CIP deviations: The role of U.S. banks' liquidity and regulations

Bazán, Walter and Ortiz, Marco and Terrones, Marco and Winkelried, Diego

Universidad del Pacifico

15 September 2023

CIP deviations: The role of U.S. Banks' liquidity and regulations *

Walter Bazán-Palomino
wn.bazanp@up.edu.pe

Marco Ortiz[†]
ma.ortizs@up.edu.pe

Marco E. Terrones
me.terrones@up.edu.pe

Diego Winkelried
winkelried_dm@up.edu.pe

School of Economics and Finance
Universidad del Pacífico (Lima, Perú)

This version: September 15, 2023

Abstract

This paper inquires how private bank regulation and liquidity in the US are related to the deviations from the covered interest parity (CIP) condition. We find evidence that bank liquidity effects on CIP deviations partially offset those resulting from regulatory changes in a sample of 11 OECD countries over the 2001-2019 period. This finding supports an old conjecture that changes in private banks' liquidity and regulation could significantly affect the wedge between liquid US dollars and illiquid foreign exchange forward contracts in international financial markets. Interestingly, the effects of liquidity on CIP deviations become more important when the impact of bank regulation intensifies, reflecting the presence of interaction effects.

JEL Classification	:	E44, F31, G14, G15, O24
Keywords	:	Cross-currency bases, covered interest rate parity bank regulation, liquidity.

*We thank Jean Paul Zúñiga for outstanding research assistance. We gratefully acknowledge the financial support of the Research Center of Universidad del Pacífico, Project PPA 2021. We alone are responsible for the views expressed in this paper and any remaining errors.

†Corresponding author. School of Economics and Finance, Universidad del Pacífico, Av. Salaverry 2020, Lima 15072, Peru. Phone: (+511) 219 0100 extension 2713.

1 Introduction

The covered interest rate parity (CIP) is a crucial non-arbitrage principle in international finance. According to the CIP, a trader should not make gains from borrowing and lending in different currencies while also hedging against foreign exchange (FX) risk in forward exchange markets. Historical records, such as those found in studies by Levich (1985, 2017), indicate that from the end of the Bretton Woods system in the early 1970s until the onset of the Global Financial Crisis (GFC) between mid-2007 and early 2009, the CIP condition typically held in the data for the most traded currencies vis-à-vis the US dollar. Yet, there were sporadic instances of CIP breakdown during market turmoil Taylor (1989). However, as documented in Cerutti et al. (2021) and Du and Schreger (2022), the CIP has systematically failed post-GFC. This persistent breakdown of the CIP has increased the profitability of FX carry trade strategies and remains a puzzle in academic discussion.

To illustrate, Figure 1 shows the so-called "cross-currency basis" for the G10 currencies vis-à-vis the US dollar, over the 2001 to 2021 period. The basis is the difference between the cost of direct lending in US dollars and synthetic lending, where a loan is denominated in a given currency but disbursed and repaid in US dollars at an established forward rate. This difference must be zero under the CIP. Otherwise, an arbitrageur can profit by demanding a high forward premium equal to precisely the CIP deviation. It is apparent from the figure that post-GFC, the CIP deviations become significant, persistent, and mostly negative, suggesting that the synthetic dollar interest rates were higher than the direct dollar rates. Even though financial conditions had returned to pre-GFC levels, the CIP deviations widened further since 2014. As famously noted by Du et al. (2018), this partially results from more stringent regulations in the US banking system.

Understanding the post-GFC CIP puzzle is essential for at least four reasons. First, most open macroeconomic and international finance models assume that the CIP condition holds. Therefore, the main results of such models, including their welfare implications, may be invalid if this condition fails. [1] Second, the CIP condition is, in practice, a key benchmark for FX market efficiency and international capital mobility. As such, CIP deviations may affect our appraisal of exchange rate dynamics, whereby the FX market is the world's largest financial market, with a daily traded volume of over US$ 6.6 trillion (Bazán-Palomino and Winkelried, 2021; Ranaldo and de Magistris, 2022). Third, the CIP deviations substantially impact corporate borrowing costs and hedging strategies. For instance, some 40% of corporations and firms have issued in recent years significant cross-currency debt with FX hedge (Liao, 2020). Fourth, as Engel (2014) discussed, deviations from the uncovered interest rate parity (UIP) may have important implications for cross-country monetary policy transmission. Therefore, a complete understanding of the nature and determinants of the UIP deviations, which besides the discrepancy between expected depreciation and forward premium contains centrally the CIP deviations, can help traders and policymakers improve market efficiency.

[1] Most general equilibrium models in international macroeconomics do not explicitly address the CIP condition. There are significant differences regarding the financial market structure among these models. The majority of them assume either complete financial markets (Backus et al., 1992; Baxter and Crucini, 1993; Galí and Monacelli, 2005)) or incomplete markets with a risk-free real non-contingent bond (Mendoza, 1991; Correia et al., 1995). In the former models, the CIP condition must hold. Introducing a financial instrument can significantly alter the main findings of the latter models. Nevertheless, the CIP condition will hold if the exchange rate risk is traded. Lastly, the applicability of the CIP condition might be limited in models with segmented financial markets (Itskhoki and Mukhin, 2021; Gabaix and Maggiori, 2015; Cavallino, 2019). De Paoli (2009) discusses how the financial market structure changes the different model results.

Although recent literature has tried identifying the factors driving CIP deviations post-GFC, most efforts have followed a piecemeal approach, partially reflecting the puzzle's novelty. The piecemeal approach could lead to omitted variable biases and potentially misleading conclusions. A remarkable exception is the empirical exploration by Cerutti et al. (2021), which does not focus on the central role of funding liquidity on CIP deviations, as we do here. In particular, we address the following questions: How are US bank regulatory changes and banks' liquidity associated with the CIP deviations? Are bank regulatory changes more important than funding liquidity in determining CIP deviations? Does the effect of bank liquidity on CIP deviations depend upon regulatory changes?

There are four main takeaways from our empirical analysis. First, we confirm Du et al. (2018) main finding, which states that the post-GFC changes in banking regulations are a key source of CIP deviations. Second, we find strong evidence that US banks' liquidity is another important factor behind CIP deviations, as bank liquidity narrows the gap between direct and indirect financing in FX markets through its effects on liquidity premiums, as conjectured by Bianchi et al. (2021). Third, we show that these two factors, whose effects on CIP deviations are of opposite signs, operate jointly but with different time lags, thus suggesting that banks could partially offset the impact of regulatory changes in their funding costs with changes in their liquidity. Finally, and perhaps more importantly, we find evidence of interaction effects between these two factors as the effects of liquidity on CIP deviations intensify precisely when the impact of bank regulations is most pronounced. These findings are both robust and, the last three ones, novel.

Our contribution to the emerging literature on the drivers of the CIP puzzle is twofold. First, by jointly investigating the roles of bank regulation and liquidity in shaping CIP deviations, we highlight that their effects are interconnected and thus should not be studied in isolation, as often has been done in previous studies. Notably, the interaction between these two factors reveals that their influences on CIP deviations are interdependent. When post-GFC banking regulatory changes lead to binding constraints, banks need to hold sufficient liquidity to offset the adverse impact of these changes on their operating costs.

Second, we utilize two short-term funding cost indicators, the London Interbank Offered Rate (LIBOR) and Overnight Indexed Swap (OIS), commonly used by financial intermediaries in the empirical analysis. We proceed this way to avoid biases in measuring counterparty risk within forward contracts. Remember that the spread between the LIBOR and the OIS proxies the default likelihood of borrowing banks, indicating credit risk. Interestingly, the findings obtained when utilizing "risky" LIBOR closely align with those derived from using "stable" OIS. This suggests that credit risk is of secondary importance as a driver of CIP deviations once we control for changes in bank regulation and funding liquidity.

The rest of the paper is organized as follows. Section 2 presents a review of the literature. Section 3 introduces some definitions and discusses methodological issues. Section 4 describes the data used in our empirical exploration. Section 5 presents our main findings on the role of changes in regulation, liquidity and their interactions on CIP deviations. Section 6 offers closing remarks and some avenues for further research. An online supplement contains several robustness checks to our main findings.

2 Literature Review

CIP deviations are a long-standing concern in the literature, as revealed by early surveys by Officer and Willett (1970) and Hodjera (1973)), which provide important insights about the potential drivers of these deviations and a thorough examination of forward FX markets.

