Pontifícia Universidade Católica
do Rio de Janeiro

Raphael de Oliveira Vasconcelos

Macroeconomic and regulatory drivers of CIP deviations

Dissertação de Mestrado

Dissertation presented to the Programa de Pós–graduação em Economia of PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Economia.

Advisor: Prof. Márcio Gomes Pinto Garcia

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Abstract

Vasconcelos, Raphael de Oliveira; Garcia, Márcio Gomes Pinto (Advisor). **Macroeconomic and regulatory drivers of CIP deviations**. Rio de Janeiro, 2022. 57p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Covered Interest Parity deviations (CIP) have been large and persistent among G10 currencies since the global financial crisis in 2008. One of the explanations for the CIP condition breakdown are the new banking regulations that arose in the post-crisis period. On the other hand, CIP deviations for the Brazilian economy have been associated with the EMBI+ index, which is a measure of country risk, as in Garcia and Didier (2003). Building on the recent literature on Covered Interest Parity deviations (i.e, the currency basis) among G10 currencies, I show the recent evolution of the cross-currency basis for the G10 economies, during the 2020 pandemic crisis, and then I study the macroeconomic and regulatory drivers of the Brazilian currency basis. Using the regression approach of Cerutti et al (2021), I find that the FX bid-ask spread has a prominent effect on the real/dollar basis. Using a difference-in-differences approach, I find that the Brazilian currency basis rises at quarter-ends, which is the period when forward contracts appear on banks' balance sheets. This points to a causal effect of banking regulation on the currency basis, in line with Du, Tepper and Verdelhan (2018).

Keywords

Covered interest parity; Interest rate differentials; Forward foreign exchange market; Financial market arbitrage.

Resumo

Vasconcelos, Raphael de Oliveira; Garcia, Márcio Gomes Pinto. **Determinantes Macroeconômicos e regulatórios dos desvios de paridade coberta da taxa de juros**. Rio de Janeiro, 2022. 57p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Desvios de Paridade Coberta da Taxa de Juros (CIP) têm sido amplos e persistentes, entre economias do G10, desde a crise financeira mundial de 2008. Uma das explicações para a quebra na relação de paridade (CIP) são as novas regulações bancárias que surgiram no período pós-crise. Por outro lado, desvios de CIP na economia brasileira têm sido associados ao índice EMBI+, que é uma medida de risco país, tal como em Garcia and Didier (2003). A partir da literatura recente sobre desvios de CIP (i.e., a *currency basis*) entre as economias do G10, eu mostro a evolução recente da *cross-currency basis* para essas economias, durante a pandemia de 2020, e então eu estudo os determinantes macroeconômicos e regulatórios da *basis* do Real. Usando a estratégia empírica de Cerutti et al (2021), eu encontro que o bid-ask spread (medida de liquidez) do dólar futuro tem um efeito proeminente. Em uma abordagem de diferença-em-diferenças, eu encontro que a *basis* brasileira sobe aos finais de trimestres, coincidindo com o período em que os contratos futuros aparecem no balanço patrimonial dos bancos. Tal evidência sugere um efeito causal de regulação bancária na *currency basis*, em linha com Du, Tepper and Verdelhan (2018).

Palavras-chave

Paridade Coberta da taxa de juros; Diferenciais de taxa de juros; Mercado futuro de câmbio; Arbitragem em mercados financeiros.

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1
Introduction

The Covered Interest Parity (CIP) is one of the most famous textbook relationship in international finance. It postulates, based on a no-arbitrage condition, that investing in a riskless bond in one currency is equivalent to exchanging this currency to another, investing in a riskless bond of same maturity denominated in the other currency, while also buying forward the original currency. In other words, "the interest rate differential between two currencies in the cash money markets should equal the differential between the forward and spot exchange rates (Borio (2016))".

Before the Global Financial Crisis (GFC) of 2008, the CIP condition worked pretty well[1.1], at least for developed economies, or economies whose country risk is negligible. However, since the crisis, persistent CIP deviations have been observed for a large class of currencies. The first goal of this work is to review some of regulatory factors that emerged post-GFC and that have contributed to explain those persistent deviations.

The main ideas are that i) international imbalances in the supply and demand of FX-hedging exert a pressure in FX swap markets for currency hedging and ii) capital and leverage requirements limit the use of banks balance sheet to make CIP arbitrage trades, which leads to iii) CIP deviations, or the cross-currency basis, emerge not as an arbitrage opportunity, but as a compensation for FX-hedging operation by constrained financial intermediaries. We also comment on the role of monetary policy divergence on the relative demand for bonds denominated in different currencies, which may also exert pressure on the CIP deviations when the investments in other currencies are currency-hedged.

The second goal of this work is to take a first look at the recent evolution of the CIP basis. I show that, at least for the 1-year cross-currency basis, it seems that there are no permanent effects of the 2020 pandemic crisis on the cross-currency-basis. For the 3-month cross-currency-basis, I comment the potential effects that the provision of dollar liquidity swap lines by the Federal Reserve, in coordination with other central banks, may have had on the

[1.1] Before, any CIP violations were short-lived during a financial crisis (Frenkel & Levich (1979), Dooley & Isard (1980), and Fletcher & Taylor (1996))

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cross-currency-basis. For the 1-year cross-currency-basis, I show that, for the currencies we analyse, the interest rate differential exerted a negative pressure on the basis, while the forward premium exerted a positive pressure.

The third and main goal of this paper is to apply the recent literature on CIP deviations for the G10 economies on the Brazilian case. CIP deviations for the Brazilian economy have been associated with the EMBI+ index, which is a measure of country risk Garcia & Didier (2003). Following the regression approach of Cerutti et al. (2021), I evaluate the importance of a set of potential macroeconomic drivers of CIP deviations. The FX bid-ask spread, which we may call as a "liquidity factor", turned out to be the most prominent macroeconomic driver. Finally, using a difference-in-differences approach, I find that the Brazilian currency basis rises at quarter-ends, which is the period when forward contracts appear on banks' balance sheets. This points to a causal effect of banking regulation on the currency basis, in line with Du, Tepper and Verdelhan (2018).

On section 2, I review the definition of the CIP, the cross-currency basis and the factors that help explaining the persistent CIP deviations. On section 3, I discuss the recent evolution on the cross-currency basis. On sections 4 and 5, I study the macroecomic and regulatory drivers, respectively, of the Brazilian CIP deviations. Section 6 concludes.

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2
Determinants of CIP deviations

2.1
Covered Interest Parity as a no-arbitrage conditon

Denote $r_{t,t+n}$ and $r^*_{t,t+n}$ by, respectively, the continuously compounded n-year risk-free interest rate on the domestic currency and in US dollars, which we use as the foreign currency. Let S_t express the spot exchange rate as units of domestic currency per US dollars. Let $F_{t,t+n}$ be the n-year Forward exchange rate in units of domestic currency per US dollar. The CIP establishes that:

$$e^{nr^*_{t,t+n}} = e^{nr_{t,t+n}} \frac{S_t}{F_{t,t+n}} \tag{2.1}$$

Or, in log terms:

$$r^*_{t,t+n} = r_{t,t+n} - \frac{1}{n}(f_{t,t+n} - s_t) \tag{2.2}$$

This condition tells us that two alternative risk-free investments strategies should deliver the same returns. For instance, an investor who has 1 U.S. dollar may deposit it for 1 year and earn the U.S. risk free rate $e^{r^*_{t,t+1}}$. Alternatively, he may exchange his dollars for S_t of some other currency, deposit the amount exchanged for 1 year and earn $S_t e^{r_{t,t+1}}$ in the other currency. Along with the deposit, he may enter in a forward contract, with price $F_{t,t+1}$ that exchanges $S_t(1 + r_{t,t+1})$, amount to be received in the other currency (known at the time of the investment) for $\frac{S_t}{F_{t,t+1}}(1 + r_{t,t+1})$ U.S. dollars. In both alternative investment strategies, the investor ends up receiving a payoff in dollars. Note, however, that for this condition to hold, one should assume that the i) interest rates are risk-free and that ii) there is no counterparty risk in the forward contract. If i) and ii) are true, there are riskless profit opportunities when equation (2) does not hold.

The cross-currency basis

From equation (2), define:

$$x^i_{t,t+n} = \underbrace{(r^*_{t,t+n} - r^i_{t,t+n})}_{\text{Interest rate differential}} + \underbrace{\frac{1}{n}(f^i_{t,t+n} - s^i_t)}_{\text{forward premium}} \tag{2.3}$$

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Superscript i is a currency index, and $x^i_{t,t+n}$ is the difference between direct" dollar investment/funding, and the "synthetic" dollar investment/funding, using currency swaps "[2.1]. We call $x^i_{t,t+n}$ the currency i basis. A negative basis, $x^i_{t,t+n} < 0$, means that it is costlier to invest in dollar using the second investment strategies mentioned above, that is, buying domestic currency, investing in the domestic risk free-rate and buying forward dollars.

Figure 1 below shows that the cross-currency basis was approximately zero for the G-10 currencies.[2.2] Then, large basis appeared following the Global Financial Recession, which isn't unusual for periods such as that (due to, among other things, U.S. dollar shortage that makes costlier the synthetic dollar investment), but it persistently remained distant from zero since then, which is unusual. In fact, the persistence of CIP deviations for developed economies is so challenging that a large literature emerged after the GFC trying to explain it.

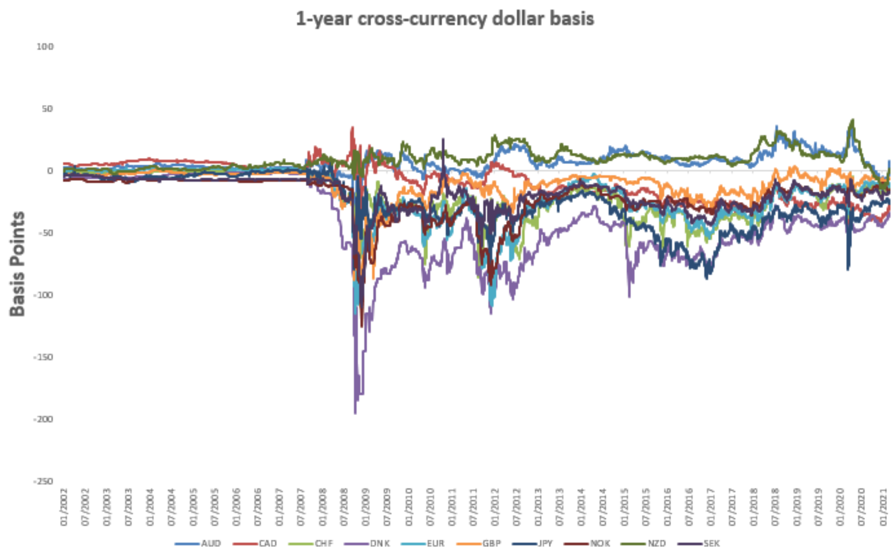

Figure 2.1: 1-year cross currency basis

2.2 Regulatory reforms and limits to arbitrage

The persistency of CIP deviations, after the GFC and the regulatory reforms that followed it, points to the likely existence of frictions in the financial markets. We present three potential structural explanations from Du et al. (2018).

[2.1]In other words, $x^i_{t,t+n}$ is the difference between the RHS and the LHS of equation (2).
[2.2]we took the cross- currency dollar basis series from the Thomson Reuters datastream. In the appendix we identify each currency by its "datastream code".

