Persistence of Covered Interest Rate Parity Deviations

a macroeconomic story of global capital flows, banking regulation, and financial frictions

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Abstract

In this paper I review literature investigating the recent finding of persistent deviations from Covered Interest Rate Parity. I argue with evidence from empirical research papers, that there are various macroeconomic factors contributing to the phenomenon. Most factors are tightly connected to the balance sheets of the agents functioning in the FX market, for which the US Dollar plays a pivotal role. One view is that post-crisis banking regulation drives the deviations in the short run. Another view is that the deviations arise in the first place from imbalances in FX hedging demand of US Dollar. A model that I review explains the deviations with financial frictions arising because of more cautious risk management. A compromise in the middle is that the factors in the demand side of USD hedges open the deviations, and the tightened regulation and risk management raises the costs for arbitrageurs to close them.

This paper does not contribute to the existing literature with any new findings. The purpose is rather to combine a few convincing findings of the literature, pointing towards the phenomenon being not only a consequence of one simple exogenous factor, but rather an inefficiency that is affected by various macroeconomic factors.

Keywords Covered Interest Rate Parity; Foreign exchange market; Macroeconomics; International economics; International capital flows; Financial frictions; Banking regulation; Risk management
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1 Introduction

Covered Interest Rate Parity (CIP) is a mathematical condition that was for a long time deemed as “the closest thing to a physical law in international finance” (Sushko et al., 2018). It is a no-arbitrage condition, which has throughout history been the cornerstone for pricing of currency instruments. This paper reviews some important contributions to the growing literature trying to identify the main drivers of the failure of the condition and connect it to recent developments in the global economy.

Deviations of the CIP have after the Global Financial Crisis of 2007-08 (GFC) persisted at high levels even if the crisis is just a memory these days. This implies that there has happened a substantial change in the global capital markets and the macroeconomy. Du and Schreger (2021) argue that the CIP deviations are an important health barometer of global capital markets, and that the breakdown of CIP has put financial frictions and intermediary constraints at the heart of international finance, and macroeconomics. Du, Tepper and Verdelhan (2018) suggest that the CIP deviations may have led to important deadweight losses in the economy. Vast majority of the research on the topic however concentrates on the causes and drivers of the deviations, rather than their consequences. Welfare effects are thus out of this papers’ scope.

Foreign exchange (FX) market is a complex system, where the exchange rates of currencies are affected by various drivers, and the agents involved in the currency trade have different means. The over-the-counter (OTC) derivative market around the currencies has increased massively in size in the recent decades, and global imbalances in the demand and supply of these derivatives has been identified as one of the main drivers of the CIP deviations. Sushko et. al. (2018) identifies two types of agents taking part in these markets, which this paper is specially interested in: Preferred Habitat investors (banks, institutional investors, corporate bond issuers) who need to hedge against the currency risk involved in their investments, and “arbitrageurs” (predominantly banks) who seek to exploit the profits available from covered arbitrage. The fact that banks have a dual role in the market, complicates things a little: banks are both in the supply and demand side in the market.

The US Dollar (USD) has a very central role in the FX markets, and measures for its strength have been found to correlate strongly with the deviations (Avdjiev et al., (2019), and Cerutti et al., (2021)). Another important finding has been that the post-crisis regulatory changes appear to have a causal relationship with the deviations. This is found first by Du et al., (2018), where the researchers argue that the phenomenon could be a concrete example of the trade-off between the stability and efficiency of financial markets. Furthermore, central banks’ monetary policy is by the likes of Borio et al. (2016) identified as an important short-run driver of the deviations, making the topic an example of international transmission of monetary policy.
All in all, everything mentioned in the previous chapter is very much connected to the balance sheets of the agents involved in the market – the “arbitrageurs” in the supply side are unable to exploit the “free lunches” in front of them because of exogenous constraints on their balance sheets, and this appears to lead to the deviations of the parity. Another theory is that these “shadow costs” to the agents’ balance sheets are not only exogenous but arise endogenously in relation to the quantity in which an agent demands currency for hedging purposes (Sushko et al., 2018).

There are various limitations to the research around the subject. Macroeconomic researchers make simplifying assumptions of the world and admit that their models may leave some important factors out of their equations. The world also changes constantly, and previous research may not always give a truthful picture of the present time. A difficulty with writing this paper is the slight polarization in the research: in both short and long maturities, the CIP fails, but the researchers have differing views on which factors can explain the persistence of the deviations. Sushko et al. (2018) builds a long-run model for the equilibrium forward rate of USD, which is presented in this paper. This model neglects the possibility of the constraints on liquidity affecting the long-term deviations, hence their persistence. Du and Schreger (2021) in other hand view the more binding post-GFC leverage ratio requirements as a key factor explaining the persistence of the deviations. Borio et al. (2016), a paper from the same authors as the Sushko et al., describes the regulatory factors not as drivers that open the deviations, but as ones that cannot close them. This thesis follows the same conclusion.

The paper is organized as follows: Second section presents the most important characteristics of foreign exchange. Third section introduces the theory of interest rate parity, and particularly concentrates on the Covered Interest Rate Parity condition, such as its “success” all the way up until the GFC. Fourth section is devoted to the finding of persistent CIP deviations. Fifth section treats the US Dollar. Sixth section presents an equilibrium of the FX derivative markets. Seventh section discusses the findings. Eight section concludes. The last page is an appendix for abbreviations used.
2 Foreign exchange market

Bank of International Settlements (BIS), a financial institution owned by 63 central banks, publishes a survey of the FX markets every three years. This section’s information is based on the April 2019 survey. Globalization, digitalization, and financial innovations have made foreign exchange what it is today – one of the largest, most liquid, and most perfectly competitive markets in the world, open 24 hours a day. There are currently 180 currencies in circulation. As it is not efficient to have a currency pair for every possible combination, a selected few have prevailed as “currencies of the currencies”. US Dollar continues to be the vehicle currency as a legacy of the Bretton Woods system (1945-1971), where the USD was fixed in the value of gold, and all major currencies were pegged to it. In April 2019, the USD was on one side of 89% of the FX trades. Few other very important currencies are in order of their turnover share the euro (32%), the Japanese yen (17%), and the British pound (13%). All the major currencies are nowadays allowed to float freely in the market. The daily total turnover of the FX trades measured in USD was on average 6.6 trillion in April 2019.