From the outset, authors associated CIP deviations with funding liquidity, i.e., the availability of funds to finance the purchase of financial assets or to settle obligations immediately when due. Tsiang (1959), for instance, underscores its pivotal role: "The availability of arbitrage funds does not experience an abrupt cessation at any specific juncture. More plausibly, arbitrageurs (predominantly banks with overseas operations) tend to exhibit a growing reluctance, beyond a certain point, to shift their spot liquid assets from the domestic center to a particular foreign center [...] due to the fact that spot assets yield certain intangible returns in terms of convenience or liquidity, in addition to their interest returns" (Tsiang, 1959, p. 81).

The literature has also noted the connection between funding liquidity and the regulatory environment. To the best of our knowledge, Klopstock (1965) is among the first to have examined this connection, noting that during specific periods, such as end-month, mid-year, and end-of-year, financial institutions engage in a "window dressing" of their balance sheets. This typically involves liquidating foreign market positions to comply with liquidity regulations or desired ratios. Consequently, these periods witness an accumulation of "unusual amounts" of domestic liquidity, including cash and eligible trade bills for central bank discount operations. This strategy enables liquidity-pressed banks to sell foreign-denominated assets to raise needed funds or secure borrowing at higher rates. These elevated rates prompt non-stressed banks to divest foreign positions to capitalize on lucrative short-term rates domestically.

The importance of funding liquidity and regulations in the context of the CIP lost traction during the following decades, as authors favored alternative notions of transaction costs (Prachowny, 1970; Frenkel, 1973; Frenkel and Levich, 1975; Taylor, 1987); capital controls (McCormick, 1979); destabilizing expectations (Kesselman, 1971; Haas, 1974)) and heterogeneous underlying risk across securities (Stoll, 1968). Only in the late 1990s did the market-microstructure literature embrace the liquidity concept to characterize arbitrageurs' behavior. For instance, the influential work of Shleifer and Vishny (1997) explores the challenges arbitrageurs face when obtaining funds from third-party sources. Another notable dimension is the emergence of mark-to-market losses even in covered positions, as emphasized by Gromb and Vayanos (2002), who introduce collateral constraints into a parallel framework.

The deviations from CIP during and after the Global Financial Crisis reignited scholarly interest in its financial drivers. For instance, Baba et al. (2008) examine CIP deviations before the Lehman Brothers bankruptcy (September 2008) and attribute them to dollar funding shortages among non-US financial institutions. Similarly, Baba and Packer (2009) and Hui et al. (2011) underscore the role of ECB-provided dollar liquidity facilities in understanding the observed dynamics during the 2007-2009 period. Mancini Griffoli and Ranaldo (2012) elaborate on three possible sources of liquidity constraints behind CIP deviations– lender pressure for deleveraging, prudential hoarding of liquidity by lenders, and capital constraints on secured arbitrage. Funding liquidity-related constraints emerged as key drivers of the CIP arbitrage breakdown. More recently, Du et al. (2018) present compelling empirical evidence linking post-GFC bank regulatory changes with persistent CIP deviations, constraining arbitrage possibilities. They identify a correlation between CIP deviations and interest rate spreads measuring funding liquidity. Expanding on the nexus between funding liquidity and CIP breakdown, Kohler and Müller (2019) adopt a "direct approach" and utilize rates encompassing liquidity funding risk (i.e., cross-currency repo rates). These studies find that CIP deviations narrow when funding liquidity is included in the analysis.

On the theoretical front, a few models have highlighted the role of funding liquidity in driving dollar dynamics and CIP deviations. For instance, Bianchi et al. (2021) develop a general equilibrium model that includes a banking sector subject to matching frictions in foreign currency reserves markets, linking global liquidity measures to exchange rate determination. Likewise, Armas and Ortiz (2020) introduce hedging and liquidity mechanisms into the exchange rate determination process, analyzing the impact of spot and forward foreign exchange intervention tools on liquidity, CIP, and UIP deviations. Other important theoretical contributions are Gabaix and Maggiori (2015) and Itskhoki and Mukhin (2021), who underscore the limitations to arbitrage. These studies, however, focus on distinct financial aspects, such as borrowing constraints and market segmentation.

The recent empirical literature on CIP deviations also comprises other competing explanations. Cerutti et al. (2021) establish a nexus between CIP deviations, credit risk, and market liquidity. Syrstad and Viswanath-Natraj (2022) highlight the importance of funding cost dispersion, which, coupled with stricter regulatory constraints on banks' balance sheets post-GFC, introduce complications in forward rate pricing. Additionally, Rime et al. (2022) examine the influence of regulatory shifts and the dominance of specific banks in certain markets. In this framework, top-rated banks directly access US dollar funding, while lower-rated banks resort to synthetic US dollar funding, contributing to CIP disparities. Finally, using trading volume indicators, Ranaldo and de Magistris (2022) focus on the impact of market liquidity on global currency markets.

Our research also aligns with the existing literature on global contagion, capital flows, and exchange rates. For instance, studies by Lustig et al. (2011), Forbes and Warnock (2012), and Fratzscher (2012) emphasize the global nature of capital flows to emerging markets, driven by liquidity and risk considerations. Following a different tack Ivashina et al. (2015) establish a connection between credit quality shocks and reduced dollar lending by non-U.S. banks, leading to increased borrowing costs and limited overseas dollar liquidity. Avdjiev et al. (2019) highlight a stronger dollar's impact on wider CIP deviations and reduced growth in cross-border bank lending in dollars. Relately Ibhagui (2020) explores the link between macro-financial variables and CIP deviations, finding positive associations between relative money supply and cross-currency basis swap spreads, with varied connections between real output and CIP deviations across European and non-European countries. Chatziantoniou et al. (2020) also examine network effects during stress periods in international financial markets, measured by CIP deviations. They show how US dollar funding shortages from one currency pair can spill over to other markets.

3 Empirical methods

In this section, we introduce key definitions and methods. In particular, we present the main hypothesis of the paper, namely that CIP deviations are associated with US banks' liquidity and regulatory measures. We also develop the specific regression equation and discuss its properties.

We begin by presenting the formula for the n-period covered interest parity condition is:

$$\frac{1+Z^{i}_{t,t+n}}{1+Z^{US\$}_{t,t+n}} = \frac{F_{t,t+n}}{S_t}\,, \tag{1}$$

where $Z^{i}_{t,t+n}$ and $Z^{US\$}_{t,t+n}$ represent the n-period interest rate in currency i and in US dollars, respectively. S_t and $F_{t,t+n}$ denote the spot and the n-period forward exchange rates expressed in units of currency i per US dollar. The indexing i of the mentioned variables is omitted to avoid cluttering the notation.

Equation (1) equates two fundamental differentials. First, the gross return difference of holding currencies as measured by the n-period interest rate difference between country i and the US. Second, the difference between the n-period forward exchange and spot exchange rates. The CIP condition posits that arbitrage opportunities for riskless profit would not arise without financial frictions.

Defining $f_{t,t+n} = \ln(F_{t,t+n})$, $s_t = \ln(S_t)$, $z^{i}_{t,t+n} = \ln(1+Z^{i}_{t,t+n})$ and $z^{US\$}_{t,t+n} = \ln(1+z^{US\$}_{t,t+n})$, where ln() denotes natural logarithm. We establish:

$$X_{i,t+n} = z^{US\$}_{t,t+n} - z^{i}_{t,t+n} + f_{t,t+n} - s_t\,, \tag{2}$$

as the “cross-currency basis” between currency i and the US dollar at time t for a horizon of n periods. The basis $X_{i,t+n}$ quantifies the difference between the dollar interest rate in the cash market and the “synthethic” dollar interest rate implied in the foreign exchange swap market by the CIP condition. Thus, a negative difference $X_{i,t+n} < 0$ indicates that funding in dollars ($z^{US\$}_{t,t+n}$) is cheaper than borrowing local currency ($z^{i}_{t,t+n}$) and swapping into dollars ($s_t - f_{t,t+n}$). Upon taking logarithms to equation (1), it follows that $X_{i,t+n} = 0$ whenever the CIP condition holds.

We adopt the convention of using the negative cross-currency basis, $Y_{i,t} = -X_{i,t+n}$, following the observation that $X_{i,t+n}$ tends to be negative, and thus $Y_{i,t}$ tends to be positive. To alleviate the notation, we leave the dependence of the main variables on n implicit.

