying effect. For market risk it is the opposite, the variable has no direct estimated effect but does interact with domestic bank FX hedging demand. For the case of foreign FX hedging demand, the results imply that counterparty risk amplifies the effect of foreign hedging demand, but market risk is insignificant. The triple interaction term between hedging demand and the two balance sheet variables is not statistically significant in either case. These results corroborate the earlier regressions in Table 2 for the 3 month tenor showing counterparty risk is important, and provide evidence that market risk is actually important when interacting with domestic bank hedging demand, although it is not clear how to interpret the positive sign on the interaction between bank hedging demand and FX Implied volatility.

[26]This complements evidence in Hernandez (2014) that LIBOR-OIS spreads are important for Mexican CIP deviations.

Table 5: Domestic bank hedging interaction with balance sheet cost variables

	Dependent variable: CIP deviations (basis, 3m)				
	(1)	(2)	(3)	(4)	(5)
Transaction Cost	-0.128	-0.116	-0.131	-0.127	-0.142
	(0.0962)	(0.0995)	(0.0939)	(0.101)	(0.0993)
RelRepoFF	-0.0430	-0.0674	-0.0370	-0.0711	-0.0338
	(0.115)	(0.122)	(0.109)	(0.125)	(0.110)
Libor_OIS 3M	-0.225**	-0.257*	-0.242**	-0.227	-0.214
	(0.111)	(0.152)	(0.109)	(0.167)	(0.137)
FX Implied Vol.	-0.0634	-0.0779	-0.0713	-0.0919	-0.0778
	(0.109)	(0.107)	(0.0937)	(0.107)	(0.0951)
Hedge, Dom. Bank	-0.344***	-0.361***	-0.382***	-0.323**	-0.353**
	(0.125)	(0.117)	(0.107)	(0.148)	(0.135)
Hedge*LIBOR-OIS		-0.0778		-0.104	
		(0.129)		(0.128)	
Hedge*FX Implied Vol.			0.255***		0.259***
			(0.0510)		(0.0525)
Triple Interaction				0.0840	0.0578
				(0.147)	(0.111)
Observations	53	53	53	53	53
Adjusted R^2	0.121	0.109	0.174	0.093	0.158
F	5.683***	5.405***	12.48***	4.880***	14.15***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

Sigma = σ = FX Implied Volatility, Theta = θ = Libor-OIS.

Table 6: Foreign hedging interaction with balance sheet cost variables

	Dependent variable: CIP deviations (basis, 3m)				
	(1)	(2)	(3)	(4)	(5)
Transaction Cost	0.0715	0.0451	0.0451	0.0507	0.0492
	(0.114)	(0.115)	(0.117)	(0.122)	(0.127)
RelRepoFF	-0.102	-0.102	-0.108	-0.0617	-0.0956
	(0.103)	(0.106)	(0.107)	(0.112)	(0.113)
Libor_OIS 3M	-0.150	-0.143	-0.149	-0.211*	-0.171
	(0.122)	(0.106)	(0.119)	(0.113)	(0.120)
FX Implied Vol.	-0.109	-0.109	-0.111	-0.0507	-0.0917
	(0.139)	(0.134)	(0.132)	(0.144)	(0.153)
Hedge, For. Fin.	0.771***	0.759***	0.746***	0.792***	0.756***
	(0.184)	(0.169)	(0.195)	(0.182)	(0.212)
Hedge*LIBOR-OIS		-0.281**		-0.360**	
		(0.132)		(0.155)	
Hedge*FX Implied Vol.			-0.165		-0.164
			(0.135)		(0.139)
Triple Interaction				0.293	0.0927
				(0.299)	(0.264)
Observations	49	49	49	49	49
Root Mean Sqrd. Error	0.754	0.727	0.743	0.719	0.743

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

Hegde, For. Fin. is instrumented by its 3rd and 4th lags.

4.3 Emerging Market Risk

It may be the case that the pricing of emerging market sovereign bonds used in an arbitrage strategy does not capture fully their riskiness. One independent measure of creditworthiness is the CDS spread for the bond, a market price for the cost of default insurance. The buyer of CDS does not have to own the underlying bond, so the CDS captures a broad set of market participants perceptions. Table 7 reports estimation results including the most commonly traded Mexican CDS spread and Emerging Market CDS spread.[27] The estimated coefficients are the correct sign (a wider spread is associated with a wider basis), however the CDS spreads are not statistically significant. The model that includes only the Mexican CDS spread (column (4)) has slightly better global statistics, but the estimated coefficient on the Mexican CDS spread is not statistically different from 0.