The currencies are not only traded directly at the current rates. Most of the trades are done using over-the-counter (OTC) derivatives. BIS divides the currency instruments in the following six categories: Spot transactions are transactions involving the exchange of two currencies at the prevalent market rate, agreed for value or delivery within two business days. Outright forwards are contracts where the exchange of two currencies is agreed to some time in the future at a certain rate. Foreign exchange swaps (FX swaps) are transactions involving the exchange of two currencies at the market price, and an agreement to reverse the exchange in the future at a certain rate. Currency swaps are contracts where the counterparties exchange interest in one currency for the same in another currency. OTC options are contracts that give the right to buy or sell a currency at a specified rate during a specified period. Other products are derivatives that do not fit in the previous.

Today, the most important of these instruments are the FX swaps, accounting for 49% of the daily turnover. Direct spot trades come second at 30%, and outright forwards third at 15%. The rest account for less than 5%. The importance of the FX swaps can be explained by them being the most efficient way to hedge against currency risk that comes with investing in assets denominated in a foreign currency. The pricing of the FX swaps is also easy, because it is based on available forward quotations, and thus the covered interest rate parity condition is satisfied (Bartolini, 2002).
3 Covered Interest Rate Parity

3.1 Conceptual framework

As stated in *Macroeconomics* by Burda and Wyplosz (2017), the interest rate parity condition lies behind the determination of interest rates and nominal exchange rates in the short run. This condition requires that the returns on similar assets in different countries and/or currencies cannot be systematically different. The interest rate parity, essentially the short run equilibrium condition of the international financial markets, can be further divided in two: Covered Interest Rate Parity where the exchange risk is eliminated by using a forward contract, and Uncovered Interest Rate Parity, where the investment is left unhedged, and the investor carries currency risk. This work will only concentrate on the former.

Among the first to present the Covered Interest Rate Parity in systematic form was John Maynard Keynes in his work “A Tract on Monetary Reform”, published in 1923. As quoted by many economists such as Peel and Taylor (2002) & Cerutti *et al.* (2021), Keynes wrote:

*“forward quotations for the purchase of the currency of the dearer money market tend to be cheaper than spot quotations by a percentage per month equal to the excess of the interest which can be earned in a month in the dearer market over what can be earned in the cheaper.”* (Keynes, 1923, p. 103)

This can be grasped better through a mathematical equation, and an example:

\[
(1 + i) = (1 + i^*) \frac{S_t}{F_t} \quad (1)
\]

where \(i\) stands for the domestic interest rate, \(i^*\) for the foreign interest rate, \(S_t\) for the spot exchange rate, and \(F_t\) for the outright forward exchange rate, both in present time \(t\). The interest rates and the exchange rates are nominal, and the latter can be expressed in British terms – as foreign currency per domestic unit, or European terms – as a domestic currency per foreign unit.

Consider Finnish investors seeking for very certain investment opportunities. They could earn the left-hand side of the equation 1 by investing in a domestic nearly riskless asset denominated in euro. However, they notice that a similar asset denominated in Swedish krona promises higher interest. They make a FX swap contract to hedge against the currency risk and proceed with the investment. In the end they should notice that because they paid a price for the hedge, they earned the same as if they had invested domestically. So as a definition, arbitrage should be impossible according to the CIP.
The condition seems almost a little too good to be true, and that indeed is the case. Deviations of the parity have been documented through history, but they were especially in the post-war era considered economically meaningless, as the FX market functioned extremely efficiently and arbitraged them away. This was the truth all the way until the Global Financial Crisis of 2007-08. What followed, is a persistent phenomenon of deviations of the parity.

Cross-currency basis measures the size of the mentioned deviations. It indicates the difference in the interest paid between borrowing one currency by swapping it against another and directly borrowing it in the cash market (Borio et al. 2016). Stated mathematically:

\[
(1 + i) = (1 + i^* + b) \frac{S_t}{F_t}
\]

where the variable \( b \) is the measure for the cross-currency basis, simply introduced to the equation 1. The value of \( b \) can be either positive or negative.

### 3.2 History of the CIP deviations, and arbitrage exploiting them

Generally, the Covered Interest Rate Parity has been regarded to hold if the foreign interest rate is risk free, and there’s no counterparty risk regarding the forward contract (Du et al., 2018). Pioneers of the currency trade were however able to notice that some windows for arbitrage exploiting the deviations of the CIP did from time to time open. The before noted J.M. Keynes, and Paul Einzig, an economic writer inspired by Keynes’ work, made the most important contributions to the literature before the Second World War. Peel and Taylor (2002) review the works of the two, and test whether their observations of the FX market in the interwar period were correct with actual data of the 1920s money markets of London and New York, to which is mostly thanking Einzig who presented comprehensive data tables of currency rates in his book *World Finance* (1937).

Keynes and Einzig agreed that deviations of the CIP were not arbitraged away unless the profit available exceeded 0.5%, or 50 basis points. They further saw that even then the arbitraging progressed slowly because the supply of funds was inelastic due to limits on banks’ liabilities, and other market inefficiencies. Peel and Taylor named this two-part notion the *Keynes-Einzig conjecture* and validated it by conducting the first empirical test of the time’s FX market using nonlinear econometric methods. Results of their Univariate Threshold Autoregression Regression Model, and a Multivariate Threshold Vector Error Correction Model cannot reject the Keynes-Einzig conjecture. The modern FX transactions are much faster and more cost-efficient than around 100 years ago, contain arguably less political risk, and overall, the world is completely different. Either way, the conclusions of Keynes and Einzig regarding the elasticity of the supply-
side and slow arbitraging of the CIP deviations still appear to be the best guess of many economic researchers in the big picture, as will be shown in later sections.