To assess the importance of the various potential factors driving the observed CIP deviations, particularly changes in banking regulation and US banks' liquidity, we estimate the following panel regression equation:

$$Y_{i,t} = \sum_{k=0}^{m} \delta_k L_{t-k} + \beta_R R_t + \alpha_i + \theta_t + \boldsymbol{x}_{it}{}'\boldsymbol{\beta}_x + \varepsilon_{i,t} \;\; for\ t = 1,\ldots,T. \tag{3}$$

The variable L_t is a proxy of US banks' liquidity. The effect that this variable may have on Yi,t does not need to be instantaneous. Indeed, equation (3) distributes the effects of L_t and $Y_{i,t}$ over m periods. On the other hand, the variable R_t is a regulatory indicator , first developed by Du et al. (2018), that induces deviations from the CIP condition immediately on impact. In addition, α_i is a currency fixed effect, θ_t is a time fixed effect, and $\boldsymbol{x}_{i,t}$ is a vector comprising all other control variables that may be currency-specific. Finally, $\varepsilon_{i,t}$ is an error term assumed to be independent across i. Note equation (3) resembles the equations utilized by Du et al. (2018) or Cerutti et al. (2021) augmented to include a distributed lag model of L_t.

The coefficients δ_0, δ_1, …, δ_m capture how shocks to L_t transfer to Y_{it} over time, holding everything else constant. Upon a simple parameterization, equation (3) can be rewritten as:

$$Y_{it} = \sum_{k=0}^{m-1} \beta_k \Delta L_{t-k} + \beta_L L_{t-m} + \beta_R R_t + \alpha_i + \theta_t + \boldsymbol{x}_{it}{}'\boldsymbol{\beta}_x + \varepsilon_{it} \; for\ t = 1,\ldots,T. \tag{4}$$

Where $\beta_k = \delta_0 + \delta_1 + \cdots + \delta_k$ defines the interim multipliers, which capture the cumulative impact of a persistent increase in L_t on Y_{it}. By employing equation (4), it is possible to differentiate between liquidity's short-run and long-run effects on CIP deviations. Specifically, the values of β_0, β_1, ..., β_{m-1}, $\beta_L \equiv \beta_m$ illustrate the transition from the initial impact multiplier δ_0 to the long-run multiplier β_L.

4 Data description

Our primary sources of information are the Bloomberg and the Federal Reserve Economic Data (FRED) databases. Although most variables are available at a daily frequency, we can calculate US banks' liquidity at a weekly frequency only. Because of this, we utilize weekly averages of the daily data in the regression analysis. Similarly, the sample runs from January 2001 to December 2019, because the input variables needed to construct the liquidity ratio are available until 2019. The data appendix provides details on the different variables, including their construction, tickers, and availability.

4.1 Cross-currency basis

To compute $Y_{i,t}$, the negative of equation (2), we collect data on spot and forward exchange rates, as well as interest rates in globally traded currencies. This includes the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Danish krone (DKK), Euro (EUR), Pound Sterling (GBP), Yen (JPY), Norwegian krone (NOK), New Zealand dollar (NZD), Swedish krona (SEK), and US dollar.

Likewise, to calculate the forward premia, we contemplate the following annual day count conventions (see the Bloomberg Currencies Indices Methodology): (a) 360 days for CHF, DKK, EUR, JPY, NOK and SEK; and (b) 365 days for AUD, CAD, GBP and NZD. We also consider two contract maturities: weekly and monthly. The actual data on maturity in days is not always available, so we rely on some approximations. We used seven days of forward data for one-week contracts for all points. On the other hand, for one-month contracts:

- First, we considered the set of all dates greater than or equal to the respective spot date plus one calendar month. For example, if the spot date is March 31st, adding one-month results on April 30th, and the first set to consider will be all dates greater than or equal to April 30th. This relationship between the spot date and the resulting date, after adding one month) is also applicable for other dates such as March 30th and April 30th, May 2nd and June 2nd, and January 31st and February 28th.
- Then, we considered only the trading dates from this reduced set of dates. Trading dates refer to the days when the market is open and trade can take place. We selected the minimum date from this doubly reduced set.
- Finally, the contract maturity in days is calculated as the difference between the selected minimum and spot dates.

This approach assumes that the financial instrument under consideration is traded in a market with regular trading days, and the contract maturity is defined as the number of trading days between the spot and the maturity dates. Clearly, the accuracy of this approximation depends on the trading calendar used, which may vary depending on the market and the instrument traded. Therefore, choosing an appropriate trading calendar and ensuring its consistent application throughout the analysis is crucial. A visual inspection of our resulting computations of cross-currency basis reveals striking similarities to the data used in influential studies such as Du and Schreger (2022).

4.2 US Banks' Liquidity

We measure banks' liquidity by using the liquidity ratio introduced in Bianchi et al. (2021). The numerator of this liquidity ratio is the sum of reserve balances maintained with Federal Reserve Banks (`RESBALNSW`) and government securities (Treasury and agency) held by commercial banks (`TASACBW027NBOG`), and the denominator is the sum of financial commercial paper outstanding (`FINCPN`) and demand deposits component of $M1$ (`WDDNS`). The variable L_t in (4) is the natural logarithm of the described liquidity ratio multiplied by 100.

4.3 Regulation

The variable R_t is a scaled version of the regulatory dummy variable introduced by Du et al. (2018), based on end-of-quarter dynamics. In particular, we create a dummy variable D_t *at the daily frequency* that identifies the trading dates when the one-week or one-month contract appears on the quarter-end balance sheet. Then, we calculate the weekly average of this dummy variable and compute $R_t = D_t \times \text{MAD}(\Delta L_t) \div \text{MAD}(D_t)$, where $\text{MAD}(X)$ represents the mean absolute deviation of X. Thus, our regulatory variable R_t is normalized at weekly frequency in the scale of the changes of L_t. The coefficients $\beta_0, \beta_1, \ldots, \beta_{m-1}$, β_L and β_R are then the effects of variables of the same order of magnitude. It is worth noting that the values of R_t depend on the contract (weekly or monthly) and on the sample used in its calculation, but this dependency is kept implicit.

4.4 Fixed-effects and control variables

All regressions include currency fixed effects and time fixed effects. The latter are a set of quarterly dummy variables that control for the variation of currency returns at business cycle frequencies, as shown in Colacito et al. (2020).

The vector $\boldsymbol{x}_{it}$ includes as a control $\ln(\text{VIX})_{t-1}$, the logarithm of the CBOE Volatility index VIX (times 100), and $\Delta \ln(\text{VIX})_t$ to allow for a distributed lag. As noted in Avdjiev et al. (2019), the co-movements between the VIX and CIP deviations increase in bad times when the global financial conditions are tighter. The vector $\boldsymbol{x}_{it}$ also includes $\text{Spread}_{i,t-1}$, the differential between the bid and ask of the forward rates expressed in basis points, and $\Delta\text{Spread}_{i,t}$ to allow for dynamics. Non-trivial differences between bid and ask prices for forward and spot FX transactions often signal market liquidity and other conditions that are likely to correlate with CIP deviations (Borio et al. (2016), Cerutti et al. (2021)).

5 Results

In this section,, we present our main findings for multiple variants of equation (4). In particular, we focus on the coefficients associated with the regulatory and bank liquidity variables.

We first provide the estimated coefficients for the full sample ranging from 01/2001 to 12/2019. Motivated by the presence of the GFC and the change in banking regulation, we next split the sample period into different subsamples, namely Pre-Crisis (2001-2008) and Post-Crisis

(2009-2019) and within the latter Pre-Regulation (2009-2014) and Regulation (2015-2019) subperiods. Because of the severity of the GFC and regulatory changes, we expect the structural stability of parameters to be questionable. Therefore, we conduct tests on breaks in equation (4) and perform recursive estimations to gain deeper insights. Specifically, this estimation method helps us to identify potential variations in the effects and significance of the key variables, offering a more nuanced understanding of the CIP deviations.

Moreover, using two different measures for the cross-country basis (one based on LIBOR and the other on OIS interest rates) allows for robustness checks and a comparison of results obtained from different funding sources.[2] It helps ensure that the findings are not driven solely by the choice of one particular measure and increases the reliability of the conclusions.