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Non-Risk-Weighted Capital Requirements:

The first regulatory reform to mention is that on the leverage ratio requirement of bank's balance sheet. Under the post-GFC Basel III framework, banks had to maintain at least 3% of total capital over the average total consolidated assets (which includes off-balance sheet exposure along with on-balance sheet assets). This minimum requirement did not exist before for foreign (non-U.S.) banks, and, for some financial institutions characterized by the FED as "systemically important", the minimum leverage ratio is even higher, ranging from 5% to 6%.

CIP arbitrage trades, by requiring the bank's balance sheet expansion (e.g. for currency swaps), may not be sufficiently attractive for small CIP deviations. For instance, as in Du et al. (2018), for a 3% leverage requirement and a return of capital of 10%, banks would need 30 bps of the currency-basis in order for the trade to be attractive.

Risk-Weighted Capital Requirements:

Capital requirements also increased under Basel III. For globally systemic banks (the G-SIBs), total capital ratio increased from 8% to around 11,5-15%. Since the cross-currency basis became more volatile post-crises, the VaR (value-at-risk) on CIP trades increased, which poses a constraint on CIP arbitrage, especially for long-term tenors.

The Volcker Rule:

The Volcker Rule is a section of the Dodd-Frank Act, enacted on july, 2010. It prohibits banks from engaging in proprietary trading in exchange rate forward and swaps. Therefore, there are not only new, more restrictive bank's balance sheet constraints that limit CIP arbitrage, but there are also limits to the CIP trade itself - bank's can't explore CIP arbitrage opportunities by themselves.[2.3].

2.3
Why don´t the market players play? More on limits to arbitrage

Besides mentioning the limits banks face when operating CIP trades, it is also important to understand how other players could arbitrage away CIP deviations, as well as which limitations they would face. I follow, again, Du et al. (2018), and briefly review each player's capacities and constraints.

[2.3]That is, an investment for direct market gain, instead of on behalf of clients. Note, however, that the Volcker Rule applies to the U.S. It does not prevent, say, the PBOC from exploring the japanese yen's large basis by lending out its USD reserves.

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Hedge funds:

Hedge Funds are one of the best examples of a market player that acts as arbitrageur, so it is natural to start by them. For a CIP arbitrage strategy to be attractive enough, a Hedge Fund would need to lever up its strategy. Hedge Funds obtain its funding from prime brokers, which are capital constrained. Then, if the leverage position is high enough, and given prime broker's binding capital requirements, borrowing costs to the leverage funding may be so high that the CIP trade strategy is no longer attractive. This points to the spillover effects of the regulated entities on the cost of leverage of nonregulated entities, such as hedge funds.

Money Market Funds:

Money Market Funds (MMFs) are mutual funds that invests in low risk, high liquidity assets such as US Treasury bills, certificates of Deposits (CDs) and Commercial Papers (CPs). MMFs are a good alternative for investors seeking short-term low risk, low return investments to foreign banks. MMFs are a source of cross-border dollar funding to foreign banks that issue CDs and CPs.

These funds suffered heavy redemptions during the GFC; so, to reduce the susceptibility of new such runs from the fund, a monetary reform was implemented in 2014. The reform required a floating Net Asset Value (NAV) for non-government MMFs, and required the imposition of liquidity fees if the fund's liquidity reaches a level below a specified threshold. This reform led to large outflows from government MMFs, which are not subject to floating NAVs and which don't hold foreign banks CPs or CDs. Then, the MMFs reform restricted the cross-border dollar funding. As a result, the cross-currency basis widened.

FX reserve managers:

FX reserve managers are also important players that could potentially operate CIP arbitrage trading. The People's Bank of China (PBOC) deserves special mention, since it has more than $3 trillion in FX reserves (as of 2021), most part of which in U.S. dollar. The PBOC may affect the cross-currency basis by engaging in the "synthetic" dollar investment instead of the direct dollar investment. For instance, instead of holding U.S. Treasury bills, It may exchange dollars for japanese yens, invest in japanese government bonds and swap back the currency for dollars. Not only the PBOC, but Central Banks, in general, may explore the cross-currency basis by lending US Dollars.

Bank treasuries and corporate issuers:

Regarding bank treasuries and corporate issuers, those institutions could arbitrage CIP deviations by issuing debt in different currencies while also

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swapping into their desired currency. For instance, since U.S. banks and supranational institutions borrow in U.S. dollars at lower costs than by the synthetic funding, they are a good candidate to explore the cross-currency basis by optimally shifting the currency denomination of their borrowing in response to the basis Borio (2018).

2.4 International Imbalances and the challenge to the no-arbitrage condition on CIP

International Imbalances on the supply and demand of *FX hedging*, coupled with regulatory constraints, may challenge the very concept of CIP as a no-arbitrate condition, according to Borio (2018).

On the demand side, there are institutional asset managers and banks who may swap out of domestic currencies to fund long-term investments in USD, for instance, due to higher yields abroad. Corporate issuers wiling to swap out of cheap foreign currency funding into USD and vice versa can also access cross-currency markets. Both agents, in doing so, exert negative pressure on the dollar basis. For them, the currency-basis is a cost - the cost of currency hedging.

On the supply side, there are banks (specially central banks) and highly rated supranational and sovereign agencies. For them, as mentioned in section 2.2, the currency basis represents a profit opportunity. By combining the supply and demand of FX hedging, then, I can see CIP deviations as a price.

Borio (2018) use bank's net USD liabilities (the difference between consolidated global on-balance sheet assets and liabilities in U.S. dollar or, as they call it, the "funding gap"), aggregated by country, as a proxy for FX hedging demand and proceed to show that the funding gap has an effect on the currency basis. But if CIP deviations are a price, and if CIP is a non-arbitrage condition, then CIP deviations (prices) should not be affected by variations in the banks funding gap (demand)- the FX hedging supply should be perfectly elastic. This is why CIP deviations should not be seen as a no-arbitrage condition.

But why isn't the FX hedging supply as elastic as it was before the GFC? Borio (2018) argue that it is due to new regulations (mostly Basel III) and prudent risk management, in line with the discussed above. Remember that, by item ii), the absence of counterparty risk is one of the necessary conditions for the CPI to hold. Since the GFC, though, finantial institutions haven't been treating cross-currency positions as absent from counterparty risk. Indeed, financial institutions have been required to report potential losses on their off-

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balance sheet exposures to derivatives such as currency swaps. These potential balance sheet costs stem from the fact that almost all FX derivatives are traded over-the-counter, which exposes counterparties to collateral risk. [2.4]

2.5
Balance Sheet constraints and dollar strength

As Borio (2018), Avdjiev & Shin (2019) argue that the currency basis is a compensation (i.e, a price) global banks receive for using their balance sheet capacity to supply hedging services to investors. In this sense, a dollar appreciation relative to a basket of the other currencies, by increasing the risk on the bank's credit portfolio, is associated with less dollar credit and a higher compensation for hedging services, which means a fall on the currency basis. There is, as the authors put it, a "triangular relationship" between cross-border dollar credit, the currency basis and dollar strength.

Suppose, for instance, that a Japanese life insurance company wants to hedge the currency risk of its global investments in dollar-denominated assets (since it has to pay its holders on yen). To do so, it uses a FX swap to sell forward dollar to a global bank. Absent a counterparty to the FX operation, the bank itself assumes the other part of the FX swap and so the currency risk associated with it. The bank, then, borrows dollar so as to compensate its long dollar position (the FX swap) with a short dollar liability. But,in doing so, the bank uses its balance sheet capacity, and demands a compensation for it - the currency basis.

Now, assume there is an increase in the dollar strength - a dollar appreciation relative to a basket of currencies. This increases the risk in global bank's lending, and so puts more pressure on its balance sheet, reducing its leverage capacity. The bank, then, demands a higher compensation for hedging services, which means a reduction in the currency basis. In sum, an increase in dollar index is negatively correlated with the dollar basis.

2.6
Divergent Monetary Policy and the spillover of pricing anomalies

Another factor that helps explaining CIP deviations, particularly those for longer maturities, is monetary policy divergence between countries. Liao (2020) and Brauning & Victoria (2017) explain why it may be the case.

Liao has been the first to show that aggregated credit spreads between corporate bonds with same maturity denominated in different currencies, each over their respective risk-free rates, have been exhibiting large and

[2.4] So, it is a decentralized exchange.

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persistent differences since the GFC. Those spread differentials, He notes, are not associated with fundamentals or currency-specific risk factors, so they are a pricing anomaly. Interestingly, this pricing anomaly has shown a remarkable comovement with another pricing anomaly - the cross-currency basis. The pricing anomalies are interlinked because both affect FX-hedged borrowing costs - the currency basis through the cost of FX hedging, the credit spread differential through the relative cost of bond issuing in one currency over another.

In a model of market segmentation, Liao shows that trying to arbitrage away either one of the pricing anomalies ends distorting the other. For instance, a risk-averse arbitrageur willing to take advantage of the CIP deviation would need to lend and borrow in different currencies. To take advantage of the credit spread differential, the arbitrageur would need to hedge FX risk by trading forwards or swap.

This mechanism may explain the recent evolution of the euro dollar basis. First, Liao documents that, for the euro, currency basis moves closely with corporate bond spreads over longer horizons (especially 5 years). As **?** observe, the quantitative easing program pursued by the European Central Bank (ECB) from march 2015 to december 2018, amid the Federal Reserve monetary tightening cycle, reduced the borrowing costs in euro relative to in U.S. dollar. This could have encouraged the issuance of FX-hedged corporate bonds in euros. The higher FX hedging demand could have raised the price of dollar swaps and thus widened the euro dollar basis. The issuance of corporate bonds in euros, trying to explore one pricing anomaly (the credit spread differential of bonds in dollar and in euro), could have amplified the other (CIP deviations).

Complementing the discussion above, Brauning & Victoria (2017) show how monetary shocks in one country affect global bank's lending decisions in different currencies. Overall, the idea is that, if the global bank has a fixed amount of equity to lend in different currencies, it will allocate its lending so that, in equilibrium, marginal returns on domestic and foreign lending, expressed in the same currency, have to be equal. Since monetary policy affects the marginal return on lending, it affects the optimal lending decisions of the bank.

Therefore, I have that monetary policy divergence, while also affecting the lending decisions in different currencies, may also affect the CIP deviations. For instance, if global banks shift its lending from dollar to euro, exploring its higher yield, but at the same time FX-hedge its lending, then it would affect the euro dollar basis.

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2.7
Cross-currency basis due to search for yield motives

As Du et al. (2018) argue, countries that have a large supply of savings, but low interest-rates, such as Japan and Switzerland, create a demand for investments in high-yield currencies, as the New Zealand and Australian dollar. Suppose, again, a japanese life insurance company that, looks for high yields in the U.S. Treasury market (which are least higher than the yen-based Treasuries). Since the japanese company will probably have to pay its depositors back in japanese yen, it decides to FX hedge its operations abroad, by selling dollars and buying forward yene. The Financial Intermediaries that are FX-hedging suppliers, not wanting to bear the currency risk, hedge their currency exposure of their positions in the FX swap market by going long in low-interest-rate currencies and short in high-interest-rates currencies. The currency basis emerge, once more, as a compensation to the financial intermediary for the cost of capital associated with the trade.

One prediction from the search for yields intuition is that, the lower the domestic currency interest rate compared to the U.S. interest rate, the higher the demand for U.S. dollar-denominated investment opportunities. This induces greater FX hedging demand to sell U.S. dollars and buy foreign currencies in the forward or the swap market. Because FX-hedging supply is costly for financial intermediaries, the cross-currency basis has to become more negative so as to justify the higher balance sheet costs from the larger positions.