Literature in the post 2nd World War era seems to have reached a consensus of CIP deviations arising, but them being arbitraged away very quickly by the arbitrageurs in the market. Thus, the textbook explanation was for decades that the CIP generally holds. Deviations of the parity were often documented, but they were explained away by for example data imperfections.

Mark P. Taylor (1987a) finds evidence supporting the market efficiency hypothesis, and the CIP by using London FX market high frequency data. Taylor doesn’t find a single profitable arbitrage opportunity by phoning a London broker every 10 minutes for a 3 days’ time, and simply counting whether covered arbitrage would have been profitable. The same author conducted another study (1989b), where examining the FX markets in times of economic turbulence he found, that small and potentially profitable covered arbitrage opportunities did arise, but that they still were not enough to reject the CIP, as they could be explained away by the existence of credit limits and implicit liquidity constraints, characteristics of times of crises.

Akram, Rime and Sarno (2008) argue that Taylor’s “landmark study” of 1987 has some flaws such as its short period, and low time frequency – to improve it, they provide to their knowledge the first empirical test using high-frequency tick data. Using Reuters data of 2004, they find that positive economically meaningful deviations of CIP do arise, but that they are very short-lived, and arbitraged away almost instantaneously. Based on this, they argue that the FX market is efficient, CIP deviations are simply a verifier of Grossman-Stiglitz’s ‘arbitrage paradox’ (if there was never arbitrage, no-one would watch the market), and that a macro-finance researcher using low-frequency data could safely assume that the CIP holds. Akram et al. unfortunately jinxed the economy at this time, as the market famously crashed in 2007-08, and seems to have for the time being washed away the CIP.

**Box 1: Covered arbitrage in modern times (Du and Schreger, 2021)**

Covered arbitrage has throughout the time provided small, but sure profits for the arbitrageurs. Annualized profits of 3-month CIP arbitrage are on average around 20 basis points (0.2%). In comparison, the uncovered arbitrage, also carry trade or UIP arbitrage, can be expected to yield significantly larger profits, up to 5% annually. The main difference between these two strategies is the risk involved in them. The profits of covered arbitrage are known beforehand, whereas the uncovered arbitrage is uncertain by nature. Sharpe ratio (financial metric measuring the performance of an investment comparing it to a riskless one) of uncovered arbitrage is around 0.54, whereas for covered arbitrage it approaches infinity. Covered arbitrage is thus a free lunch in the market, but requires a lot of capital, limiting the number of agents able to practice it.
4 Deviations of Covered Interest Rate Parity

4.1 Failure of Covered Interest Rate Parity during the Global Financial Crisis

GFC, the most severe crisis since the Great Depression of 1930s, is considered to have happened because of a combination of United States housing bubble (and especially the complicated derivatives linked to mortgage loans), excessive risk-taking by banks, and loose financial regulation after decades of deregulation process starting from the 1970s (Crotty, 2009). The research on the effects of the crisis on FX markets makes the following important notions: the CIP deviations spiked to record high basis points, as a combination of US Dollar funding shortages and increased counterparty risk. The Federal Reserve direct swap lines (agreements granting access to European & Swiss Central Banks to lend dollars directly from the Fed) reduced the size of the deviations significantly.

Baba, Packer and Nagano (2008a) find that the instability of the financial markets created turbulence in the money market, and that this turbulence spilled over to the FX markets. Since the financial institutions around the world owned assets linked to the crisis, many started to have US Dollar funding shortages in the second half of 2007. This resulted in increased demand for currency instruments, and hence deviations of CIP. Baba and Packer (2009b) further investigate the deviations during the crisis in a second paper, using Exponential Generalized Autoregressive Conditional Heteroskedastic Model regressions. Firstly, they find that increased counterparty risk resulted in bigger CIP deviations: Credit default swaps (CDS) of dollar Libor measuring the counterparty risk in different areas have positive statistically significant relationship with the CIP deviations. Secondly, they show that direct swap lines introduced to facilitate overseas money operations reduced the size of the CIP deviations: variables measuring the Fed swap lines’ impact have statistically significant negative relationship with the deviations. Time frame of the work of Baba and Packer is a period before the bankruptcy of Lehmann Brothers, which further deepened the severity of this ‘dollar crunch’. Role of the dollar in global lending is assessed more closely in Section 5.

4.2 Puzzling persistence of the CIP deviations: not explainable by credit risk

As we know from Taylor (1989b), the deviations from the CIP is a phenomenon that has throughout the time been linked to uncertain times and financial crises. The years after the GFC have been rather turbulent, containing some negative developments (e.g. Eurocrisis), but not turbulent enough to explain away the phenomenon of persistent deviations from the CIP in the relatively stable times of 2014-2019. This has turned the spotlight on the century-old theory, as researchers all over the world wonder what could possibly explain the persistence of the deviations.
Figure 1: Three-month Libor basis: January 2002-December 2020 (Cerutti, Obstfeldt, Zhou 2021)

Figure 1 depicts the CIP deviations of 10 big currencies (against US Dollar) from years 2002-2020, using their 3-month Libor rates (indicative Eurocurrency deposit rates based in London) as a reference (this graph is a recent update of a graph made by Du, Tepper and Verdelhan in 2018). It’s evident that the deviations have increased significantly in size since 2007, and never returned to the pre-crisis time of near-zero cross-currency basis. The big spike of 2008 is the climax of the financial crisis around the time when Lehmann Brothers had declared bankruptcy – the cross-currency basis reached record-high -200 basis points. In 2012, the spikes are likely linked to the Eurocrisis. Covid-19 crisis of 2020 sees a big spike in the basis as well, interestingly opposite to the GFC (the post-2019 characteristics of the deviations are out of this paper’s scope). Some other notions from the graph are that Australian and New Zealand Dollars have positive cross-currency basis, opposite to the rest of the lot (explanations in Section 6.2). Du et al. also find the cross-currency basis to persist at longer maturities, by measuring the cross-currency basis swaps (xccy) of the same currencies. The xccy’s are used more often for longer maturities, than the more usual direct swaps.