Regarding forward contracts, estimating equation (4) with different maturities (one week and one month) provides insights into how the time horizon of currency forward contracts impacts CIP deviations. In principle, shorter maturities may be more sensitive to certain factors, such as liquidity constraints or regulatory changes, while other macroeconomic factors, like VIX, might influence longer maturities. This approach helps us to identify potential differences in the drivers of CIP deviations across different time frames. The emphasis, but not the exclusivity, of our exposition below, is on the CIP deviations from one-week contracts. Analyzing CIP deviations from one-week contracts might reflect more short-term market dynamics and respond quickly to changing conditions (immediate market events and policy instruments). To reconcile the two approaches, we first study them separately and without any other control – thus, we exclude the variables in $\boldsymbol{x}_{it}$. Then, we analyze the effects of regulation and banks' liquidity together after controlling by FX market conditions—i.e. uncertainty or investor fear (VIX), bid-ask FX spreads, or the timing of compliance with banking regulations.[3]

5.1 Banking regulation

Table 1 displays the estimation of two alternative specifications based on equation (4). Panel A shows the estimated coefficient of the regulatory variable in a regression where the funding liquidity variable L_t is excluded (imposing $\beta_k = 0$ for all k and $\beta_L = 0$). The aim is to replicate the results in Du et al. (2018).

Column (1) shows a statistically significant positive effect of $\beta_R = \{1.124, 1.209\}$ for the LIBOR or OIS rates, respectively, over the entire sample. However, this effect shows substantial subsample heterogeneity, with non-significant effect prior to the GFC (Column 2), as opposed to a large and significant effect after the crisis (Column 3) of $\beta_R = \{1.423, 1.119\}$ for the LIBOR and OIS rates, respectively.

As mentioned earlier, the post-crisis period can be further partitioned into an initial "Pre-regulation" period (Column 4) with $\beta_R = \{0.301, 0.190\}$, and Regulation period (Column 5), where banking regulations are found to exert the most significant influence on CIP deviations. In this latter sub-period, it is found that $\beta_R = \{2.391, 1.919\}$ for the LIBOR and OIS rates,

[2] Our baseline results use all available information, which includes various instances where one interest rate is available but the other is not. When considering only observations where LIBOR and OIS rates are available, the sample size shrinks by 30 to 40 percent compared to the sample in the baseline regressions. We report the full set of estimates using the "balanced sample" in an online supplement. The results are similar to those discussed in the main text and provide no further insights.

[3] In general, the main features of our empirical results (significance, sign, and magnitude) regarding the effects of regulation and bank liquidity are robust to the inclusion or exclusion of the control variables in $\boldsymbol{x}_{it}$. The online supplement contains the details of these exercises, with and without control variables, that complement those discussed in the main text.

respectively.

5.2 US dollar liquidity

Panel B of Table 1 presents the regression results of equation (4) for $m = 4$ and excluding R_t (imposing $\beta_R = 0$) to assess the liquidity effect on $Y_{i,t}$. Our results indicate that the effects of funding liquidity operate in the opposite direction to those of regulatory changes, as expanded availability of US dollar liquidity is associated with a reduction in CIP deviations, which may manifest with lags. The estimates in Column (1) indicate an important full-sample long-run effect of $\beta_L = \{-1.857, -3.397\}$ for the LIBOR and OIS rates, respectively.

Our regressions show important parameter stability when using the subsamples mentioned above. A striking finding emerges from the contemporaneous β_0 negative effect of funding liquidity on CIP deviations over the different subsamples. As can be seen in Columns (4) and (5) of Table 1(B), its strong influence emerges in the Post-crisis and Regulation eras. It is worth mentioning that regardless of the interest rates utilized in the regressions, the liquidity effect remains substantial in the Regulation period.

Another notable finding is the negative long-run effect over the subsamples, which is much smaller than in Column (1) and is not statistically different from zero in most cases. Note that only the OIS rates produces a negative β_L in the post-crisis period. This suggests that the liquidity effect is generally transitory and exerts no permanent or very small changes, if any, on CIP deviations. The significant long-run effects found in Column (1) are associated with the level shift in L_t as a response to the GFC (see Bianchi et al., 2021).

5.3 The roles of banking regulation and US dollar liquidity

Table 2displays the regression results of including the regulatory and liquidity effects simultaneously, i.e., equation (4) with no restrictions. What stands out in Table 2 is that the contemporaneous and long-run effects of both regulation and liquidity coexist, and their behavior is similar to what was described in Table 1. Before the GFC (Column 2), both the (positive) regulatory effect and the (negative) contemporaneous and long-run liquidity effect are negligible and mostly non-significant. On the contrary, after the GFC (Column 3), these effects are of the same magnitude by opposite signs and significant.

It is essential to highlight that the long-run liquidity effect does not show statistical significance in the most recent sub-period (Column 5). In particular, during the Regulation sub-period, the regulatory effect appears to have the strongest influence. However, intriguingly, in this subsample, the short-run effects of funding liquidity are of comparable magnitudes to the regulatory effects.

Overall, these findings shed important light on the simultaneous effects of regulation and funding liquidity on CIP deviations from 2015 to 2019. The observed comparable magnitudes of short-run liquidity and regulatory effects suggest that market reactions to US banks' liquidity changes can be swift and impactful. Short-term adjustments in funding liquidity conditions might have notable consequences on FX markets and investor behavior. It could be argued that the availability of dollar liquidity may be an important factor to arbitrage away the CIP deviations produced by, among other things, regulation.

5.4 Recursive estimations

It is crucial to examine parameter instability in our regression analysis. Towards this objective we follow formal statistical procedures such as recursive estimation, i.e., tracking the evolution of the estimated coefficients after adding several observations at a time. This contrasts with the sample partition followed by Du et al. (2018).

Consider the complete specification in Table 2. The evolution of recursive estimates of the funding liquidity effect on impact β_0 (contemporaneous effect) and its long-run effect β_L (long-run effect) are shown in Figure 2 for the regressions using both the LIBOR and OIS basis. The left panels depict the estimates of the full sample; while the right panels display the post-GFC results.

The recursive estimations unveil marked dynamics, unearthing a pivotal moment during the GFC that ushers in a structural break, notably impacting both contemporaneous and long-run effects. We encounter distinct instability, particularly in β_0, after 2015, aligning remarkably with Du et al. (2018)'s findings.

In this recursive exploration, we validate the persistent presence of the US bank's liquidity effect both before and after the GFC, with several β_k coefficients standing as statistically significant evidence. Yet, the post-GFC period is remarkable, as the funding liquidity effect strengthened substantially, particularly from 2015 to 2019. Finally, the varying US banks' liquidity effect across different periods implies that the relationship between liquidity and CIP deviations is not static. It is subject to shifts in market conditions and, in particular, regulatory frameworks.

5.5 One-month contract results

The main results are qualitatively similar when the CIP deviations use one-month forward contracts. An important difference, however, is that the stability analysis of the recursive estimations of equation (4) indicates no need to partition the sample besides the evident structural change brought by the GFC. See Figure 3.

Tables 3 and 4 show the corresponding regression exercises. As before, Table 3 shows the regulatory and bank liquidity effects estimated separately, whereas Table 4 shows the effects estimated jointly. These effects are significant, have opposite signs, and their magnitudes tend to move together because the coefficients characterizing the long-run funding liquidity effect β_L are large (in absolute value) in the samples where the regulatory effect β_R is also large. In particular, consider Table 4 where the magnitude of the point estimates are small in the pre-GFC sample (using the LIBOR and OIS rates, respectively, $\beta_R = \{-0.049, 0.206\}$ and $\beta_L = \{-0.143, -0.323\}$), but increase noticeably in the post-GFC period ($\beta_R = \{1.277, 1.190\}$ and $\beta_L = \{-1.111, -0.770\}$).

5.6 The interaction between banking regulation and US dollar liquidity

Our preceding exploration brings to light a compelling revelation - the coexistence of important regulatory and funding liquidity effects on CIP deviations. Notably, these effects tend to move in tandem, creating an intriguing interplay that captivates our attention. Interestingly, larger coefficients for the liquidity effect manifest in samples where the regulatory effect assumes greater magnitude (in absolute value). Since these effects have opposite signs, does this mean they compensate each other?

With this in mind, we estimate an extended version of the regression equation, allowing for interactions between liquidity and regulation. The modified equation is:

$$Y_{i,t} = \sum_{k=0}^{m-1} (\beta_k + \alpha_k R_t)\Delta L_{t-k} + (\beta_L + \alpha_L R_t) L_{t-m} + \beta_R R_t + \alpha_i + \theta_t + \boldsymbol{x}_{it}{}'\boldsymbol{\beta}_x + \varepsilon_{it}\,, \quad (5)$$

and is obtained upon augmenting equation (4) with the terms $R_t \Delta L_{t-k}$ for $k = 0, 1, \ldots, m-1$ and $R_t L_{t-m}$. In this specification, the funding liquidity effect depends on the state of regulation: the short-run multipliers are $\beta_k + \alpha_k R_t$ for $k = 0, 1, \ldots, m-1$, and the long-run effect is $\beta_L + \alpha_L R_t$. In periods when $R_t = 0$, the regulation does not exert any influence on the CIP deviations. Hence, the β_k and β_L coefficients capture the funding liquidity effect in such periods. On the other hand, when $R_t > 0$, the α_k coefficients measure the *additional* funding liquidity effect in periods when CIP deviations are influenced by regulation.