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3
The recent evolution of CIP deviations: a first look at the data

3.1
Short-term cross-currency basis

I now analyse the recent evolution of the cross-currency basis, with special focus from 2020 onward, and on the 3-month and 1-year maturities.[3.1]

I start with the short term cross-currency basis because they are likely more affected in periods of financial stress in which low liquidity and flight to dollar potentially exert pressure on the basis. In the figure below[3.2], I can see a dramatic fall, by mid-march 2020, on the currency basis for the japanese yene (JPY), the swiss franc (CHF) and the British Pound (GBP). The new zealand and australian dollar basis (NZD and AUD) didn't experience such a fall - indeed, their basis widened even further upward. Then, JPY, CHF and GBP basis reverted its movement, as well as AUD and NZD. At the end of the year, all currency-basis were more or less close to zero, and more os less close to one another. Both facts can be explained by monetary policy convergence, as I will argue latter.

[3.1]Longer maturities are left in the appendix and can be consulted, although I do not intend to discuss them in this work.

[3.2]Data from Thomson Reuters. Countries selected according to data availability

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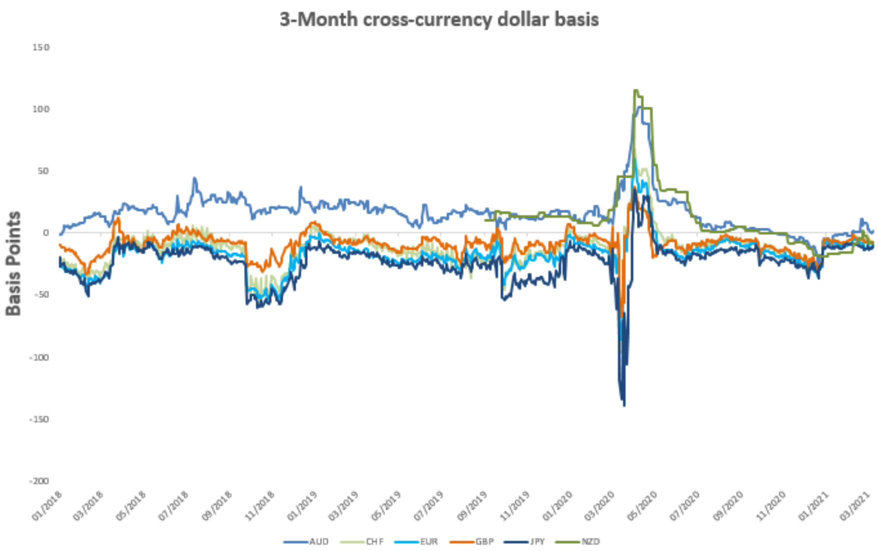

Figure 3.1: 3-Month cross-currency dollar basis

The table below presents some facts about the average behavior of the cross-currency basis across diferent periods, along with the day and level of the "peak" currency basis (when it achieved its highest level, in absolute terms, in 2020). The fact that 16/03 is the day when CHF, EUR and GBP experinced the lower level may be related to the decision by the FED, on the day before, to cut even further the FED Funds rate, that then reached the range between 0% and 0.25%. March/2020, in spite of the high "peak" levels, was not an unusual month, on average, at least for CHF, EUR, GBP. This is partially explained by the reversion that started at the end of the month and became more pronounced on april, when the basis became positive for all analysed countries. The reversion then was followed by a period of lower (in absolute terms) and closer (to each other) currency basis.

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Table 3.1: Cross-currency basis: descriptive statistics

Cross-currency basis (units in basis points)					
Country code	Peak (in 2020)	Average 03/20	Average 04/20	Average 05-12/2020	Average 2018/19
AUD	101,5 (08/04)	38,6	86,9	4,6	17,6
CHF	-96,7 (16/03)	-15,7	44,6	-10,0	-16,2
EUR	-86,0 (16/03)	-17,8	33,7	-13,8	-20,8
GBP	-67,2 (16/03)	-11,4	15,0	-10,2	-9,3
JPY	-139,3 (19/03)	-64,4	17,7	-17,2	-26,4
NZD	114,5 (03/04)	38,1	96,2	2,2	13,9

3.1.1
Central Banks swap lines and coordinated policy action.

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On march, 15th of 2020, the FED not only decided to reduce the FED funds rate to the 0%-0.25% range. It has also decided, in conjunction with the Bank of England, the European Central Bank, the Bank of Canada, the Bank of Japan, and the Swiss National Bank to announce a coordinated action to increase the provision of liquidity by lowering the pricing of standing U.S. dollar liquidity swap line arrangements by 25 points.

On march 19th, the FED established temporary swap lines arrangements with the Reserve Bank of Australia, the Banco Central do Brasil, the Danmarks Nationalbank (Denmark), the Bank of Korea, the Banco de Mexico, the Norges Bank (Norway), the Reserve Bank of New Zealand, the Monetary Authority of Singapore, and the Sveriges Riksbank (Sweden). The facilities included the provision of up to 60 billion dollars each for the Reserve Bank of Australia, the Banco Central do Brasil, the Bank of Korea, the Banco de Mexico, the Monetary Authority of Singapore, and the Sveriges Riksbank, and up to 30 billion each for the remaining banks. These arrangements were set to be in place for six months, but the FED extended them twice and now they are set to be in place until September, 2021. Below we see the evolution of the swap lines positioning for each one the g10 Central banks, as well as the total amount of U.S. dollar liquidity swap by the FED[3.3]

[3.3] The difference between the latter and the former is the total amount of swap lines with the Singaporean, the Brazilian, the Mexican and the Korean central banks.

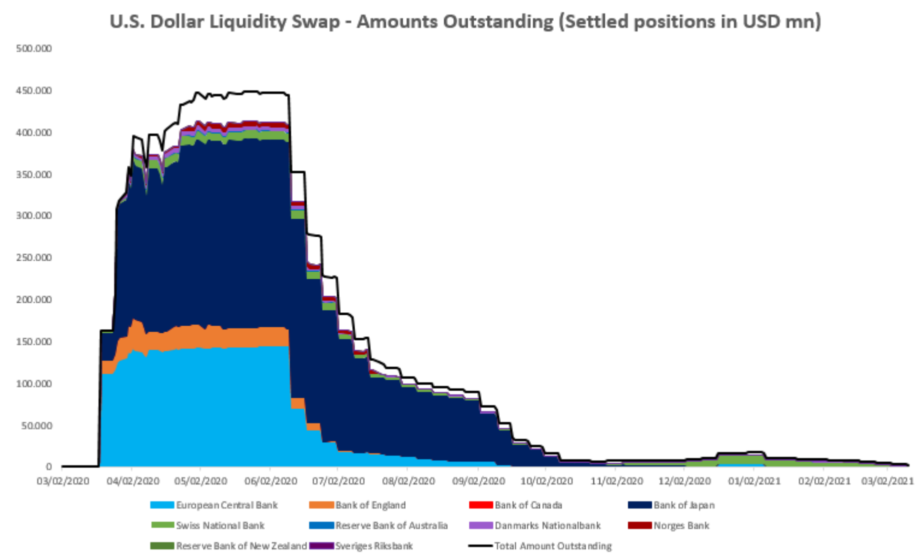

Figure 3.2: U.S. dollar liquidity swaps

From march 19th on, the stock of swap lines starts to increase considerably until April, it stabilizes from April to october and then starts to fall by to pre-crisis level at the end of the year. I suggest that the coordinated policy actions may have contributed to improve financial conditions amidst the Pandemic crisis and may have been a driver behind the above described recent behavior of the cross-currency basis - notably the reversion following the extension.

3.2 Long-term cross-currency basis

I proceed to analyse the 1-year cross currency basis. To do this, I first show the g10 currencies basis divided in three groups (for convenience and due to similarities between them). The three groups I separated are: the high yield currencies (NZD,AUD), the currencies of economies that have a Libor denominated in local currency (i.e JPY, EUR, GBP, CHF) and the scandinavian (plus Canada) currencies, that is (CAD, NOK, SEK, DKK). Then, using the basis decomposition as in equation (3), I look separately at the evolution of interest rate differential and forward premiums, for each group.

3.2.1 New Zealand and Australia

As confirmed in figure 4, Australia and New Zealand dollar basis exhibit a very similar pattern. Both basis widened onward in march/april 2020 and then entered negative territory for the first time at least since the Global Financial Crisis.

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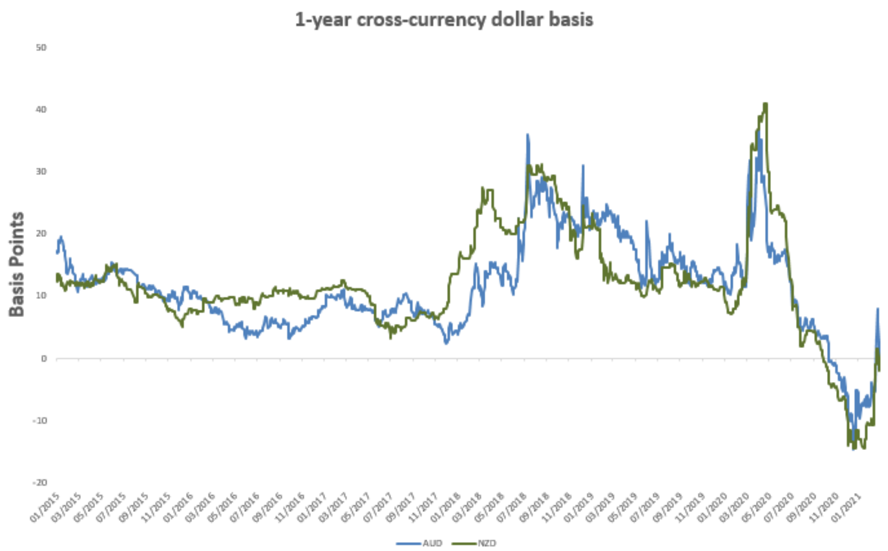

Figure 3.3: 1-Year cross-currency dollar basis (AUD,NZD)

Figure 5 shows that interest rate differentials, that were largely in favor of the New Zealand and Australian currencies, reverted on 2018. After the FED monetary loosening at the onset of the pandemic crisis, the deposit rates converged.

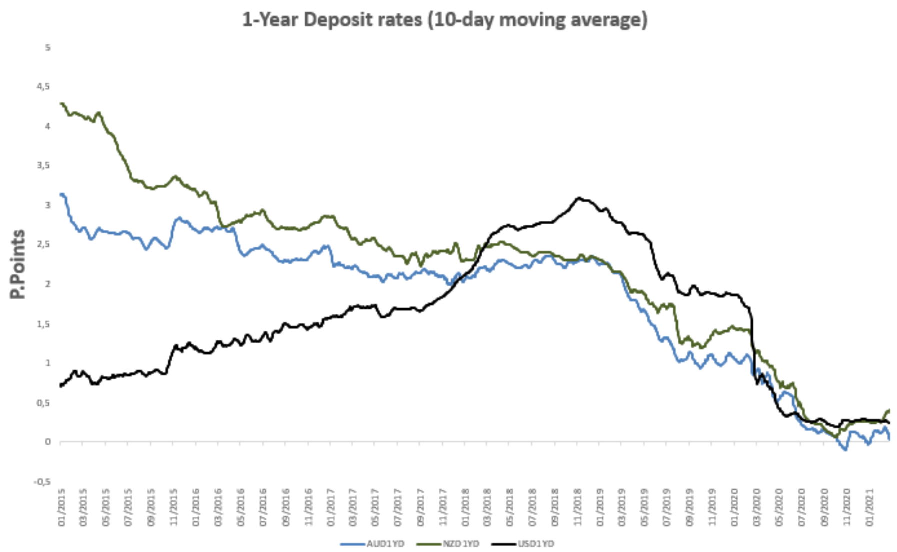

Figure 3.4: 1-Year Deposit rates (AUD, NZD)

Since the FED's monetary loosening exerts a negative pressure on the basis, by reducing the cost of direct dollar funding vis-à-vis the synthetic dollar funding, what drove both currency basis up were spikes in the forward premium, as shown in figure 6.