Du et al. demonstrate that two possible riskless covered arbitrage strategies both at short and long maturities would have been profitable in years 2009-2016. Based on this, authors argue that credit risk cannot explain away the CIP deviations. As most researchers, Du et al. use the indicative Libor rates to measure the CIP deviations. They in contrary to Baba and Packer (2008) regard counterparty risk of secondary importance for the pricing of currency instruments, because of their high degree of collateralization. They do however raise concerns on Libor rates’ indicative
nature, and default risk. Regressing the weekly changes in 5-year credit risk of banks (CDS spread) against the changes in Libor xccy swaps of currencies they find no clear evidence for credit risk explaining the deviations. They anyway take the hypothetical credit risk in account, and test using general collateral repo rates (short-term) and AAA-rated German KfW bonds (long-term), which are fully backed by the German government, whether different profitable arbitrage strategies would have been possible. The strategies end up being successful with both two of the two nearly riskless assets, and thus the possibility of credit risk explaining the CIP deviations is neglected.

Du et al. proceed to present 2 potential explanations for the phenomenon: post-crisis banking regulation and international imbalances in investment demand and funding supply.

Sushko, Borio, Iqbal, McCauley and McGuire (2018) in hand examine the term structure of the CIP deviations to find out what could drive them, to form their hypothesis. Conducting a principal component analysis (PCA), they find that most of the variance (on average 69%) in the deviations is explained by one single factor for the deviations of EUR/USD, USD/JPY, and AUD/USD. A second factor explains on average around 17% of the variance for the same currency pairs. To link this to the drivers of the deviations, Sushko et al. determine the most important latent factors, and find out that the first factor, proxied by the level of the deviations, is correlated with FX hedging demand imbalances in currencies against the USD, whereas the second factor, proxied by the slope of the CIP deviations, is correlated with measures of risk and liquidity.

The following sections will try to validate the 2-part prediction of Du et al., (2018) and provide economical evidence for the results of the PCA-analysis of Sushko et al., (2018) (including their own) starting from the central role of US Dollar, whereafter discussing the supply and demand sides of the FX derivative markets separately and finishing with the equilibrium model for the forward rate of USD by Sushko et al. (2018).

5 US Dollar: Protagonist of the FX Markets

This section treats the US Dollar, and how its strength is connected to the CIP deviations and global capital flows. Since the US Dollar plays such a centric role in the FX markets, its relationship with the CIP deviations is a well-researched topic and provides a good starting point for the analysis. The strength of the USD can best be tracked by broad dollar, a trade-weighted index updated by the US Federal Reserve, attempting to measure the competitiveness of the USD against other currencies.

Avdjiev, Du, Koch and Shin (2019) establish a triangular relationship between the strength of the USD, the CIP deviations, and cross-border dollar flows. When the dollar strengthens, CIP deviations increase, and the cross-border dollar flows contract. This points towards the strength
of USD being seen as a global risk factor. Something linked to the balance sheets of the agents involved in the trade of USD and USD nominated assets appears to drive the deviations.

Firstly, Avdjiev et al. prove that there is a negative, statistically significant, and economically meaningful relationship between the strength of the broad dollar, and the CIP deviations. In time series, regressing the changes in the cross-currency basis on changes in the dollar index and changes in bilateral USD exchange rates, controlling for risk factors such as the VIX (a famous ‘fear index’ measuring volatility of stock market), authors find that dollar appreciation is associated with more negative CIP deviations. The coefficients for the bilateral rates in other hand are statistically insignificant, which implies that the idiosyncratic risk of the fluctuations of other currencies do not drive the CIP deviations. Also, the VIX is statistically insignificant, implying that the stock market volatility does not have a big effect.

Assessing the broad dollar in cross-section, Avdjiev et al. find it to have positive relationship with the average cross-currency basis, suggesting that the strength of the USD acts as a risk factor which is priced in in the currency rates. Using BIS locational banking statistics, they further find that the strength of the USD is negatively correlated with cross-border bank credit. That will say, the appreciation of dollar raises the value of USD nominated assets, making it more expensive to hold them in the banks’ balance sheets. Thus, an appreciation of the dollar should at the same time make the ‘safe haven’ currencies appreciate, which could widen the CIP deviations. Cerutti et al. demonstrate this to be true by regressing the USD Libor basis against variables recording the global asset price movements and the primary dealer squared leverage ratio. These factors’ effects vary a little through time and in different currencies but provide the necessary evidence for the authors to conclude that there are various monetary and financial drivers of the basis, complementary to the broad dollar - some reflecting risk-taking capacity (appreciation of USD is associated with greater risk aversion globally as the eyes turn to ‘safe haven currencies’), and others exchange-market liquidity (leverage ratio indicates pressure on risk-taking capacity). Cerutti et al. also measures the importance of the relative size of non-US central banks’ balance sheets, and the premium of dollar (if higher price on hedging dollar, less foreign demand on US
assets). They find that increase in the non-US central bank balance sheet sizes makes the CIP deviations bigger and a rise in the USD premium makes them smaller in hand.

Evidently, the findings of this section point strongly towards costly balance sheets of the agents involved in the trade of USD explaining the CIP deviations. Next, the attention is given to the agents on supply and demand sides of the FX derivative market, and the economic developments that have affected them post-GFC. An equilibrium model of the markets is presented.

6 Equilibrium of the FX markets

6.1 Supply-side: banks and their regulatory environment

Banks are on the supply side of the FX market, selling currency instruments and thus arbitraging the market. This subsection treats the proposed regulatory factors affecting the banks liquidity, and thus allegedly causing the CIP to not hold. Du et al. (2018) presents the first evidence of a causal relationship between the post-crisis banking regulation (presented in Box 2 below) and the CIP deviations. The regulation has a direct effect on banks, but also spillover effects on other agents.