Table 7: Hedging needs direct effect on CIP deviations, with CDS

	Dependent variable: CIP deviations (basis, 3m)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Transaction Cost	-0.128	0.0715	-0.183	-0.166	-0.200	-0.130	0.0680
	(0.0962)	(0.114)	(0.120)	(0.114)	(0.122)	(0.101)	(0.115)
RelRepoFF	-0.0430	-0.102	-0.0115	-0.0406	0.0325	-0.0285	-0.0718
	(0.115)	(0.103)	(0.144)	(0.121)	(0.131)	(0.131)	(0.121)
Libor_OIS 3M	-0.225**	-0.150	-0.206	-0.190	-0.236*	-0.224*	-0.187
	(0.111)	(0.122)	(0.143)	(0.130)	(0.133)	(0.122)	(0.130)
FX Implied Vol.	-0.0634	-0.109	0.1000	0.109	0.0841	-0.0509	-0.148
	(0.109)	(0.139)	(0.118)	(0.118)	(0.117)	(0.114)	(0.145)
Hedge, Dom. Bank	-0.344***					-0.336**	
	(0.125)					(0.145)	
Hedge, For. Fin.		0.771***					0.811***
		(0.184)					(0.200)
D.Mexico CDS			-0.240	-0.350		-0.0166	0.268
			(0.359)	(0.224)		(0.409)	(0.347)
D.EM CDS			-0.131		-0.276	-0.101	-0.0557
			(0.340)		(0.216)	(0.321)	(0.213)
Observations	53	49	52	52	52	52	49
Adjusted R^2	0.121	.	0.023	0.041	0.038	0.088	.
F	5.683	.	3.653	4.513	3.771	3.944	.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.

Hegde, For. Fin. is instrumented by its 3rd and 4th lags.

[27] The most commonly contracted credit default swap is for a 5-year maturity.

5 Conclusion

This paper analyzes the Mexican peso FX markets, in particular documenting persistent CIP deviations at tenors of up to 12 months. Regression analysis, using monthly data for July 2013 to November 2017, asks whether hedging needs by domestic banks and foreigners had an effect on the CIP deviations, either directly or via interactions with arbitrageur balance sheet constraints. I find that the FX funding gap of the domestic banking system has a direct impact on the Mexican peso - US dollar CIP deviations. There is also evidence that foreign hedging also has a direct and significant impact. These effects are robust to including variables proposed in the CIP literature such as bid/ask spreads, funding costs and measures of counterparty and market risk, as well as CDS spreads. However, interacting hedging demand and arbitrageur balance sheet cost variables (counterparty and market risk) gives mixed results, suggesting arbitrage constraints may not be a key factor in the US dollar - Mexican peso market.

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6 Appendix

Table 8: Summary statistics for regression analysis variables

	count	mean	standard deviation	min	max
Basis, 1m	53	1.849434	46.60147	-144.1	111.15
Basis, 3m	53	-11.07302	32.40309	-68.69	82.15
Basis, 6m	53	-8.060755	34.52957	-55.92	88.89
Basis, 12m	53	-10.00283	33.15115	-58.44	94.28
Hedge, Dom. Bank	53	12685.92	2577.703	5877	18492
Hedge, For. Fin.	53	-16839.57	11211.25	-38354	5684
RelRepoFF	53	.0932076	.1804777	-.6999999	.3800001
Transaction Costs, 1m	53	-.019717	.0178243	-.0699997	0
Transaction Costs, 3m	53	-.0242453	.0227527	-.1049995	0
Transaction Costs, 6m	53	-.0264152	.0241067	-.1050005	-.0049996
Transaction Costs, 9m	53	-.0274528	.0234238	-.1049995	-.0049996
Transaction Costs, 12m	53	-.0284907	.0235867	-.1049995	-.0049996
LIBOR-OIS, 1m	53	.0103189	.0593938	-.0124002	.4042001
LIBOR-OIS, 3m	53	-.0209434	.053266	-.243	.125
LIBOR-OIS, 6m	53	-.0238057	.0765594	-.2999997	.1199999
FX Implied Vol., 1m	53	11.63509	2.92992	6.02	21.89
FX Implied Vol., 3m	53	11.86245	2.477982	6.91	18.43
FX Implied Vol., 6m	53	12.10208	2.111715	7.49	16.21
FX Implied Vol., 12m	53	12.55132	1.774412	8.42	15.9
CDS_EM	53	278.6849	57.64491	174.364	403.094
CDS_MEX	53	125.6359	33.72226	67.82	198.221

Summary statistics for regression analysis variables.

Table 9: Exclusion restriction for
FX derivatives with Foreign counterparty

	Dependent variable: CIP deviations (basis, 3m)				
	(1)	(2)	(3)	(4)	(5)
RelRepoFF	-0.0956	-0.0996	-0.0838	-0.107	-0.0697
	(0.0957)	(0.0975)	(0.0986)	(0.115)	(0.110)
Transaction Cost	0.0410	0.0293	0.0418	0.0450	0.0393
	(0.0950)	(0.0936)	(0.108)	(0.118)	(0.114)
Libor_OIS 3M	-0.196**	-0.163*	-0.172	-0.162	-0.149
	(0.0926)	(0.0944)	(0.123)	(0.127)	(0.132)
FX Implied Vol.	-0.0889	-0.0568	-0.0567	-0.0532	-0.0728
	(0.0993)	(0.103)	(0.127)	(0.122)	(0.125)
Hedge, For. Fin.	0.217	0.221	0.355*	0.490**	0.698***
	(0.219)	(0.225)	(0.181)	(0.203)	(0.191)
L.1	0.489*				
	(0.248)				
L.2		0.487*			
		(0.272)			
L.3			0.374		
			(0.232)		
L.4				0.214	
				(0.272)	
L.5					-0.0660
					(0.226)
Observations	52	51	50	49	48
Adjusted R^2	0.427	0.430	0.415	0.387	0.372
F	10.75	10.36	8.853	8.027	7.650

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. HAC robust standard errors.