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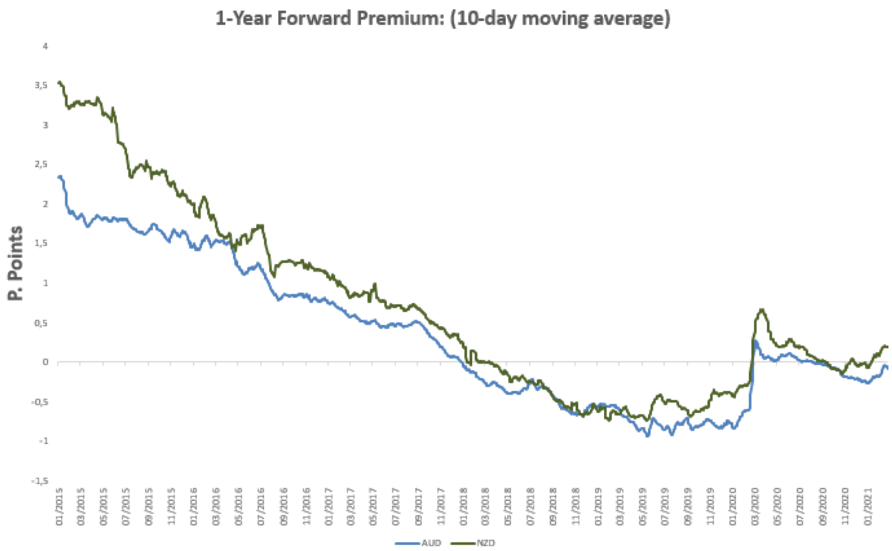

Figure 3.5: 1-Year Forward Premium (AUD, NZD)

3.2.2
Switzerland, Euro Area, Great Britain and Japan

Turning to the 4 countries that have Libor rates denominated in their currencies, we note in figure 7 that, for the 1-year maturity, the four currency-basis experienced a negative pressure on march (as a reflection of greater global aversion, maybe) did not experience a strong reversion on April, as we observed for the short-term maturity. Neither basis, for instance, reached positive territory, suggesting that the coordinated policy actions I just described had a more pronounced effect on the short-term. cross-currency basis.

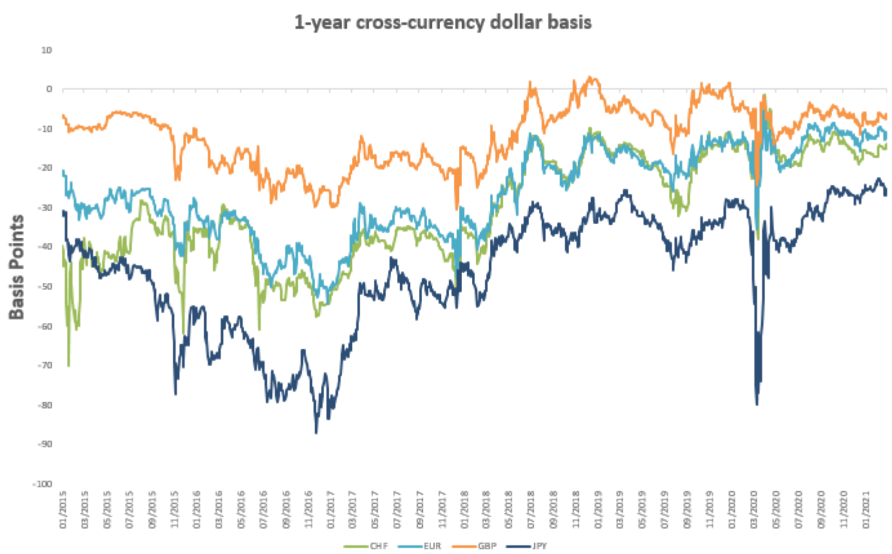

Figure 3.6: 1-Year cross-currency dollar basis (CHF,EUR,GBP,JPY)

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Table below shows that, on march/20, the cross-currency basis became more volatile. Taking the month average, though, only the yene and british pound basis seem to have above average (in absolute terms) levels. The average over April and December 2020 is very close to the average over 2018/29, which suggests that the there are permanent level effects on the currency basis due to the pandemic crisis. Nevertheless, it is out of the scope of this work to investigate if the absence of permanent level effects is due to governments macroeconomic stimulus during the pandemic.

Table 3.2: Cross-currency basis volatility: CHF,EUR,GBP and JPY

Cross-currency basis (units in basis points)						
Country code	Std. Dev. 19	Std. Dev. 20	Avg (03/19)	Avg (03/20)	Avg (04-12/2020)	Avg (2018/19)
CHF	0,9	8,4	-10,3	-15,2	-10,9	-17,6
EUR	0,7	6,2	-14,6	-20,9	-12,4	-19,7
GBP	1,1	6,6	-0,4	-9,7	-5,7	-4,3
JPY	0,8	13,7	-24.0	-55,7	-29,3	-33,2

In figure 8, the evolution of the Libor rates displays a reduction on the interest rate differential, from march/2020 on, which exerts a negative pressure on the basis.

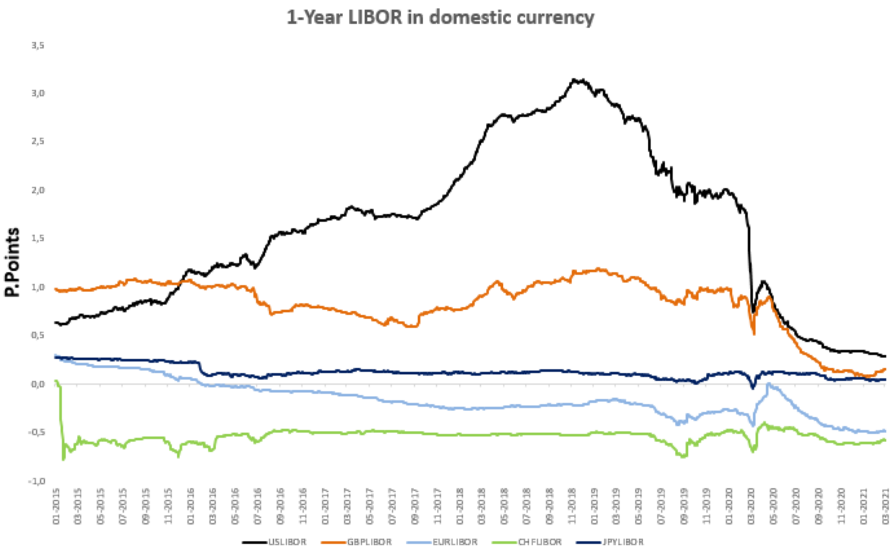

Figure 3.7: 1-Year Libor (CHF,EUR,GBP,JPY)

In figure 9, we see an increase in the forward premium for all currencies. This exerts a positive pressure on the basis, contrary to the reduction on the interest rate differential.

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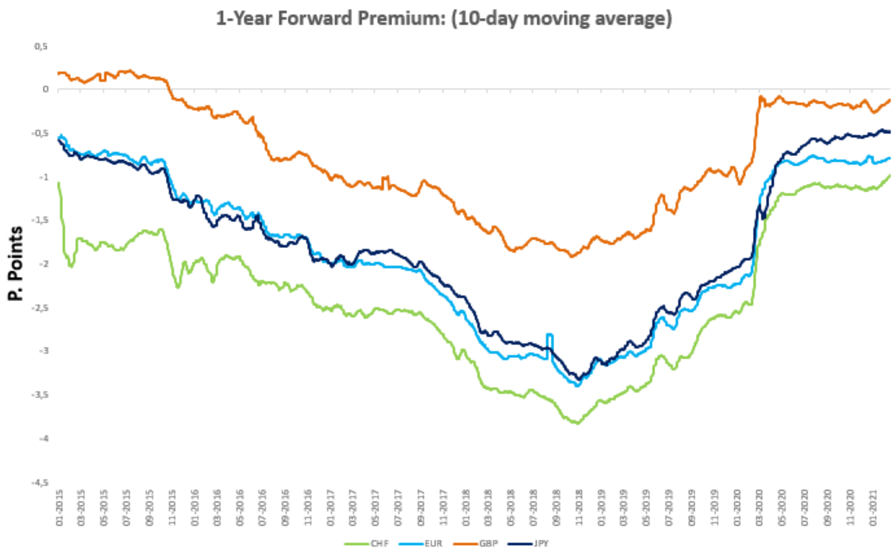

Figure 3.8: 1-Year Forward Premium (CHF,EUR,GBP,JPY)

I calculate the cross-currency basis correlation with the interest rate differential and with the forward premium, for 2019 and 2020. Results are in the table below. By equation (3), each correlation should be positive, *ceteris paribus*. If a currency had a positive basis correlation with the interest rate differential, but a negative correlation with the forward premium, then the interest rate differential is basis movements in that period, and that these movements occurred in spite of the opposite pressure of the forward premium. If both correlations are positive, then the higher one is the main factor behind the movements. From the table, we see that the forward premium is the main component explaining the swiss franc basis movements in 2020, and that the interest rate differential is the main component explaining the euro, pound and japanese yene basis movements on the same period.

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Table 3.3: Cross-currency basis correlations: CHF,EUR,GBP and JPY

Cross-currency basis correlations				
Country code	Interest Differential (19)	Interest Differential (20)	Forward Premiun (19)	Forward Premium (20)
CHF	-36%	-4%	6%	56%
EUR	6%	39%	-10%	-5%
GBP	-42%	33%	23%	-16%
JPY	-50%	50%	38%	47%

3.2.3
Canada, Denmark, Norway, Sweden

Turning to the remaining countries, left as a separate group just for convenience and because they don't have Libor denominated in their currencies.[3.4]Figure 10 shows that the cross-currency basis dynamics of this group are very similar to the "Libor" currencies.

Figure 3.9: 1-Year cross-currency basis (CAD, DKK, NOK, SEK)

Note that the interest rate differential also became lower from march/2020 on.

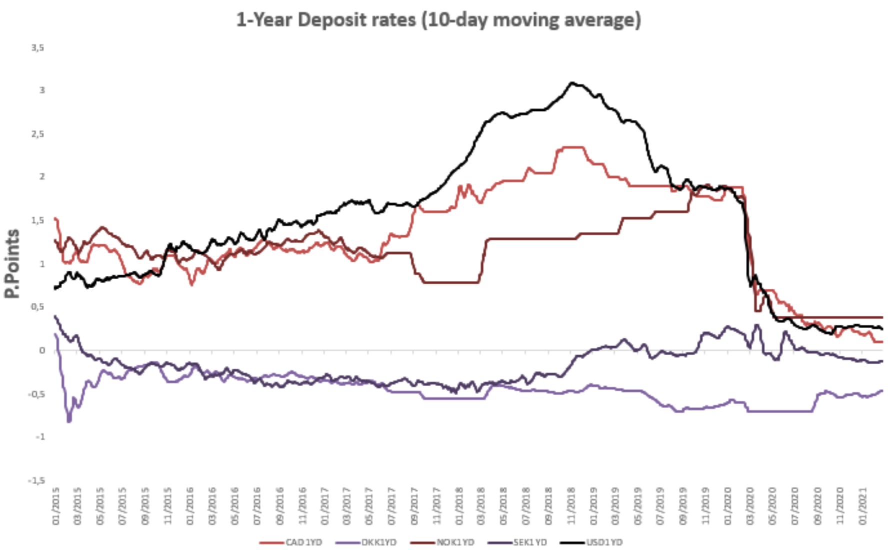

Figure 3.10: 1-Year Deposit rates (CAD, DKK, NOK, SEK)

[3.4]Different choices of deposit rates may result in different interest rate differentials. So I prefer to separate the "Libor" currencies from the rest.