Box 2: Post-crisis banking regulation (Du et al. 2018 & Du and Schreger 2021 & BIS 2018)

To prevent the behaviour that led to the development of the Global Financial Crisis, the financial regulation has been tightened, and a host of disincentives for banks to take risk have been introduced. The Basel Committee on Banking Supervision (under BIS) from time to time updates their recommended regulations for the banking industry, referenced as the Basel Accords. These recommendations are voluntary but followed by important institutions such as the Fed and the European Central Bank. After the GFC, the prevailing Basel II was deemed insufficient, and Basel III was introduced. As a response to the shortcomings of its predecessor, the 3rd accord includes recommendations to increase minimum capital requirements and holding of high quality liquid assets, and to decrease bank leverage. Basel III requires the following leverage ratio:

\[
\text{Leverage ratio} = \frac{\text{Tier 1 Capital}}{\text{Total exposure}} \geq 3\%,
\]

where “Tier 1 Capital” is equity and earnings preserved at end of reporting periods, and “Total exposure” everything else. At the end of the reporting periods, leverage ratio is recommended to be disclosed at minimum.

After the Basel III, the Bank of International Settlements has introduced a framework for the global banks of systematical importance (G-SIB), where based on their financial reports, the banks are scored and divided in different buckets, where depending on their score, they face a different higher loss absorbency (HLA) requirement, Tier 1 Capital as a % of risk weighted assets (RWA).
participants in the market, such as hedge-funds and money market funds, as the big volumes required for covered arbitrage force for example hedge-funds to lend capital from the banks.

Du et al. (2018) test the impact of the leverage ratio requirements using a difference-in-difference test, where they regress the weekly and monthly cross-currency basis of currencies against an indicator variable taking the value 1 if the settlement of a derivative contract is within the last week or month of the reporting period, and its maturity date is in the following period. Dummy variables that take in account the overall increase of the cross-currency basis post-2007, and the implementation of the post-crisis regulation in 2015, are also included. Findings are that in the end of reporting periods, the indicators have positive and statistically significant coefficients: deviations of CIP increase in quarter-ends, when the banks face tighter constraints. Authors do not provide concrete evidence on which exact part of the regulation affects the deviations but conclude it anyway to have a causal effect on them based on this empirical finding of period-end dynamics of the CIP.

In the same paper, Du et al. shows that banks’ balance sheet constraints account for two thirds of the CIP deviations. Financial institutions have after 2015 increased their IOER federal fund arbitrage to improve their liquidity coverage ratio – that will say, the big global institutions lend money from smaller ones, and then proceed to earn a risk-free profit from the central bank IOER’s. Using the differential between IOER-rates (higher than for example OIS or repo) and market rates as a proxy for the shadow cost of balance sheet constraints, Du et al. shows that the institutions’ adjustments allocate capital that could be used for covered arbitrage to just being deposited at central banks. They even further show that costly financial intermediation results also in spreads in other near-arbitrage asset classes, correlated with the CIP deviations.

Cerutti et al. (2021) shows that the regulations imposed on the Global Systematically Important Banks (G-SIB) in 2016 have further increased the pressure in the FX market and widened the CIP deviations. Banks exploit loopholes in the regulation to reduce the size of their balance sheets by “window dressing” around the ends of reporting periods. By doing this, they avoid being subjected to a higher “bucket” of surcharges. Using an event study, Cerutti et al. demonstrate that the three-month forward contracts registered in late September and trades completed in late December, that do not enter the banks’ balance sheets in the same year, increase the magnitude of the CIP deviations.

Sushko et al. (2018) agrees with Cerutti et al. on G-SIB window-dressing driving the CIP deviations around reporting days but raises critical concerns on the conclusions of the likes Du et al. (2018) about the leverage ratio regulation’s direct importance for FX markets. They remind that FX swaps are treated off balance sheet, and thus argue that the existing literature explaining the quarter-end deviations by tightened leverage regulation has made a mistake: according to them only 1% of the FX forward positions are counted to the exposure calculation under the leverage ratio,
which as of January 2015 must be publicly reported by international banks. Sushko et al. are more confident that the quarter-end dynamics can be attributed to developments in the repo markets, which are treated in Box 3 below.

**Box 3: Repo markets and quarter-end characteristics (Sushko et al. 2018)**

Repurchase agreements (repos) are short term collateralized loans, used to raise capital by banks, for example overnight. The central banks also participate in the repo market by conducting open market operations to control the supply of money. Unlike derivatives, repos are included in the banks’ balance sheets. Banks in Europe and Japan thus participate less in the repo market around quarter-ends, to better their scores in the financial statements. This forces the repo rates denominated in euro and yen to momentarily turn negative, which switches the eyes of the banks on US Dollar, as they seek for higher yields. They need access to USD, so they conduct more FX swaps. So, in fact the quarter-end characteristics are a consequence of the regulation, but instead of them being directly connected to the FX markets and the leverage ratio from the supply side, they appear to follow from spillovers of repo markets, leading to a positive demand shock in the market for FX hedges.

Sushko et al. take a longer-term approach and admit that the changes in liquidity factors resulting in quarter-end anomalies can drive the CIP deviations, but most likely only in the short run. Going back to the PCA analysis conducted by the same authors (introduced in section 4.2), the second factor of the CIP deviations, the slope of their term structure, was correlated with the measures of liquidity and risk. As these drivers were not in line with the first factor, proxied by the imbalances in FX hedging demand (discussed in the next subsection), Sushko et al. argue that the persistence of the CIP deviations thus hardly follows from the leverage ratio requirements, affecting the supply side of FX hedging more than the demand side. If the arbitrage was completely risk-free, the prices (CIP deviations) should not respond to quantities (hedging demand imbalances).

Judging by the findings of Du et al. and remembering the findings of Avdjiev et al. (2019) and Cerutti et al. (2021) in section 5, it is certainly true that the liquidity factors and the post-crisis regulations’ effect to them play a big role in the big picture. However, research does not completely agree with the foundations of the quarter-end anomalies of the CIP deviations. Regulatory factors seem to make it less profitable for banks to practice covered arbitrage – but does that open the deviations in the first place? Are exogenous regulatory factors the only thing affecting the banks’ liquidity? Evidence is not unanimous. Other explanation is that banks manage their risks tighter than before, and this leads to an additional mark-up in the forward rates of USD. This explanation is treated deeper in subsection 6.3, where an equilibrium model is presented.
6.2 Demand side: international imbalances in hedging demand

The instruments supplied in the FX market by banks, are demanded by various agents. Sushko et al. simplify the demand function of FX hedges to consist of three types: banks, institutional investors, and corporate bond issuers. The same authors discuss the agents more clearly in their less technical paper (Borio et al., 2016). Du and Schreger (2021) makes a similar division. Following chapters combine the three paper’s notions of the agents and follow to discuss the monetary policy of central banks possibly affecting the CIP deviations.