Table 5 showcases the post-GFC sample results and alternative forms of measuring the CIP deviations. As observed previously, the β_k coefficients remain significantly negative, underscoring the presence of a funding liquidity effect even when $R_t = 0$. Interestingly, this effect gains further strength when $R_t > 0$, supported by the negative and statistically significant α_k coefficients. These findings solidify the notion that the funding liquidity effect plays a pivotal role in arbitraging the CIP deviations explicitly induced by regulation.

6 Discussion and closing remarks

Previous studies provided little or no evidence about the simultaneous effects of US bank liquidity and banking regulation on CIP deviations. We find, in contrast, strong evidence that both of these variables help explain the CIP deviation, albeit in opposite directions. These effects intensify post-GFC and are even stronger in the Regulation period. These results are robust and novel, particularly regarding the dynamics of the liquidity coefficient, which becomes more prominent when the regulatory effect occurs.

Our reading of these findings is as follows. Banks are required to report their financial positions at the end of each quarter. This typically involves disclosing their holdings and exposures, including foreign exchange positions, to the regulatory authorities. Because of this, banks may use the forward FX market to adjust their currency positions for the upcoming reporting date. For example, suppose a bank anticipates having an excess of foreign currency liabilities at the end of the quarter. It may use forward contracts to hedge or offset these positions in that case. Once the quarter-end reporting passes and regulatory requirements are met, banks may reverse their window-dressing actions, potentially leading to a reversal in the currency markets. This is the so-called demand side.

On the other hand, the supply side plays an important role in mitigating the regulatory impact on CIP deviations. Liquidity is typically high when the Fed supplies US dollars to the market. Under these conditions, it is not difficult to execute large currency transactions, and the opportunities to exploit interest rate differentials through covered interest rate parity are limited. In such cases, deviations from covered interest rate parity tend to be mild and temporary, as market participants can quickly bring the exchange rates back into equilibrium.

As market participants become aware of the banks' window dressing behavior, they will adjust their strategies as the end of the quarter approaches. Increased market activity driven by banks' window-dressing activities can lead to short-term volatility in both spot and forward exchange rates. However, they might also be aware of the funding liquidity effect. When there is a shortage of dollars, demand for dollars increases relative to its supply. The surge in demand can lead to a higher forward premium on the US dollar, representing the difference between the forward exchange rate and the spot exchange rate transactions. If the forward premium on the dollar increases, it may deviate from what is implied by the interest rate differential between two currencies, thus violating the CIP condition. The counterargument is also true (i.e. when the supply of dollars increases relative to its demand).

Lastly, we find evidence that the interactions between US banks' liquidity and regulatory factors are dynamic. Researchers, market participants, and policymakers should consider the dynamic effect of funding liquidity and its interplay with regulatory changes in their decisions. However, they should proceed cautiously as it may be essential to consider the broader economic context to grasp these implications fully.

References

Armas, A. and Ortiz, M. (2020). Exchange Rate Determination: The Role of Portfolio and Liquidity Shocks. Documentos de Trabajo 004-2020, Superintendencia de Banca y Seguros.

Avdjiev, S., Du, W., Koch, C., and Shin, H. S. (2019). The dollar, bank leverage, and deviations from covered interest parity. *American Economic Review: Insights*, 1(2):193–208.

Baba, N. and Packer, F. (2009). Interpreting deviations from covered interest parity during the financial market turmoil of 2007-08. *Journal of Banking and Finance*, 33(11):1953–1962.

Baba, N., Packer, F., and Nagano, T. (2008). The spillover of money market turbulence to FX swap and cross-currency swap markets. *BIS Quarterly Review*, March 2008:73–83.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International Real Business Cycles. *Journal of Political Economy*, 100(4):745–775.

Baxter, M. and Crucini, M. J. (1993). Explaining saving–investment correlations. *The American Economic Review*, pages 416–436.

Bazán-Palomino, W. and Winkelried, D. (2021). FX markets' reactions to COVID-19: Are they different? *International Economics*, 167:50–58.

Bianchi, J., Bigio, S., and Engel, C. (2021). Scrambling for Dollars: International Liquidity, Banks and Exchange Rates. Working Paper 29457, National Bureau of Economic Research.

Borio, C., McCauley, R. N., McGuire, P., and Sushko, V. (2016). Covered interest parity lost: Understanding the cross-currency basis. *BIS Quarterly Review*, September 2016:45–64.

Cavallino, P. (2019). Capital flows and foreign exchange intervention. *American Economic Journal: Macroeconomics*, 11(2):127–70.

Cerutti, E. M., Obstfeld, M., and Zhou, H. (2021). Covered interest parity deviations: Macrofinancial determinants. *Journal of International Economics*, 130:103447. NBER International Seminar on Macroeconomics 2020.

Chatziantoniou, I., Gabauer, D., and Stenfors, A. (2020). From cip-deviations to a market for risk premia: A dynamic investigation of cross-currency basis swaps. *Journal of International Financial Markets, Institutions and Money*, 69:101245.

Colacito, R., Riddiough, S. J., and Sarno, L. (2020). Business cycles and currency returns. *Journal of Financial Economics*, 137(3):659–678.

Correia, I., Neves, J. C., and Rebelo, S. (1995). Business cycles in a small open economy. *European Economic Review*, 39(6):1089–1113.

De Paoli, B. (2009). Monetary policy and welfare in a small open economy. *Journal of International Economics*, 77(1):11–22.

Du, W. and Schreger, J. (2022). CIP deviations, the dollar, and frictions in international capital markets. In Gopinath, G., Helpman, E., and Rogoff, K., editors, *Handbook of International Economics: International Macroeconomics*, volume 6 of *Handbook of International Economics*, chapter 4, pages 147–197. Elsevier.

Du, W., Tepper, A., and Verdelhan, A. (2018). Deviations from covered interest rate parity. *Journal of Finance*, 73(3):915–957.

Engel, C. (2014). Exchange rates and interest parity. In Gopinath, G., Helpman, E., and Rogoff, K., editors, *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, chapter 8, pages 453–522. Elsevier.

Forbes, K. J. and Warnock, F. E. (2012). Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of International Economics*, 88(2):235–251.

Fratzscher, M. (2012). Capital flows, push versus pull factors and the global financial crisis. *Journal of International Economics*, 88(2):341–356.

Frenkel, J. A. (1973). Elasticities and the interest parity theory. *Journal of Political Economy*, 81(3):741–747.

Frenkel, J. A. and Levich, R. M. (1975). Covered interest arbitrage: Unexploited profits? *Journal of Political Economy*, 83(2):325–338.

Gabaix, X. and Maggiori, M. (2015). International liquidity and exchange rate dynamics. *Quarterly Journal of Economics*, 130(3):1369–1420.

Galí, J. and Monacelli, T. (2005). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies*, 72(3):707–734.

Gromb, D. and Vayanos, D. (2002). Equilibrium and welfare in markets with financially constrained arbitrageurs. *Journal of Financial Economics*, 66(2-3):361–407.

Haas, R. D. (1974). More evidence on the role of speculation in the Canadian forward exchange market. *Canadian Journal of Economics*, 7(3):496–501.

Hodjera, Z. (1973). International short-term capital movements: A survey of theory and empirical analysis. *IMF Staff Papers*, 20(3):683–740.

Hui, C., Genberg, H., and Chung, T. (2011). Funding liquidity risk and deviations from interest rate parity during the financial crisis of 2007-2009. *International Journal of Finance & Economics*, 16(4):307–323.

Ibhagui, O. (2020). Covered interest parity deviations in standard monetary models. *Journal of Economics and Business*, 111:105909.

Itskhoki, O. and Mukhin, D. (2021). Exchange rate disconnect in general equilibrium. *Journal of Political Economy*, 129(8):2183–2232.

Ivashina, V., Scharfstein, D. S., and Stein, J. C. (2015). Dollar funding and the lending behavior of global banks. *Quarterly Journal of Economics*, 130(3):1241–1282.

Kesselman, J. (1971). The role of speculation in forward-rate determination: The Canadian flexible dollar 1953-1960. *Canadian Journal of Economics*, 4(3):279–298.

Klopstock, F. H. (1965). The international money market: Structure, scope and instruments. *Journal of Finance*, 20(2):182–208.