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And Forward Premium became higher for the danish krone and the Swedish krona, and not so much for the Canadian dollar and the Norwegian krone (which experienced a brief upward pressure on late march, but then their forward premiums reverted and stabilized at a level similar to the pre-march one).

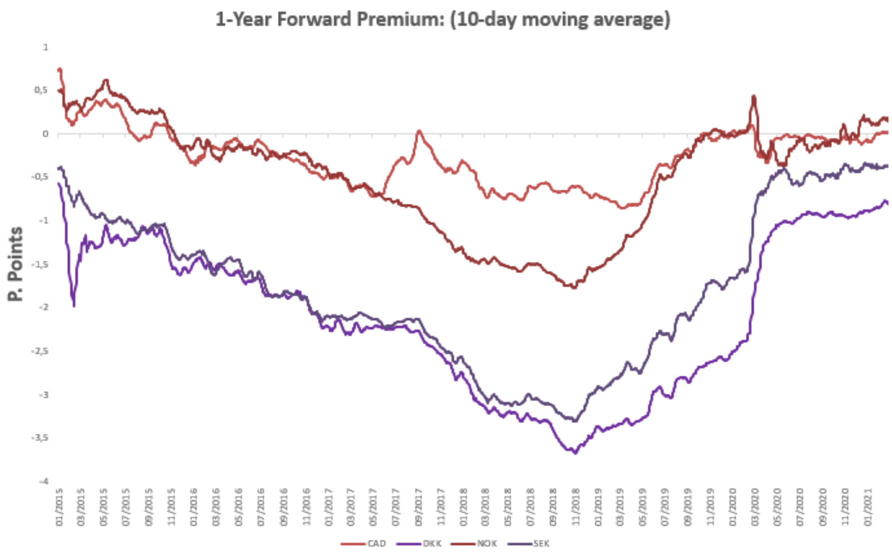

Figure 3.11: 1-Year Forward Premium (CAD, DKK, NOK, SEK)

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4
Applications to Brazil: macroeconomic drivers

4.1
Empirical strategy

I follow Cerutti et al. in our baseline empirical specification. From (2.3), I start by the regression equation:

$$\frac{1}{n}(f_{t,t+n} - s_t) = \alpha + \beta r_{t,t+n} - \beta^*_{t,t+n} r^*_{t,t+n} + \epsilon_t \tag{4.1}$$

Note that, if the CIP holds, then we should expect $\beta, \beta^* = 1$ and $\alpha = 0$.

Alternatively, we can subtract $r^*_{t,t+n} - r_{t,t+n}$ from (4.1), which yields the regression specification:

$$x^{BR}_{t,t+n} = \alpha + \gamma r_{t,t+n} - \gamma^* r^*_{t,t+n} + \epsilon_t \tag{4.2}$$

In this specification, $\gamma = \beta - 1$ and $\gamma^* = \beta^* - 1$. If CIP holds, then, we should expect $\gamma, \gamma^* = 0$ and $\alpha = 0$. For consistency with the recent literature[4.1], I will work with (4.2) in first differences:[4.2]

$$\Delta x^{BR}_{t,t+n} = \alpha + \gamma \Delta r_{t,t+n} + \gamma^* \Delta r_{*t,t+n+\eta_t} (4.3)$$

Following Cerutti et al. (2021), I use changes in monthly averages of both the independent and the explanatory variables. The reason for the use of monthly averages, as in Cerutti et al. (2021), is to alleviate issues related to period-end jumps in the bases. Our data covers the period between May 2003 and November 2021. Regarding our Libor basis series, I define it as the difference between the 3-month on-shore dollar rate, known as *cupom cambial* and the 3-month Libor. Therefore, the Libor basis captures the difference between a synthetic and a direct dollar rate - the synthetic being the yield, in dollars, for an on-shore investment applied in Brazilian currency.

[4.1]The ideia is to avoid possible unit roots

[4.2]the sign of γ is reversed to reflect it's a regression equation

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4.2
Interest rate factor

Table 1 presents time series results based on specification in (6). I cover 4 subperiods: pre-GFC (2003-06),GFC (2007-09),post-GFC (2010-19) and COVID-19 (2020-21). The coefficients on the pre-GFC subperiod are not statistically significant. During the GFC, the coefficient on changes in the US Libor is positive and statistically significant; for te post-GFC period, I find a positive and statistically significant coefficient for changes in the Brazilian 3-month rate; finally, for the pandemic period, I find negative and statistically effects of changes in the US Libor on the Brazilian basis. Table 10 in the appendix presents similar results, but using the Treasury basis as dependent variable.

Table 4.1: Interest rates and CIP deviations

	IBOR basis				
	(1)	(2)	(3)	(4)	(5)
Δx	(2003-06)	(2007-09)	(2010-19)	(2020-21)	(2003-21)
Δr	0.189	0.326	0.144*	0.088	0.086
	(0.165)	(0.452)	(0.084)	(0.090)	(0.065)
Δr^{*}	−0.704	0.193**	0.065	−0.753***	0.070
	(0.556)	(0.078)	(0.175)	(0.189)	(0.093)
Constant	0.084	0.076	0.006	−0.069	0.006
	(0.080)	(0.080)	(0.022)	(0.050)	(0.020)
Observations	43	35	119	22	223
Residual Std. Error	0.314 (df = 40)	0.461 (df = 32)	0.243 (df = 116)	0.134 (df = 19)	0.291 (df = 219)

Note: This table reports the result of simple regression of monthly changes in 3-month Brazilian dollar basis (IBOR) on corresponding interest rates. Samples are split to before (03–06), during (07–09), and after (10–21) the financial crisis. The period after the financial crisis is split to before (10-19) and during (20-21) the covid pandemic. The whole period is also included. Monthly averages are used. Newey & West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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4.3
US Dollar factor

I add 3 explanatory variables to (6): the VIX (in log), the nominal broad dollar index, and the Forward bid-ask spread. The VIX, as shown in Bruno and Shin (2015a) and Bruno and Shin (2015b), is as an indicator of risk aversion in financial markets. The dollar index is an indicator of the U.S. dollar's strength. And the forward exchange bid-ask spread is an indicator of illiquidity and volatility in foreign exchange markets.

The coefficient on the VIX is positive and statistically significant for the GFC period. For the post-GFC periods, it is not statiscally significant, in line with the recent literature on the weak relationship between the VIX and the currency basis.[4.3].

The coefficient on the broad dollar index is negative and statistically significant at the first subperiod; then negative, but not statiscally significant at the GFC and the pandemic crisis; and it is positive and statistically significant at the post-GFC subperiod. The literature finds negative and statiscally significant coefficients for the G10 currencies. Bruno and Shin (2015b) noted that dollar strength leads to less crossborder dollar lending by global banks, thus affecting the relative price of synthetic and direct dollar financing.

As for the Forward bid-ask spread, the coefficient is statistically significant for the last 2 subperiods, with the sign switching from negative, during the GFC, to positive afterwards.

Table 3 shows how the results for the (2010-19) subperiod vary across tenors. For shorter tenors, the Forward bid-ask spread is the most important factor; for longer tenors, it is the Broad Dollar index, along with the brazilian interest rate, at the 1 year tenor.

[4.3](Cerutti et al. 2017; Avdjiev et al. 2020; Forbes and Warnock 2020; Miranda-Agrippino and Rey 2020a)

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Table 4.2: US Dollar and CIP deviations

	IBOR basis				
	(1)	(2)	(3)	(4)	(5)
Δx	(2003-06)	(2007-09)	(2010-19)	(2020-21)	(2003-21)
Δr	0.092	0.060	0.101	0.233	0.084
	(0.365)	(0.616)	(0.079)	(0.150)	(0.060)
Δr^*	−0.279	0.100	−0.075	-1.004^{***}	0.066
	(0.701)	(0.122)	(0.200)	(0.239)	(0.072)
ΔLog VIX	−1.024	0.769^{*}	0.112	−0.013	0.202
	(0.716)	(0.438)	(0.168)	(0.036)	(0.132)
ΔBroad dollar	-0.114^{**}	−0.018	0.041^{*}	−0.039	0.001
	(0.048)	(0.049)	(0.022)	(0.058)	(0.019)
ΔFwd bid-ask	2.948	−18.077	9.820^{***}	42.357^{***}	0.569
	(9.426)	(13.341)	(3.768)	(8.040)	(6.405)
Constant	−0.012	0.044	0.004	−0.090	0.006
	(0.079)	(0.060)	(0.024)	(0.079)	(0.017)
Observations	43	35	119	22	223
Residual Std. Error	0.248 (df = 37)	0.419 (df = 29)	0.224 (df = 113)	0.104 (df = 16)	0.296 (df = 216)

Note: This table reports the result of a regression of monthly changes in 3-month Brazilian dollar basis (IBOR) on corresponding interest rates along with a number of control variables. Samples are split to before (03–06), during (07–09), and after (10–21) the financial crisis. The period after the financial crisis is split to before (10-19) and during (20-21) the covid pandemic. The whole period is also included. Monthly averages are used. Newey & West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

Table 4.3: Dollar effect across tenors

	IBOR basis			
	(1)	(2)	(3)	(4)
Δx	1-month	3-month	6-month	1-year
Δr	0.169	0.101	0.172	0.256^{*}
	(0.118)	(0.078)	(0.091)	(0.128)
Δr^{*}	0.623	-0.075	-0.464	-0.501
	(0.600)	(0.196)	(0.254)	(0.319)
ΔLog VIX	-0.079	0.112	0.088	0.152
	(0.240)	(0.168)	(0.151)	(0.128)
ΔBroad Dollar	0.028	0.040	0.046^{*}	0.060^{*}
	(0.035)	(0.021)	(0.018)	(0.027)
ΔFwd bid-ask	42.333^{***}	9.812^{**}	1.114	0.423
	(11.704)	(3.768)	(2.901)	(3.534)
Constant	-0.003	-0.003	-0.004	-0.010
	(0.037)	(0.024)	(0.025)	(0.028)
Observations	119	119	119	119
Residual Std. Error (df = 113)	0.406	0.238	0.217	0.218

Note: This table reports regression outputs of the Brazilian dollar basis (IBOR) on a set of regressors as in the specification of Table 4.3. Tenors of regressors from 1-month to 1-year are considered. Sample period is 2010 M1–2019 M12. Newey & West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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4.4 Risk-preference factor

I now test an alternative regression specification in which I focus on global financial cycle measures that capture risk appetite. We have already seen, on the previous section, that the VIX has a weak correlation to the basis, so here I introduce two other variables. The first one is the the Miranda-Agrippino et al. (2020) global **asset-price factor**; the second one is the the He et al. (2017) **squared leverage ratio** of primary dealers.[4.4]. The asset-price factor accounts for a sizable fraction of global asset price comovement. A higher level of the factor reflects higher risk appetite on the part of global investors. The leverage ratio squared is the inverse of U.S. primary dealer sector's aggregate capital ratio and, as Cerutti et al. (2021) explain, it can be viewed as a direct indicator of intermediary balance-sheet capacity.