Banks are the main users of FX derivatives, as they own a significant amount of assets denominated in foreign currencies and face the risk of the value of these assets fluctuating, affecting their net worth. Especially important are non-US banks, as they lack similar access to the cash markets as their US-counterparts. Banks have a dual role in the FX markets, as they also supply the hedges – but generally, the banks add to the aggregate hedging demand of currencies (Borio et al., 2016). Interesting exceptions for the banking industry are the banks of Australia and Sweden. Australians and Swedes take opposite positions as the rest of the world by funding domestic investments, such as mortgage loans, by loaning in foreign currency, and then using FX swaps to be able to supply domestically (Borio et al., 2016). This turns the CIP deviation of AUD when compared to USD positive, and the same happens to SEK when compared to EUR (almost all others were negative as is seen in Figure 1).

Institutional investors demand large amounts of dollar funding and hedging services. Particularly in Europe and Japan, the investment portfolios diversify geographically, and then need to hedge against the currency risk, similarly to the banks. For example, the Japanese institutional investors are known to have increased their US portfolio. The top-8 Japanese insurance companies have in total around 400 billion worth of USD assets, and hedge around half of it (Du and Schreger, 2021). US-based institutions are neglected in the models of Sushko et al. and Borio et al., as they have the capacity to diversify geographically in the large domestic markets of the US.

Corporate bond issuers are a third key player in the markets. Corporate issuers do not face the same funding costs in all currencies. International bond markets are very segmented, as there exists a phenomenon called “home bias” – the investors’ portfolios are very much overweighted with bonds of the local currency. Thus, the corporate issuers attempt to cut on funding costs by raising the demand of the FX hedges (more thorough treatment in Liao, 2020).

Du et al. (2018) predicted that the cross-currency basis is partly driven by international imbalances in investment demand and funding supply (complementary to their hypothesis of the banking regulation). To back this up, they find that the CIP deviations are highly
correlated with nominal interest rates, implying that the interest rate differential drives the deviations. In cross-section, the currencies with low interest rates have negative cross-currency bases, and the opposite is true for the currencies with high interest rates. The fact that the direction of CIP arbitrage is opposite to the UIP arbitrage has direct implications for UIP arbitrageurs and multinational issuers, as they are better off borrowing in high-interest rate currencies. Also in time series, the interest rate differential is found to drive the CIP deviations.

Using an event-study approach, Du et al. notices that unexpected monetary policy shocks caused by the ECB make it more expensive for the Europeans to loan in USD, as the “synthetic” USD/EUR rate rises by the widening cross-currency basis of the euro. The aggressive quantitative easing of the central banks (not only ECB), presented in Box 3 below, appears to exert additional pressure into the FX markets, resulting in bigger deviations of the CIP. The asset purchasing programs put upward pressure in the asset prices, which may attract for example the ECB and BOJ to buy more dollar denominated assets, which then again require hedging. In Borio et al. (2018), the cross-currency basis of EUR and JPY with respect to USD indeed is noted to widen around the dates when the central banks have announced new monetary policies. Cerutti et al. (2021) discusses the implications for synthetic dollar borrowers and investors and suggests that “CIP deviations may have important implications for capital flows across borders as well as for the international transmission of monetary policies”.

### Box 4: Quantitative Easing – the monetary policy of the low interest-rate era

Interest rates have been gradually declining in the western world in 21st century, following the example of 1990s Japan. Nominal interest rates have even been negative for a good while now. The central banks have not been able to practice monetary policy as they would have wanted, as the interest rates have reached the lower bound. The most important “unconventional” measure in the post-crisis era has been quantitative easing. By conducting it, the central bank buys financial assets from the markets, raising the prices of the assets, lowering their yield, and increasing the money supply. Bank of Japan started this in the aftermath of the Japanese crisis in the 1990s, and the US Federal Reserve, the Bank of England, the European Central Bank among others have later followed the same path (Joyce et al. 2012).

The recent Covid-19 crisis further forced the central banks to increase their quantitative easing to stimulate the economy. For example, the ECB launched a 750 billion euros Pandemic Emergency Purchase Programme in March 2020.

These imbalances in the demand side of FX market contribute significantly to the persistence of CIP deviations. What follows, is a model that intents to point out which exact risks lead to the shadow costs on balance sheets that lead to the international imbalances in hedging demand and supply. This at least in the long run should according to Sushko et al. explain the persistence of the CIP deviations.
6.3 Equilibrium model: theory of endogenous balance sheet costs

Diagram for the supply and demand of USD in the FX Swap markets shows how the GFC changed the game. In the vertical axis, the CIP deviation of bank rates measures the price of USD funding in the swap market. The horizontal axis measures quantity of USD funding, and hedging activities. The demand (blue in the figure) of the FX hedges responds to monetary policy shocks, as the Fed, ECB, and BOJ among others exert pressure in the market. Before the financial crisis, the supply (red curve) for the FX hedges was perfectly elastic – the CIP deviations were at near-zero levels no matter what quantity for them was in demand. After the crisis, the supply curve turned upward sloping, as the price for providing these hedges rose. Why has the supply curve turned upwards after the GFC? Literature appears to not agree on this matter. Costly balance sheets are at the heart of the phenomenon as suggested in subsection treating the USD, but from where do these costs or "shadow costs" for them arise? Du and Schreger (2021) in the most recent paper included in this thesis, argue in favour of the post-GFC regulatory changes affecting the supply side. Sushko et al. (2019) have a different approach. They based on the following economic theory and empirical tests argue that the shifting of the supply curve is more a story of frictions in the market, as risk is being priced in the derivatives even if they weren’t aligned with reality.
The factor analysis conducted by Sushko et al. (p. 17) pointed towards one factor driving the persistent deviations of the CIP – the imbalances not in the supply side, but the demand side of the FX hedging. Results of an Error-Correction Model support the factor analysis – demand imbalances indeed seem to drive long-term deviations of CIP. As an explanatory variable, the FX hedging demand is measured separately for reporting banks, non-financial corporations, and Japanese institutions from their implied cross-currency (xccy) position. The model accounts for risk by proxying it with CDS-spreads, and the VIX. Liquidity is measured by repo and deposit spreads since, as argued in the subsection 4.4, money market developments tend to spillover to the FX markets. Market risk is proxied by bid-ask spreads – the bigger the bid-ask spread, the more the intermediaries ask for premium. Researchers make a 2-way prediction: Firstly, the FX hedging demand is expected to drive the CIP deviations, and the more net short (long) the hedging demand, the more negative (positive) the CIP deviations. Secondly, credit risk and money market liquidity conditions are expected to cause spikes in the CIP deviations in the short run – thus the hedging demand is expected to not drive the temporary deviations. Every result of the model is in line with the predictions, as the coefficients are statistically significant, and the signs of the coefficients are as expected.