Kohler, D. and Müller, B. (2019). Covered interest rate parity, relative funding liquidity and cross-currency repos. Working Paper 2019-05, Swiss National Bank.

Levich, R. M. (1985). Empirical studies of exchange rates: Price behavior, rate determination and market efficiency. In Jones, R. W. and Kenen, P. B., editors, *Handbook of International Economics*, volume 2 of *Handbook of International Economics*, chapter 19, pages 979–1040. Elsevier.

Levich, R. M. (2017). CIP then and now: A brief survey of measuring and explaining deviations from covered interest parity. mimeo, BIS Symposium: CIP - RIP?

Liao, G. Y. (2020). Credit migration and covered interest rate parity. *Journal of Financial Economics*, 138(2):504–525.

Lustig, H., Roussanov, N., and Verdelhan, A. (2011). Common risk factors in currency markets. *Review of Financial Studies*, 24(11):3731–3777.

Mancini Griffoli, T. and Ranaldo, A. (2012). Limits to Arbitrage during the Crisis: Finding Liquidity Constraints and Covered Interest Parity. Working Papers on Finance 1212, University of St. Gallen, School of Finance.

McCormick, F. (1979). Covered interest arbitrage: Unexploited profits? Comment. *Journal of Political Economy*, 87(2):411–417.

Mendoza, E. G. (1991). Real Business Cycles in a Small Open Economy. *American Economic Review*, 81(4):797–818.

Officer, L. H. and Willett, T. D. (1970). The covered-arbitrage schedule: A critical survey of recent developments. *Journal of Money, Credit and Banking*, 2(2):247–257.

Prachowny, M. F. J. (1970). A note on interest parity and the supply of arbitrage funds. *Journal of Political Economy*, 78(3):540–545.

Ranaldo, A. and de Magistris, P. S. (2022). Liquidity in the global currency market. *Journal of Financial Economics*, 146(3):859–883.

Rime, D., Schrimpf, A., and Syrstad, O. (2022). Covered interest parity arbitrage. *Review of Financial Studies*, 35(11):5185–5227.

Shleifer, A. and Vishny, R. W. (1997). The limits of arbitrage. *Journal of Finance*, 52(1):35–55.

Stoll, H. R. (1968). An empirical study of the forward exchange market under fixed and flexible exchange rate systems. *Canadian Journal of Economics*, 1(1):55–78.

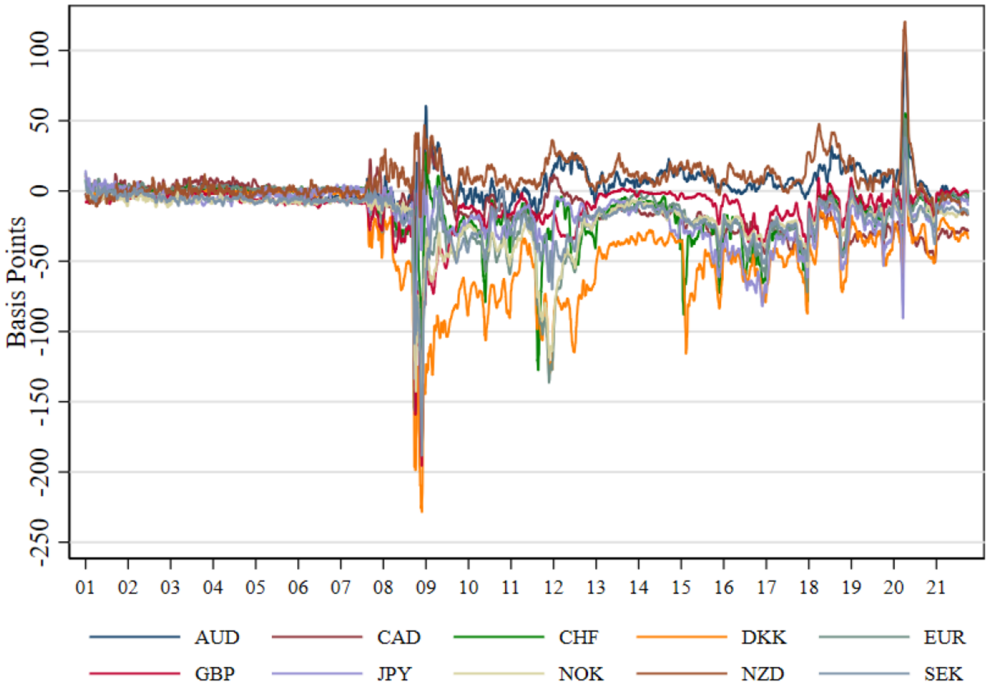
Syrstad, O. and Viswanath-Natraj, G. (2022). Price-setting in the foreign exchange swap market: Evidence from order flow. *Journal of Financial Economics*, 146(1):119–142.

Taylor, M. P. (1987). Covered interest parity: A high-frequency, high-quality data study. *Economica*, 54(216):429–438.

Taylor, M. P. (1989). Covered interest arbitrage and market turbulence. *Economic Journal*, 99(396):376–391.

Tsiang, S. C. (1959). The theory of forward exchange and effects of government intervention on the forward exchange market. *IMF Staff Papers*, 7(1):75–106.

Figure 1. *Deviations from the CIP*



Notes: 10-day moving averages of the 3-month LIBOR cross-currency basis, measured in basis points (100 pbs = 1%), for G10 currencies. The CIP implies that the basis should be zero. This is an updated version of Figure 1 in Du et al. (2018) and Cerutti et al. (2021). For definitions, see section 3.

Source: Bloomberg (see section 4 and the data appendix).

Table 1. *Regulation and funding liquidity effects on CIP deviations. One week-contracts, without control variables.*

	LIBOR (one week)					OIS (one week)				
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation
Panel A: Regulation only ($\beta_i = 0$ for $i = 0, 1, \ldots, m$)										
Regulation β_R	1.124***	0.025	1.423***	0.301***	2.391***	1.209***	0.178***	1.119***	0.190***	1.919***
	(0.052)	(0.039)	(0.064)	(0.040)	(0.110)	(0.069)	(0.068)	(0.059)	(0.038)	(0.101)
Observations	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
Adjusted R^2	0.372	0.377	0.320	0.535	0.315	0.347	0.309	0.390	0.590	0.400
Panel B: Liquidity only ($\beta_R = 0$)										
Liquidity β_0	−1.831***	0.033	−2.940***	−0.947***	−4.880***	−1.183***	−0.121	−2.283***	−0.661***	−3.879***
	(0.137)	(0.082)	(0.200)	(0.116)	(0.404)	(0.179)	(0.160)	(0.185)	(0.115)	(0.369)
β_1	−1.393***	−0.151*	−1.844***	−0.752***	−2.949***	−1.433***	−0.311*	−1.421***	−0.462***	−2.458***
	(0.132)	(0.084)	(0.196)	(0.111)	(0.457)	(0.170)	(0.171)	(0.183)	(0.110)	(0.421)
β_2	−1.350***	−0.024	−1.497***	−0.824***	−2.207***	−1.729***	−0.186	−1.003***	−0.455***	−1.707***
	(0.160)	(0.095)	(0.248)	(0.141)	(0.626)	(0.212)	(0.217)	(0.234)	(0.144)	(0.578)
β_3	−2.207***	−0.073	−2.468***	−1.024***	−3.889***	−2.770***	−0.317	−1.727***	−0.517***	−3.091***
	(0.195)	(0.115)	(0.310)	(0.172)	(0.816)	(0.261)	(0.279)	(0.293)	(0.176)	(0.755)
Liquidity β_L	−1.857***	−0.095	−0.849***	−0.602***	−0.847	−3.397***	−0.383	−0.374	−0.092	−0.657
	(0.154)	(0.100)	(0.298)	(0.160)	(0.874)	(0.213)	(0.287)	(0.285)	(0.168)	(0.811)
Observations	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
Adjusted R^2	0.372	0.377	0.304	0.543	0.262	0.376	0.307	0.381	0.593	0.367

Notes: Fixed-effects estimation of restricted variants of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