I then test the regression equation in (6) adding the Forward bid-ask spread and each of these aditional risk-prefence variables. I follow Cerutti et al. (2021) in these specifications. Table 4 shows that neither the Asset price nor the leverage ratio factor are significant for the Brazilian casa (which is similar to the NZD case from the literature). Nevertheless, I include the results here for completeness.

[4.4]Both measures expressed in units of standard deviations.

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Table 4.4: Risk factors and CIP deviations

	IBOR basis		
	(1)	(2)	(3)
Δr	0.145	0.159*	0.154
	(0.097)	(0.096)	(0.099)
Δr*	−0.078	−0.077	−0.099
	(0.353)	(0.273)	(0.345)
ΔFwd bid-ask	7.418	12.300**	11.901**
	(4.964)	(5.595)	(5.964)
ΔAsset price factor	−0.191		−0.061
	(0.184)		(0.265)
ΔLeverage ratio^2		0.193	0.157
		(0.189)	(0.285)
Constant	0.001	0.011	0.009
	(0.027)	(0.028)	(0.027)
Observations	111	107	107
Residual Std. Error	0.272 (df = 106)	0.266 (df = 102)	0.265 (df = 101)

Note: this table presents regression results on correlations between 3-month Libor basis and risk measures, controlling only for interest rates, risk measures and forward bid-ask spread. Asset price factor refers to the "global financial cycle" estimates from Miranda-Agrippino et al. (2020), while data on intermediary leverage ratio (squared) is from data on primary dealer sector's capital ratio (He et al. (2017)). As in Cerutti et al., both measures are demeaned and rescaled by its standard deviation. Sample starts at 2010 M1 and ends at 2019 M4 for the regression asset price factor and 2018 M11 for the regression including intermediary leverage. Newey & West (1994) standard errors are reported. *p<0.1; **p<0.05; ***p<0.01

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4.5 Dollar effects and safe-haven flows

I now add 3 more explanatory variables relative to the specification in table 2: the "safe haven factor",and the "Residualized Broad Dollar index" and the leverage ratio squared. The idea in this section is to decompose in two channels the effect of the broad dollar index on the basis. The fist channel, which I call the "safe haven factor", represents safe-haven demand stemming from a general drop in risk appetite, thus promoting a general flight to safe-haven currencies. The second channel, which I denote by the "Residualized Broad Dollar index", reflects mechanisms through which the US dollar affects the Dollar basis that are not associeted with the general comovement on safe-haven currencies. For insntance, an unilateral U.S. monetary tightening may induce a strong dollar that may induce an increase in the IBOR basis. Finally, I include the leverage ratio squared for consistency with Cerutti et al. (2021).

I take the safe haven factor from Cerutti et al. (2021). It is the principal component from a static factor model with the U.S. dollar, the Japanese yen and the Swiss franc. The "Residualized Broad Dollar index" is, then, the residual from the principal component estimation.

In table 5, I find a positive and statistically significant effect of changes on the safe haven factor on changes in the basis. The coefficient on the residualized broad dollar is not statistically significant. Therefore, the first channel from our decomposition is the one that predominates. That is, a stronger dollar is associated with a positive comovement on safe-haven currencies. This, in turn, is associated with a greater risk aversion, which is correlated with a CIP deviation.

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Table 4.5: safe-haven flows, residualized dollar index and CIP deviations

	IBOR basis
Δr	0.135
	(0.098)
Δr*	−0.130
	(0.285)
ΔFwd bid-ask	12.836**
	(5.696)
ΔLeverage ratio^2	0.224
	(0.283)
Δ Log VIX	0.150
	(0.212)
ΔSafe haven factor	0.330*
	(0.191)
ΔResid. Broad dollar	−0.003
	(0.031)
Observations	107
Residual Std. Error	0.286 (df = 99)

Note: this table presents regression results on correlations between 3-month Libor basis, safe haven currency factor and residuals. As in Cerutti et al. (2021), Safe haven currency factor is the first principal component of daily level of broad USD index, Japanese yen index and Swiss franc index, while Broad dollar residual is the residual for the USD equation controlling for the common factor. Sample starts at 2010 M1 and ends 2018 M11. Newey & West (1994) standard errors are reported. *p<0.1; **p<0.05; ***p<0.01

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4.6 Dollar supply-demand and the Central bank balance sheets

In table 6 I assess the importance of supply-demand factors to the IBOR basis via the portfolio rebalancing channel. The idea is that the relative size of Quantitative Easing programs by banks from advanced economies created yield differentials that induced shifts in the relative demand from bonds denominated in different currencies. For instance, one can think of a rebalancing from japanese bonds towards dollar denominated bonds of the same maturity. Since most part of this demand is FX hedged, it may potentially affect the dollar basis.

Following Cerutti et al. (2021), I add a variable that captures the relative expansion of central bank balance sheets. By defining relative balance-sheet size as the local central bank's total assets, measured in local currency and normalized by domestic M2 stock, relative to the same variable for the Federal Reserve's balance sheet, I take monthly changes in relative balance-sheet size for major central banks that engaged in balance-sheet expansion, and also for the Brazilian Central Bank.

For the Brazilian/U.S. case, the coefficient on the balance sheet factor is negative, although statistically insignificant. For the EUR/US and the GBP/US case, however, it is statistically significant. The JPY/US and CHF/US cases are not statistically significant, and so are omitted. The results suggest that QE policies from major central banks could have spillover effects upon the real/dollar basis.

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Table 4.6: central bank balance sheets and CIP deviations

	IBOR basis		
	(1)	(2)	(3)
	BR/US	EUR/US	GBP/US
Δr	0.123	0.067	0.039
	(0.105)	(0.096)	(0.083)
Δr*	−0.149	0.030	−0.054
	(0.321)	(0.294)	(0.285)
ΔDollar factor	0.339	0.420**	0.368
	(0.208)	(0.191)	(0.226)
ΔDollar residual	0.011	0.025	0.021
	(0.039)	(0.040)	(0.033)
ΔFwd bid-ask	14.212*	12.781**	12.674***
	(7.662)	(5.285)	(4.219)
ΔLeverage ratio^2	0.176	0.195	0.115
	(0.233)	(0.224)	(0.161)
ΔLog VIX	0.138	0.105	0.112
	(0.210)	(0.210)	(0.174)
ΔRelative balance sheet/M2	−0.003	−0.015**	−0.030***
	(0.009)	(0.007)	(0.008)
Observations	107	107	107
Residual Std. Error (df = 98)	0.278	0.259	0.243

Note: this table presents regression results on correlations between 3-month Libor basis, central bank balance sheets and controlling variables. As in Cerutti et al. (2021), "Δ Relative balance sheet/M2" refers to 100 times log point changes in the monthly ratio of balance sheets over M2 between foreign (BRL, EUR, GBP) central banks and the Fed. Sample starts at 2010 M1 and ends 2018 M11. Newey & West (1994) standard errors are reported. *p<0.1; **p<0.05; ***p<0.01

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5
Applications to Brazil: regulatory drivers

5.1
Quarter-end effects on the Level of CIP deviations

Banks must comply to the leverage ratio requirement, which is one of the Non-Risk-Weighted Capital Requirements, at the quarter-ends, when the balance sheet reports are published. We explore the fact that, while 3-month CIP trade always appears on one quarter-end report, only 1-month CIP trades within the last month of the quarter have to appear at it. This means that 1-month CIP trades should be more expensive at the final month of each quarter, and therefore its higher shadow cost would imply an increase on 1-month CIP deviations at the end of each quarter.

I do a similar exercise to Du et al. (2018) and test whether the BRL/USD basis exhibits quarter-end dynamics. Figure below compares 1-month and 3-month deviations, highlighting (with yellow bars) the periods within 1 month of the end of the quarter. Also, since the new regulatory restrictions have started in 2015, the difference between the two increases should be more pronounced ever since.

The figure below suggests that, within 1 month of the end of the quarter (yellow bar), both the 1-month and the 3-month CIP deviations increase towards the quarter ends, but the former seems to increase more than the latter. I follow Du et al. (2018) and test wether the difference in spikes at the quarter-end is indeed significant.

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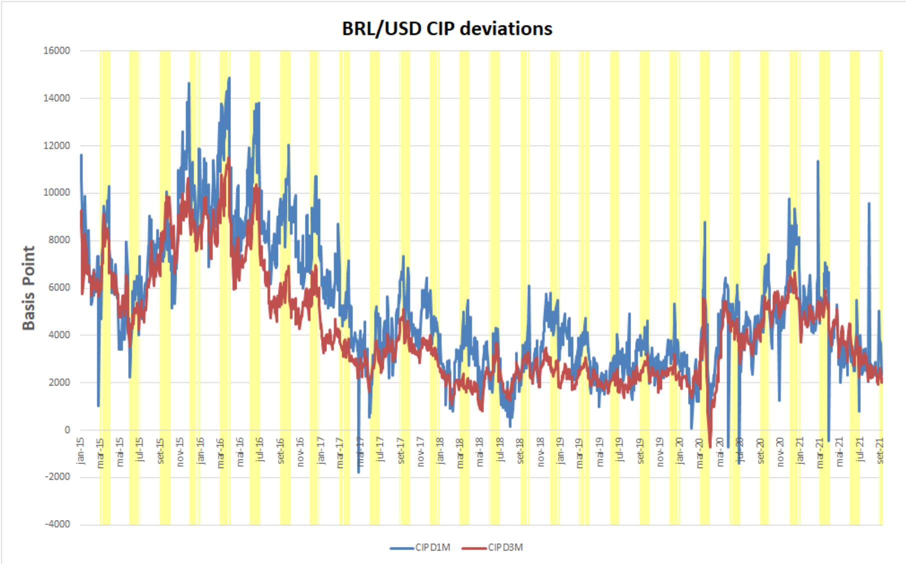

Figure 5.1: BRL/USD CIP deviations

With daily data from 05/16/2003 to 09/09/2021, I first run

$$x_{t,t+1} = \alpha + \beta_1 QEnd_t + \beta_2 QEnd_t x Post07_t + \beta_3 QEnd_t x Post15_t$$

$$+\gamma_1 Post07_t + \gamma_2 Post15_t + \epsilon_t \tag{5.1}$$

Where QEnd_t is a dummy indicating whether it is the last month of the quarter. The coefficient β_1 captures the expected mean difference in CIP deviations between quarted-ends and periods outside the end of the quarter. The coefficient β_2 captures the expected mean difference in CIP deviations between the post-2015 and the pre-2015 periods, the former being the period when the regulations were introduced. The coefficient of interest is β_3, which captures how the quarter-end effect changed since the implementation of the new regulatory restrictions. I also repeat the estimation in (7), now using the 3 month basis. The results are on table 7. Both β_3 coefficients are positive and statistically significant. This confirms our initial prediction.[5.1]

[5.1] In fact, Brazilian financial institutions have adopted the new regulation on Leverage Ratio Requirements only in 2018 (BCB's resolution 4615). I tested an alternative specification with a "post-18" dummy instead of the "post-15" one, but this worsens the result. Therefore, its is likely that, for the Brazilian case, it more important, to CIP deviations, the worldwide basel III implementation (US and Euro Area, mainly) than the Brazilian implementation.