The Error Correction Model proves the prediction of FX hedging demand driving the CIP deviations in the long run, but what then makes the demand sides’ balance sheets “costly”? Sushko et al. build a simplifying theoretical framework for the market-clearing rate of USD outright forward rate to demonstrate that market and counterparty risks are at fault and prevent the CIP from holding. Next, I will shortly introduce the model, and explain how it is empirically validated.

On the supply side, Sushko et al. place the agents involved in covered arbitrage (banks), suppose that they are risk-averse, and have an exponential utility function, where they maximize wealth. The wealth-maximizing function includes variables for the exchange rates (F for forward, S for spot) and bond-rates known beforehand (r for domestic, r* for foreign), but also for the banks’ perception of overall market risk (σ), and a probability that the counterparty defaults (θ), forcing the bank to exchange back to the initial currency at a previously unknown rate.

On the demand side is placed the sum of demand of the investors – namely the 3 types discussed in the previous subsection (banks, institutional investors, corporate issuers). Maximizing the certainty-equivalent of the demand (y) with respect to the amount of dollars supplied by the banks, the following market-clearing forward rate is attained:
\[ F_{t,\tau} = S_t + r_t - r_\tau^* + \int_0^T \rho \sigma_{t,\tau} \theta_{t,\tau} y_{t,\tau} d\tau \]  

(3)

where \( \tau \) equals maturity and \( \rho \) measures risk-aversion from inverse of banks’ balance sheet risk tolerance (this comes from the banks’ utility function). For the CIP to hold, the last term must equal 0. As it clearly has not been 0 in the recent years, the frictions in the OTC FX derivatives markets seem to contribute significantly to the persistent deviations of the CIP. The interaction of counterparty and market risks and risk-aversion adds to the market clearing forward rate a mark-up, that is proportional to the hedging demand of USD, \( y \) in the equation. The elasticity of demand (how much hedging demand affects forward premia and thus CIP deviations) depends on the interaction of the counterparty and market risk.

To validate this theoretical balance sheet constraint, the authors run a Kalman filter regression on the equation 3. They propose that the elasticity of the FX hedging demand’s effect on the level of CIP deviations (taking a long-term approach, measuring the deviations by 3-year cross-currency basis) equals the elasticity of FX hedging demand’s effect in the forward rates of currencies through the interaction of market and collateral risks, measured by CDS and FX-option implied volatility. Resulting, the coefficients indicate a good fit, and validate the proposal.

In the post-GFC environment, the cross-currency positions are according to this theory not treated as riskless, but market and counterparty risks are priced in the instruments at all times, no matter the situation in the market. The balance sheet costs or their “shadow costs” are thus not (only) exogenous variables but arise endogenously in relation to the demand of the FX hedges. Based on this, Sushko et al. argue that it is the market and collateral risks that cause the supply curve in Figure 2 slope upwards, as banks’ cautious risk management requires especially the long-term investments to be conducted extra carefully.

The same authors argue in their less technical paper (Borio et al., 2016) that it is the demand that in the first place drives the deviations and opens them but take a more accommodating stance on the role of regulation – the tightened leverage regulation is seen more as a factor that does not drive the deviations, but as a factor that prevents the banks from closing them. The less technical paper also includes regressions derived from their more technical work, that suggest that the hedging demand does not only play a big role in the tranquil times: they also seem to be unappreciated in the turbulent times, when the deviations are more commonly explained away by credit limits and implicit liquidity constraints (as in Taylor, 1989b).
7 Discussion

In this section I discuss the importance of the topic, the findings of the literature, and avenues for future research. The first thing I must state is that I found the extremely technical works reviewed in this paper to be an endless labyrinth with many details and even bigger factors that I, and probably also the researchers, could have got wrong (see Sushko et al. on research’s probable misunderstanding of the quarter-end dynamics of CIP deviations p. 15-16). Whether I covered everything or not, I hope I have told an interesting macroeconomic story of Covered Interest Rate Parity and its recent failure, explained by international hedging demand imbalances, banking regulation, and financial market frictions.

First, I discuss the model presented in Section 6.3. I must emphasize that the model is not a universal truth. The paper of Sushko et al. (2018) is referenced to by Du et al. (2018), Avdjiev et al. (2019), and Cerutti et al. (2021), but the model is not even mentioned in any of these. The model itself is rather simple, but the way it is set up and validated with all sorts of fancy statistic tools such as the PCA analysis, and the Kalman filter (which I must confess, are not familiar to me), is very complicated. A post-Keynesian economist would perhaps argue that the use of these abstract tools makes the whole model rather devious. What matters though, is that Sushko et al. makes an ambitious intent to model the equilibrium of the market, and thus takes the story further than any other sources. That is why I wanted it to play such a big role in my thesis. The model is one example of how FX markets can be simplified, and the best example I could find.