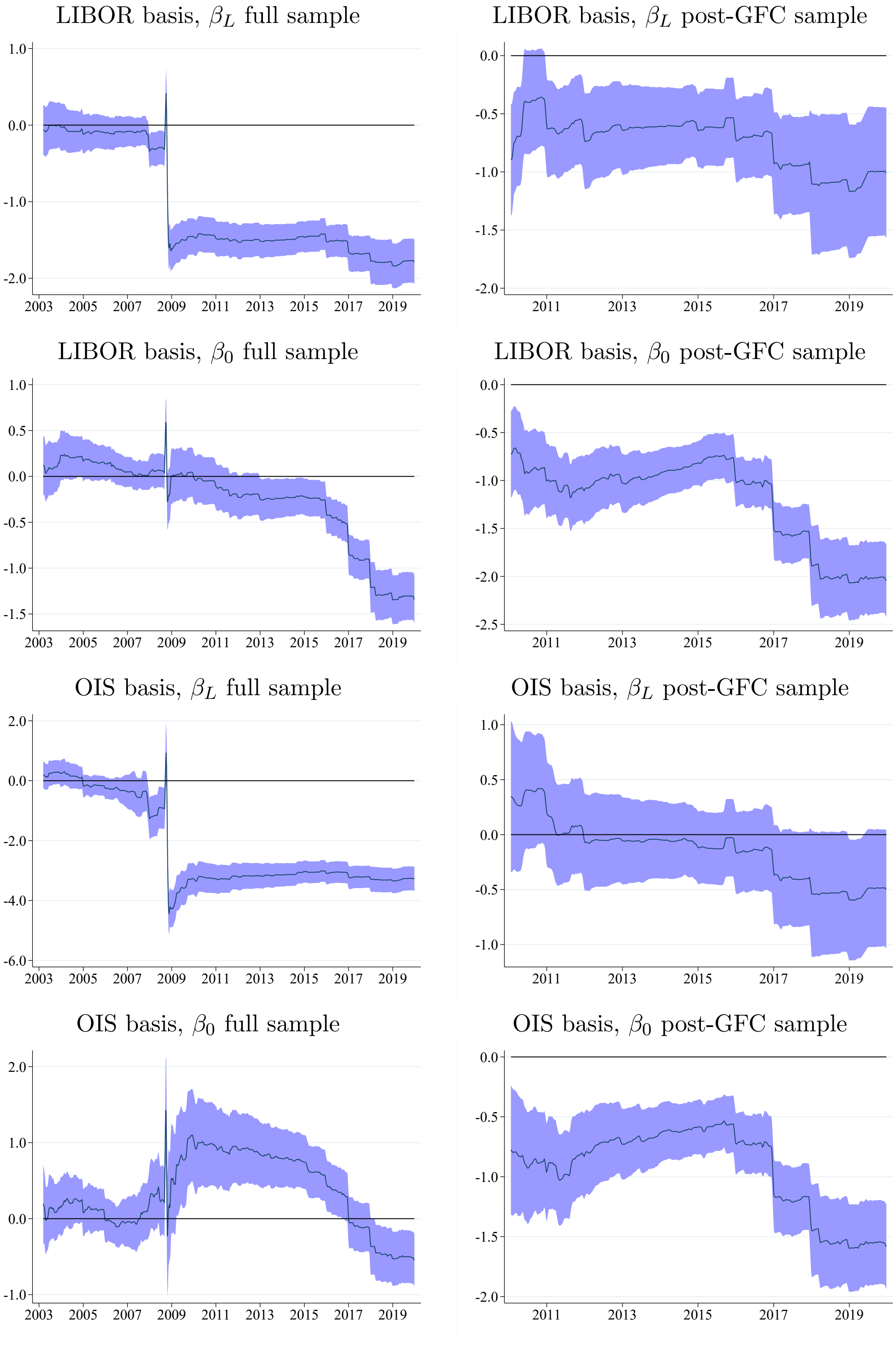
Table 2. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One week-contracts, with control variables.*

	LIBOR (one week)					OIS (one week)				
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation
Liquidity β_0	−1.356***	0.050	−2.052***	−0.818***	−2.982***	−0.557***	−0.037	−1.590***	−0.586***	−2.370***
	(0.137)	(0.084)	(0.197)	(0.118)	(0.391)	(0.179)	(0.165)	(0.185)	(0.117)	(0.365)
β_1	−0.978***	−0.142*	−1.176***	−0.632***	−1.356***	−0.932***	−0.215	−0.890***	−0.396***	−1.187***
	(0.131)	(0.086)	(0.193)	(0.111)	(0.443)	(0.170)	(0.171)	(0.182)	(0.111)	(0.417)
β_2	−1.221***	−0.012	−1.343***	−0.817***	−1.208**	−1.519***	−0.109	−0.886***	−0.451***	−0.919*
	(0.157)	(0.095)	(0.240)	(0.140)	(0.590)	(0.208)	(0.218)	(0.228)	(0.144)	(0.557)
β_3	−2.087***	−0.068	−2.156***	−0.980***	−2.403***	−2.554***	−0.319	−1.468***	−0.478***	−1.905***
	(0.190)	(0.115)	(0.300)	(0.170)	(0.772)	(0.254)	(0.277)	(0.286)	(0.175)	(0.730)
Liquidity β_L	−1.798***	−0.080	−1.027***	−0.647***	−0.139	−3.288***	−0.375	−0.512*	−0.120	−0.102
	(0.150)	(0.100)	(0.289)	(0.160)	(0.821)	(0.207)	(0.285)	(0.278)	(0.169)	(0.778)
Regulation β_R	0.972***	0.006	1.142***	0.226***	1.964***	1.182***	0.167**	0.873***	0.116***	1.548***
	(0.055)	(0.043)	(0.070)	(0.045)	(0.120)	(0.073)	(0.078)	(0.064)	(0.043)	(0.111)
Observations	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
Adjusted R^2	0.399	0.378	0.346	0.549	0.350	0.405	0.308	0.407	0.594	0.423

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Figure 2. *Recursive estimations of funding liquidity effects in CIP deviations. One-week contracts.*



Notes: Recursive estimations of equation (4), as specified in Table 2. The charts show point estimates of β_0 (Contemporaneous effect) and β_L (Long-run effect) and their 95% HAC confidence intervals as the sample size increases, for the Full sample (2001-2019) and the Post-Crisis period (2009-2019).

Table 3. *Regulation and funding liquidity effects on CIP deviations. One month-contracts, without control variables.*

	LIBOR (one month)			OIS (one month)		
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis
	Panel A: Regulation only ($\beta_i = 0$ for $i = 0, 1, \ldots, m$)					
Regulation β_R	0.941***	−0.063	1.159***	1.029***	0.214*	1.113***
	(0.066)	(0.048)	(0.074)	(0.107)	(0.112)	(0.078)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.499	0.246	0.582	0.574	0.448	0.644
	Panel B: Liquidity only ($\beta_R = 0$)					
Liquidity β_0	−0.508***	−0.170***	−0.585***	0.101	−0.382***	−0.505***
	(0.086)	(0.054)	(0.110)	(0.119)	(0.132)	(0.117)
β_1	−0.519***	−0.209***	−0.323***	−0.480***	−0.358**	−0.201*
	(0.082)	(0.055)	(0.112)	(0.113)	(0.142)	(0.119)
β_2	−0.718***	−0.273***	−0.579***	−1.208***	−0.499***	−0.390**
	(0.104)	(0.063)	(0.154)	(0.144)	(0.185)	(0.163)
β_3	−0.782***	−0.222***	−0.454**	−1.442***	−0.500**	−0.211
	(0.130)	(0.080)	(0.198)	(0.180)	(0.245)	(0.209)
Liquidity β_L	−0.679***	−0.166**	−0.280	−2.626***	−0.257	−0.006
	(0.112)	(0.070)	(0.202)	(0.153)	(0.260)	(0.213)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.487	0.251	0.550	0.611	0.449	0.616

Notes: Fixed-effects estimation of restricted variants of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