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Table 5.1: Quarter-end effects on the level of CIP deviations

	IBOR basis	
	(1-month)	(3-month)
QEnd_t	−0.019	−0.030
	(0.027)	(0.020)
Post07_t	0.401***	0.443***
	(0.019)	(0.014)
Post15_t	−0.064***	−0.090***
	(0.016)	(0.012)
QEndxPost07_t	0.036	0.042*
	(0.033)	(0.024)
QEndxPost15_t	0.089***	0.053***
	(0.027)	(0.020)
Constant	0.146***	0.053***
	(0.016)	(0.012)
Observations	4,424	4,445
R^2	0.151	0.273
Adjusted R^2	0.150	0.272
Residual Std. Error	0.383 (df = 4418)	0.283 (df = 4439)
F Statistic	157.288*** (df = 5; 4418)	332.908*** (df = 5; 4439)

Note: reports regression results for the daily one-month and three-month Libor bases. Qendt is an indicator variable that equals one if the one-month (three-month) contract traded at t is at the last month of the quarter. Post07 is an indicator variable that equals one if the trading date t is on or after 01/01/2007 and zero otherwise. Post15 is an indicator variable that equals one if the trading date t is on or after 01/01/2015 and zero otherwise. The sample period is 5/16/2003 to 09/09/2021. Newey-West standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

5.2 Quarter-end effects on the Term Structure of CIP deviations

Finally, I want to test wether 1 month CIP deviations increase more than 3 month ones, in which case we would have evidence of regulatory constraints on the CIP basis. To do this, I define

$$ts^{BR}_{t,3M-1M} = x^{BR}_{t,t+3} - x^{BR}_{t,t+1}$$

And test the quarter-end effects on $ts^{BR}_{t,3M-1M}$, that is, on the term structure of CIP deviations:

$$ts^{BR}_{t,3M-1M} = \alpha + \beta_1 QEnd_t + \beta_2 QEnd_t x Post07_t + \beta_3 QEnd_t x Post15_t$$

$$+\gamma_1 Post07_t + \gamma_2 Post15_t + \epsilon_t \quad (5.2)$$

The coefficient of interest, β_3, is negative and statistically significant, thus confirming our hypothesis that 1-month CIP deviations increase more than 3-month ones at quarter-ends.

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Table 5.2: Quarter-end effects on the term structure of CIP deviations

	$ts^{BR}_{t,3M-1M}$
QEnd_t	−0.016
	(0.015)
Post07_t	0.039***
	(0.010)
Post15_t	−0.030***
	(0.009)
QEndxPost07_t	0.011
	(0.018)
QEndxPost15_t	−0.038***
	(0.015)
Constant	−0.085***
	(0.009)
Observations	4,423
R^2	0.014
Adjusted R^2	0.013
Residual Std. Error	0.207 (df = 4417)
F Statistic	12.685*** (df = 5; 4417)

Note: reports regression results for the daily one-month and three-month Libor bases. Qendt is an indicator variable that equals one if the one-month (three-month) contract traded at t is at the last month of the quarter. Post07 is an indicator variable that equals one if the trading date t is on or after 01/01/2007 and zero otherwise. Post15 is an indicator variable that equals one if the trading date t is on or after 01/01/2015 and zero otherwise. The sample period is 5/16/2003 to 09/09/2021. Newey-West standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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6
Conclusion

In this paper, I reviewed some of the regulatory and economic factors that, since the GFC, have limited arbitrage tradings trying to explore CIP deviations (i.e. the currency basis). In particular, I discussed that capital and leverage ratio requirements increased balance sheet constraints, which then raised the financial intermediaries costs of FX-hedging supply. I also mentioned that international imbalances and monetary policy divergence exert pressure on the cross-currency-basis via FX-hedging demand.

Then, I showed the recent evolution of the cross-currency basis at the 3-month and 1-Year maturities. We saw that the 3-month the currency basis ended the year close to zero and close to each other, perhaps as an effect of monetary policy convergence and central banks coordinated provision of dollar liquidity swap lines. Regarding the 1-year cross-currency-basis, we only identified persistent effects for the australian and new zealand dollar. Effects on the other currencies seem to be restricted to the more stressful period of march/2020.

Finally, I applied the recent literature to the Brazilian case and found that liquidity factor is a prominent macro driver of CIP deviation, and also that the short-term CIP deviations have quarter-end dynamics, which points to causal regulatory effects.

It is not clear, though, what are the policy implications of permanent deviations on the Covered Interest Parity. One possible reason for concern are the countries financial conditions. As Hong & Rhee (2019), an increase in the basis spread tightens financial conditions in net debtor countries (like Australia, the UK and the Euro Area), while easing financial conditions in the net creditor ones (e.g. Japan). This is so because net debtor countries rely on foreign funding channels, as they are unable to smoothly substitute to domestic funding channels. Hong then advocates for a sort of "hedging counterpart of last resort," that helps to stabilize financial intermediation when U.S. dollar funding markets is under stress. Still, much more work is needed on the potential negative effects of permanent CIP deviations and policy prescriptions to deal it with.

On the theoretical side, it would be nice to see the interaction of CIP

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deviations with capital flows and exchange rate determination. In a seminal work, Gabaix & Maggiori (2015) develop an exchange rate determination model where CIP always holds. Breaking this relationship and understanding the new model dynamics seems to me to be a good research project.

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A
Appendix

A.0.1
Currency codes

AUD: Australian Dollar;

CAD: Canadian Dollar;

CHF: Swiss Franc;

DKK: Danish Krone;

EUR: Euro;

GBP: British Pound;

JPY: Japanese Yen;

NOK: Norwegian Krone;

NZD: New Zealand Dollar;

SWE: Swedish Krona;

A.0.2
Cross-currency dollar basis: other maturities

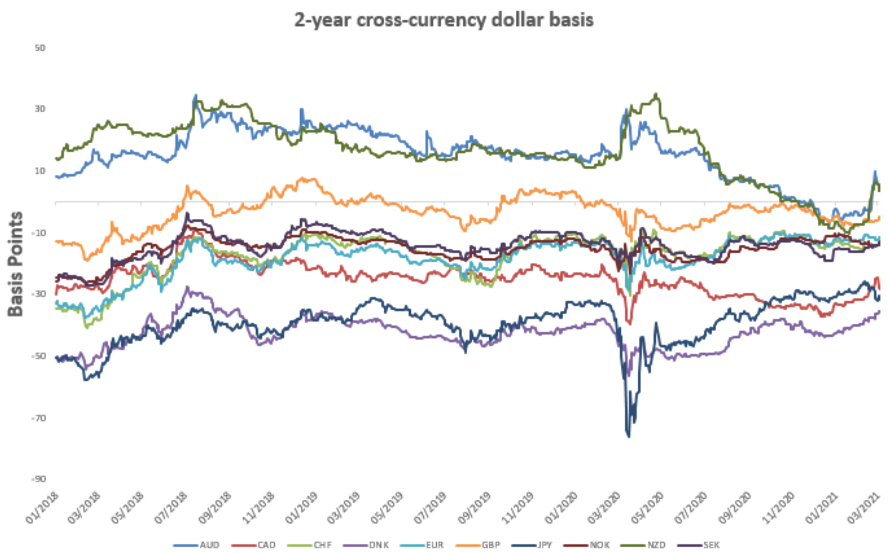

Figure A.1: 2-Year cross-currency basis

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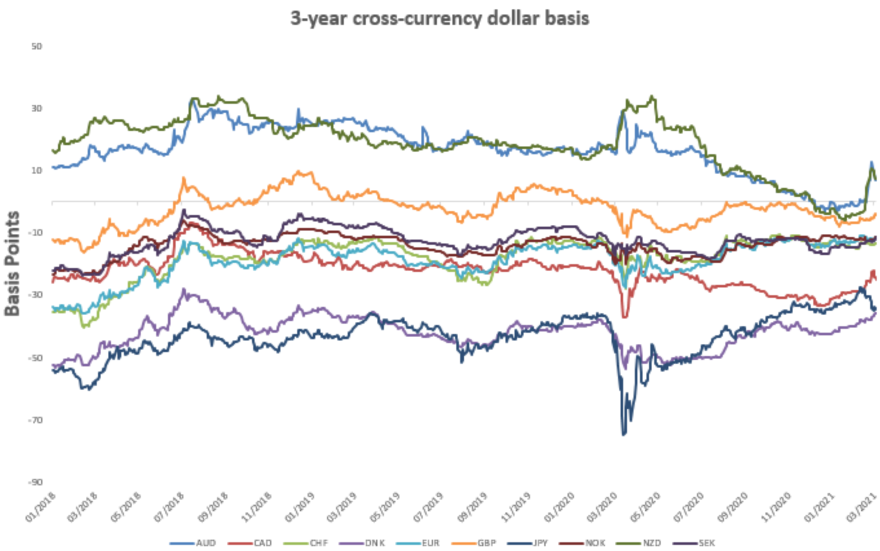

Figure A.2: 3-Year cross-currency basis

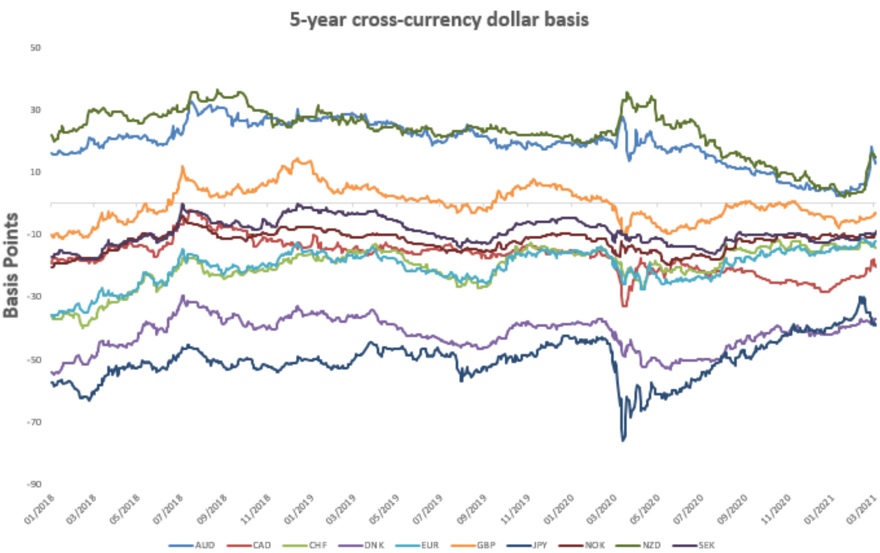

Figure A.3: 5-Year cross-currency basis

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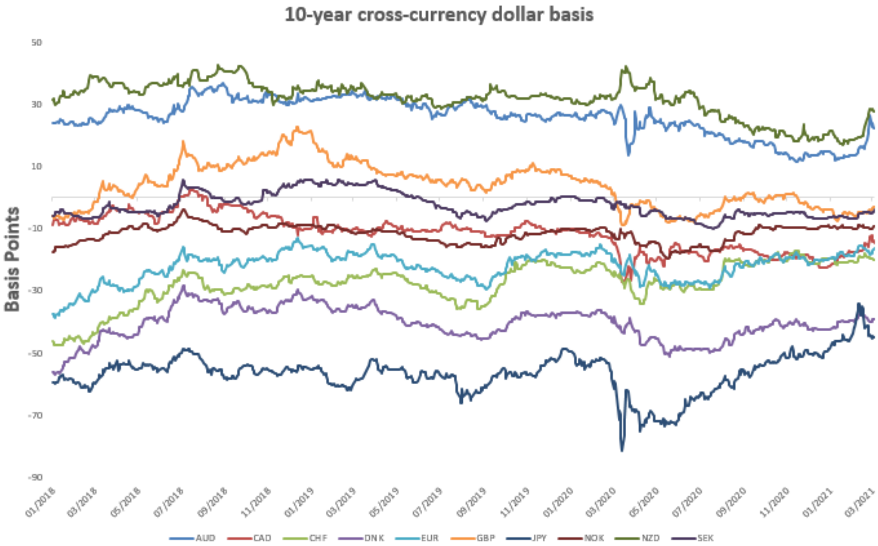