In addition to the technicalities, I am left a little puzzled with the time framing and the word persistence generally in the whole literature. The model of Sushko et al. is in first place a long-term model, and based on it, the regulatory factors that drive the short-term deviations cannot explain the persistence of the phenomenon. If the short-term deviations are persistent, why could they not also in the long run explain the persistence of the deviations? In the textbook of Burda & Wyplosz (Macroeconomics: a european text, 2019), the theory of interest rate parity is described as “the short run equilibrium condition of the international financial markets”. If the CIP should by definition hold in the short run, how valid is it to look at it in the long run at all? Long-term arbitrage strategies have been proven successful (Du et al. in Section 4.2), and thus it seems to be reasonable to look at them. However, do the maturities of the investments have anything to do with the persistence of the deviations? Sushko et al.’s Error Correction Model appears to prove so, but all researchers do not buy this. If I am not seeing what I want to see here, it seems to me like the persistence of the CIP deviations could behind the curtain be yet another example of the century-old short run vs. long run debate between economists.
For the long-term determination of exchange rates, traditionally Purchasing Power Parity has been used as a benchmark. The importance of traditional exchange rate determination models such as the interest rate parity, and the Purchasing Power Parity, appears to be decreasing. There is an increasing literature concentrating in the role of financial intermediation in the FX markets, and pricing of currency instruments. One praised work is Gabaix and Maggiori (2015), modeling the exchange rate determination in presence of moral hazard, with an application for the CIP deviations. The findings of banking regulation affecting the CIP deviations (e.g. by Du et al.) point towards works such as He and Krishnamurthy (2013, 2018) that concentrate in intermediary-based asset pricing in markets with frictions, following the footsteps of the likes of Bernanke and Gertler (1989), and Holmström and Tirole (1997).

The short-run deviations associated with the banking regulation have raised an interesting question: is there a clear trade-off between the stability and the efficiency of financial markets, and are the CIP deviations a concrete example for this? What at least can be said, is that the CIP deviations are clearly an example of the FX markets not being perfectly efficient. The regulatory constraints on liquidity are argued to be one significant factor that makes the banks’ balance sheets more costly (Borio et al., 2016). That does not yet tell everything about the big picture. A big part of the drivers that primarily open the basis are actually on the other side of the equation: the side of the diverse composition of international agents contributing to the demand of US Dollar (Sushko et al., Borio et al.).

The possible deadweight losses caused by the deviations is at least to my knowledge an uncharted territory. Du and Schreger (2021) note that a general equilibrium model is required to find out whether the deviations have important welfare effects. No authors present any strong arguments for deregulation, but the last-mentioned paper for example wonders whether the post-GFC regulation is optimal. Regarding the banking regulation, implementation of new policies does not happen by clicking fingers. The implementation of Basel III globally is an ongoing process. Let us not forget that new regulations (Basel IV) are on their way. How will they be implemented globally, and will they affect the CIP?

There are of course many other fascinating things going on in the economy, that have influenced the CIP, such as the most recent crisis in the aftermath of the Covid-19 outbreak (evident in Figure 1). Central banks, especially the Fed, are printing out unseen amounts of money and absorbing it back with ‘reverse repos’ – how does this affect the CIP? These are some examples for future research to investigate.
8 Conclusion

Deviations of the Covered Interest Rate Parity have increased in magnitude significantly after the Global Financial Crisis of 2007-08. The pre-crisis literature seems to have reached a consensus of the CIP holding rather well, at least in tranquil times. The CIP deviations spiked to record-high magnitudes in the middle of the crisis, but more importantly, the phenomenon appears to have persisted for good – in the relatively stable times of 2014-19, the deviations still constantly arose, as the arbitrageurs in the market were not able to take advantage of them. In this paper I have reviewed literature that tries to identify the causes for the persistence of the CIP deviations.

Recent research has been able to identify various macroeconomic factors contributing to the phenomenon. Strength of the US Dollar plays a central role in the matter – as the USD strengthens, global dollar flows decrease, and the CIP deviations increase. This can be seen as a triangular relationship, which points towards the balance sheets of the agents in the FX market being at the heart of the problem. One view is that the tightened post-GFC regulation is primarily accountable, and to some extent the literature agrees on regulatory factors leading to the short-term CIP deviations. Other view is that the regulatory factors are of secondary importance, and the persistence of the deviations arises primarily from imbalances in FX hedging demand. A simple model points towards the long-term deviations arising as the agents pay premia for risk factors – that will say, the deviations likely arise endogenously proportional to the hedging demand of USD.

A compromise in the middle is that the deviations are predominantly driven by the demand side of the FX hedges. As a response, the arbitrageurs in the supply side cannot close the deviations because of the tightened regulatory framework imposed on them after the Global Financial Crisis, and the banks’ own tightened risk management measures.

References

Literary references
Keynes, J. M. (1923) 'A tract on monetary reform' Macmillan, London

Other references


*I include and reference to the most recent versions of these papers. Their previous versions were available before. Thus, referencing to them by others had been possible.
Appendix

Abbreviations used throughout the text

Concepts:

BIS – Bank for International Settlements
BOJ – (Central) Bank of Japan
CIP – Covered Interest Rate Parity
ECB – European Central Bank
CDS – Credit Default Swap
Fed – United States Federal Reserve
FX – Foreign exchange
GFC – Global Financial Crisis of 2007-08
G-SIB – Global Systemically Important Banks
IOER – Interest Rate on Excess Reserves, nowadays replaced with IORB (Interest Rate on Reserve Balances). This is Fed’s rate, there are similar facilities for example in Europe
Libor – London Inter-Bank Offered Rate
OTC – Over-the-counter
PCA – Principal Component Analysis
repo – repurchase agreement
UIP – Uncovered Interest Rate Parity
VIX - Chicago Board Options Exchange's Volatility Index

Currencies:

USD – US Dollar
EUR – Euro
JPY – Japanese Yen
AUD – Australian Dollar
NZD – New Zealand Dollar
SEK – Swedish Krona

IOER – Interest Rate on Excess Reserves, nowadays replaced with IORB (Interest Rate on Reserve Balances). This is Fed’s rate, there are similar facilities for example in Europe

Cross-currency swap

Chicago Board Options Exchange's Volatility Index

Cross-currency swap