Figure A.4: 10-Year cross-currency basis

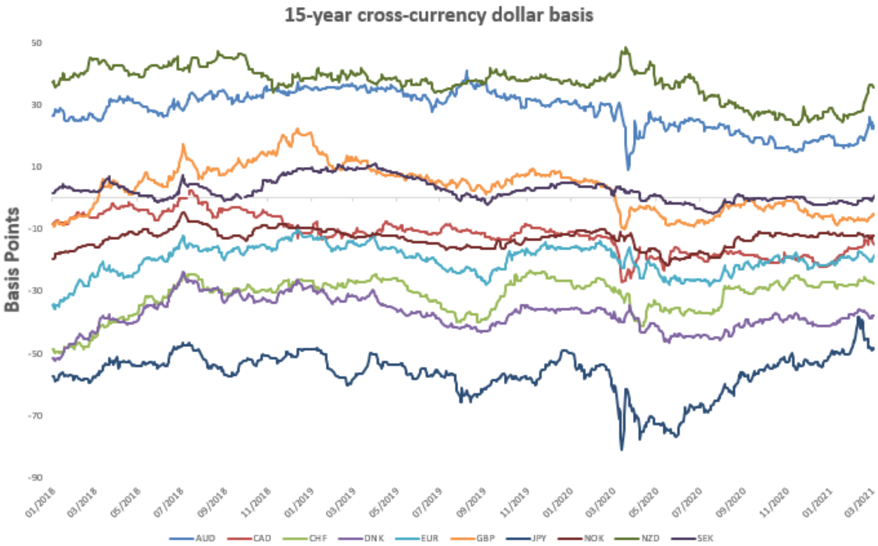

Figure A.5: 15-Year cross-currency basis

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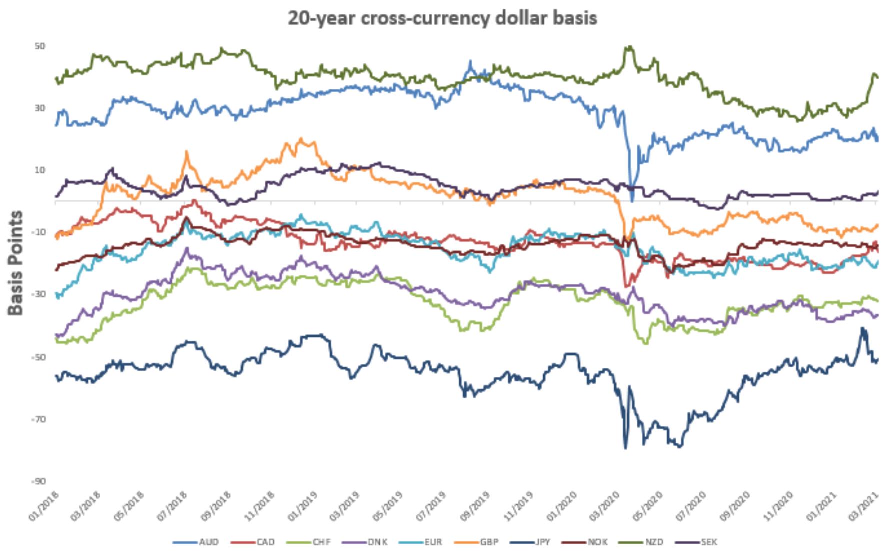

Figure A.6: 20-Year cross-currency basis

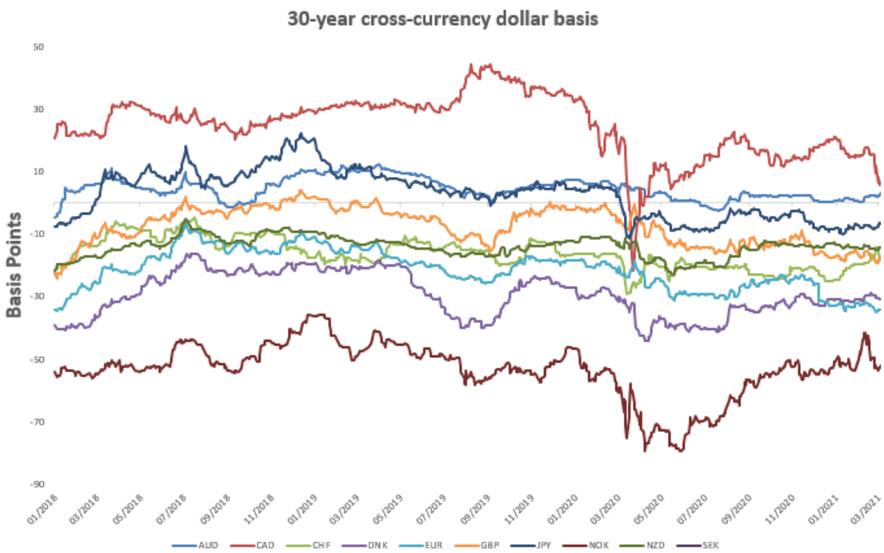

Figure A.7: 30-Year cross-currency basis

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A.0.3
Interest rate and dollar factor using the Treasury basis

Table A.1: Interest rates and CIP deviations (Treasury basis)

	Treasury basis				
	(1)	(2)	(3)	(4)	(5)
Δx	(2003-06)	(2007-09)	(2010-19)	(2020-21)	(2003-21)
Δr	0.152	0.705	0.152*	0.107*	0.124*
	(0.200)	(0.735)	(0.091)	(0.061)	(0.073)
Δr^*	−0.475	−1.101***	−0.206	−0.742***	−0.652***
	(0.430)	(0.251)	(0.196)	(0.048)	(0.162)
Constant	0.053	−0.064	0.010	−0.076*	0.008
	(0.082)	(0.118)	(0.023)	(0.045)	(0.023)
Observations	43	35	119	22	223
Residual Std. Error	0.362 (df = 40)	0.655 (df = 32)	0.232 (df = 116)	0.136 (df = 19)	0.287 (df = 219)
Note:			*p<0.1; **p<0.05; ***p<0.01		

Note: This table reports the result of simple regression of monthly changes in 3-month Brazilian dollar basis (Treasury rate) on corresponding interest rates. Samples are split to before (03–06), during (07–09), and after (10–21) the financial crisis. The period after the financial crisis is split to before (10-19) and during (20-21) the covid pandemic. The whole period is also included. Monthly averages are used. Newey and West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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Table A.2: US Dollar and CIP deviations (Treasury basis)

	Treasury basis				
	(1)	(2)	(3)	(4)	(5)
Δx	(2003-06)	(2007-09)	(2010-19)	(2020-21)	(2003-21)
Δr	0.136	0.363	0.111	0.200***	0.118
	(0.195)	(0.706)	(0.086)	(0.055)	(0.073)
Δr*	−0.413	−0.675	−0.298*	−0.755***	−0.558
	(0.381)	(0.423)	(0.167)	(0.192)	(0.157)
ΔLog VIX	−1.014**	1.668*	0.184	0.149	0.298
	(0.484)	(1.009)	(0.168)	(0.196)	(0.154)
ΔBroad Dollar	−0.106***	−0.001	0.040*	−0.030*	0.006
	(0.041)	(0.097)	(0.021)	(0.018)	(0.022)
ΔFwd bid-ask	0.812	−25.717*	11.075***	43.958***	−0.341
	(6.460)	(14.776)	(4.097)	(9.625)	(7.619)
Constant	−0.001	−0.037	0.001	−0.097**	0.008
	(0.067)	(0.097)	(0.026)	(0.040)	(0.021)
Observations	43	35	119	22	223
Resid.Std. Error	0.312 (df = 37)	0.473 (df = 29)	0.247 (df = 113)	0.109 (df = 16)	0.296 (df = 216)

Note: This table reports the result of a regression of monthly changes in 3-month Brazilian dollar basis (Treasury rate) on corresponding interest rates along with a number of control variables. Samples are split to before (03–06), during (07–09), and after (10–21) the financial crisis. The period after the financial crisis is split to before (10-19) and during (20-21) the covid pandemic. The whole period is also included. Monthly averages are used. Newey & West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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Table A.3: US Dollar and CIP deviations (controlling for Embi+ BR)

	Libor basis				
	(1)	(2)	(3)	(4)	(5)
Δx	(2003-06)	(2007-09)	(2010-19)	(2020-21)	(2003-21)
Δr	0.094	0.076	0.071	0.232***	0.084
	(0.191)	(0.599)	(0.070)	(0.065)	(0.062)
Δr*	−0.284	0.149	−0.104	−1.033***	0.066
	(0.316)	(0.120)	(0.188)	(0.112)	(0.071)
ΔLog VIX	−1.014***	1.219**	0.015	0.042	0.200
	(0.383)	(0.481)	(0.155)	(0.086)	(0.152)
ΔBroad Dollar	−0.112***	0.008	0.008	0.013	0.001
	(0.038)	(0.053)	(0.032)	(0.014)	(0.021)
ΔFwd bid-ask	2.775	−18.255**	11.182***	46.198***	0.579
	(4.506)	(9.154)	(4.191)	(14.001)	(6.536)
ΔEMBI BR	−0.0001	−0.003**	0.004*	−0.003***	0.0001
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Constant	−0.018	0.044	−0.002	−0.110***	0.007
	(0.037)	(0.100)	(0.022)	(0.030)	(0.019)
Observations	43	35	119	22	222
Residual Std. Error	0.250 (df = 36)	0.368 (df = 28)	0.225 (df = 112)	0.121 (df = 15)	0.277 (df = 215)

Note: This table reports the result of simple regression of monthly changes in 3-month Brazilian dollar basis (Libor) on corresponding interest rates. Samples are split to before (03–06), during (07–09), and after (10–21) the financial crisis. The period after the financial crisis is split to before (10-19) and during (20-21) the covid pandemic. The whole period is also included. Monthly averages are used. Newey and West (1994) standard errors are reported: *p<0.1; **p<0.05; ***p<0.01

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Table A.4: Term premium and CIP deviations

	IBOR basis		
	(1)	(2)	(3)
	(BR/US)	(EUR/US)	(GBP/US)
Δr	0.094	0.133	0.126
	(0.115)	(0.105)	(0.111)
Δr*	−0.287	−0.112	−0.145
	(0.358)	(0.308)	(0.304)
ΔDollar factor	0.394	0.342*	0.344*
	(0.203)	(0.195)	(0.197)
ΔDollar residual	0.011	0.011	0.009
	(0.047)	(0.040)	(0.042)
ΔFwd bid-ask	19.759	13.629***	12.900**
	(15.274)	(5.288)	(6.176)
ΔLeverage ratio^2	0.198	0.200	0.186
	(0.246)	(0.219)	(0.246)
ΔLog VIX	0.181	0.156	0.142
	(0.251)	(0.220)	(0.224)
Δ(tp-tp*)	−0.003	−0.183	0.023
	(0.017)	(0.230)	(0.320)
Observations	101	107	107
Residual Std. Error	0.294 (df = 85)	0.238 (df = 98)	0.282 (df = 98)

Note: this table presents regression results on correlations between 3-month Libor basis, term premium and controlling variables. As in Cerutti et al. (2021), "$\Delta(tp - tp^*)$ refers to changes in one-year yield (nine year forward) differential between domestic and US. Sample starts at 2010 M1 and ends 2018 M11. Newey & West (1994) standard errors are reported. *p<0.1; **p<0.05; ***p<0.01

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