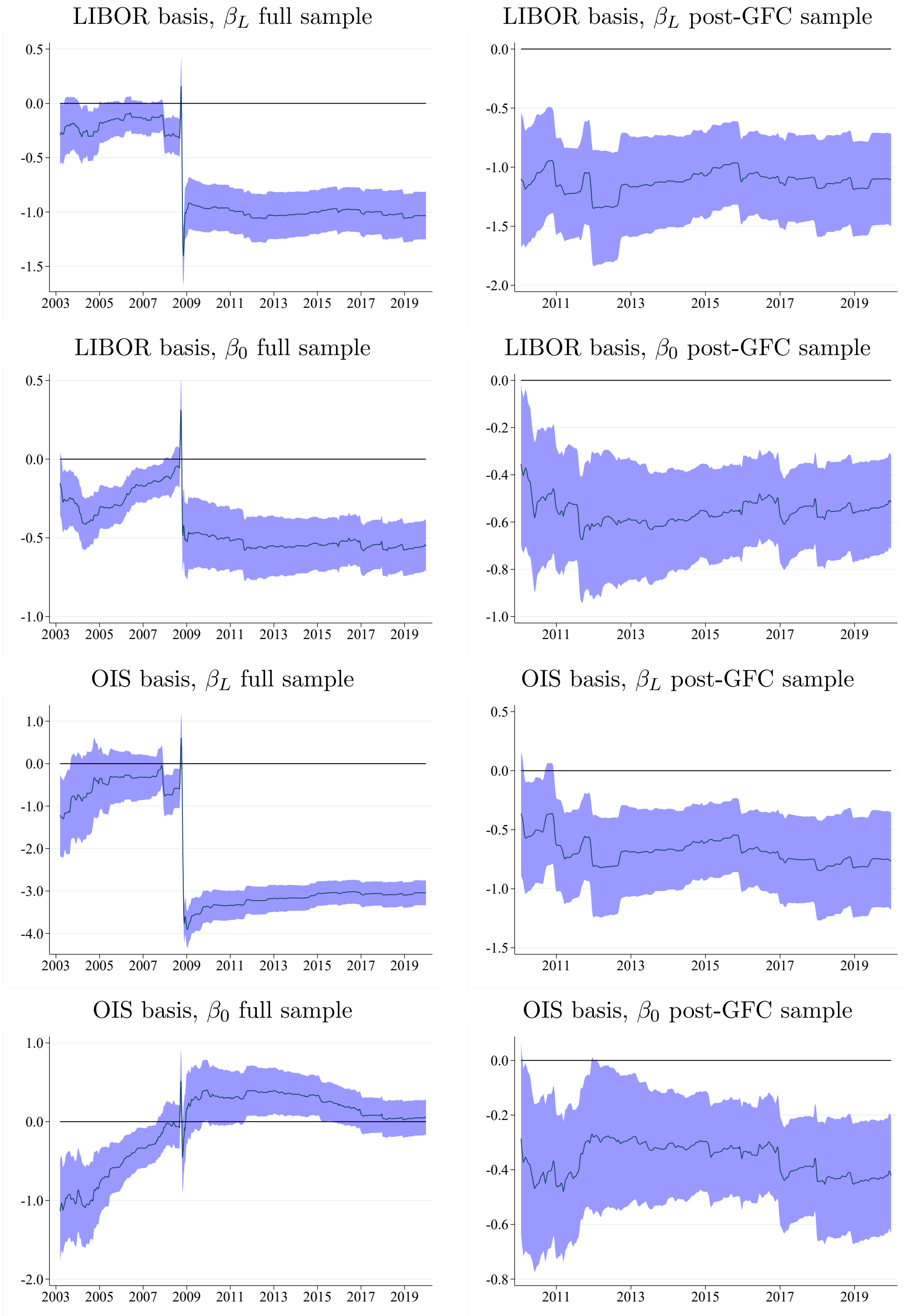
Table 4. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One month-contracts, with control variables.*

	LIBOR (one month)			OIS (one month)		
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis
Liquidity β_0	-0.553^{***}	-0.172^{***}	-0.519^{***}	0.043	-0.336^{***}	-0.424^{***}
	(0.083)	(0.054)	(0.102)	(0.114)	(0.130)	(0.109)
β_1	-0.698^{***}	-0.209^{***}	-0.598^{***}	-0.722^{***}	-0.342^{**}	-0.440^{***}
	(0.081)	(0.056)	(0.108)	(0.110)	(0.141)	(0.115)
β_2	-0.942^{***}	-0.266^{***}	-0.956^{***}	-1.460^{***}	-0.502^{***}	-0.724^{***}
	(0.102)	(0.064)	(0.149)	(0.139)	(0.185)	(0.158)
β_3	-1.156^{***}	-0.211^{**}	-1.108^{***}	-1.930^{***}	-0.534^{**}	-0.801^{***}
	(0.129)	(0.083)	(0.193)	(0.175)	(0.250)	(0.204)
Liquidity β_L	-1.038^{***}	-0.143^{*}	-1.111^{***}	-3.053^{***}	-0.323	-0.770^{***}
	(0.112)	(0.076)	(0.199)	(0.150)	(0.272)	(0.211)
Regulation β_R	1.079^{***}	-0.049	1.277^{***}	1.504^{***}	0.206^{*}	1.190^{***}
	(0.067)	(0.052)	(0.076)	(0.096)	(0.123)	(0.081)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.509	0.252	0.590	0.636	0.450	0.650

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Figure 3. *Recursive estimations of funding liquidity effects in CIP deviations. One-month contracts.*



Notes: Recursive estimations of equation (4), as specified in Table 4. The charts show point estimates of β_0 (Contemporaneous effect) and β_L (Long-run effect) and their 95% HAC confidence intervals as the sample size increases, for the Full sample (2001-2019) and the Post-Crisis period (2009-2019).

Table 5. *Funding liquidity effects, regulations effects and their interactions on CIP deviations, with control variables.*

	One-week contracts		One-month contracts	
	(1) LIBOR	(2) OIS	(1) LIBOR	(2) OIS
Liquidity β_0	-1.417^{***}	-1.072^{***}	-0.253^{**}	-0.110
	(0.191)	(0.181)	(0.121)	(0.128)
β_1	-0.602^{***}	-0.430^{**}	-0.440^{***}	-0.251^{*}
	(0.188)	(0.180)	(0.124)	(0.131)
β_2	-0.371	-0.103	-0.574^{***}	-0.343^{**}
	(0.239)	(0.231)	(0.160)	(0.169)
β_3	-0.857^{***}	-0.419	-0.698^{***}	-0.346
	(0.293)	(0.286)	(0.208)	(0.220)
Liquidity β_L	0.163	0.436	-0.906^{***}	-0.563^{***}
	(0.281)	(0.277)	(0.201)	(0.212)
Regulation β_R	1.709^{**}	2.249^{***}	3.715^{***}	4.626^{***}
	(0.728)	(0.687)	(0.703)	(0.749)
Interaction α_0	-0.532^{***}	-0.421^{***}	-0.101^{***}	-0.108^{***}
	(0.027)	(0.026)	(0.021)	(0.022)
α_1	-0.334^{***}	-0.261^{***}	-0.060^{***}	-0.067^{***}
	(0.041)	(0.039)	(0.018)	(0.019)
α_2	0.016	-0.002	-0.140^{***}	-0.137^{***}
	(0.023)	(0.022)	(0.021)	(0.023)
α_3	-0.069^{*}	-0.067^{*}	-0.140^{***}	-0.154^{***}
	(0.039)	(0.037)	(0.024)	(0.026)
Interaction α_L	-0.055^{***}	-0.053^{***}	-0.027^{***}	-0.038^{***}
	(0.008)	(0.007)	(0.008)	(0.008)
Observations	4,584	4,584	5,730	4,584
Adjusted R^2	0.414	0.451	0.594	0.656

Notes: Fixed-effects estimation of equation (5). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.The sample runs from 2009 to 2019.

A Data details

A.1 Bloomberg

Currency	Item	Period	Observations	Ticker
AUD	Spot	1/01/2001 31/12/2019	4956	AUD Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	AUD1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	AUD1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	ADDR1Z Curncy
	Ibor 1m	1/01/2001 31/12/2019	4956	ADBB1M Curncy
	OIS 1w	14/02/2003 31/12/2019	4403	ADSO1Z Curncy
	OIS 1m	4/12/2001 31/12/2019	4715	ADSOA Curncy
CAD	Spot	1/01/2001 31/12/2019	4956	CAD Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	CAD1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	CAD1M Curncy
	Ibor 1m	1/01/2001 31/12/2019	4956	CDOR01 Index
	OIS 1w	2/10/2007 31/12/2019	3195	CDSO1Z Curncy
	OIS 1m	3/05/2002 31/12/2019	4608	CDSOA Curncy
CHF	Spot	1/01/2001 31/12/2019	4956	CHF Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	CHF1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	CHF1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	SF0001W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	SF0001M Index
DKK	Spot	1/01/2001 31/12/2019	4956	DKK Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	DKK1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	DKK1M Curncy
	Ibor 1w	1/04/2005 31/12/2019	3848	CIBO01W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	CIBO01M Index
	OIS 1w	5/11/2008 31/12/2019	2909	DKSWTN1Z Curncy
	OIS 1m	4/12/2001 31/12/2019	4715	DKSWTNA Curncy
EUR	Spot	1/01/2001 31/12/2019	4956	EUR Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	EUR1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	EUR1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	EUR001W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	EUR001M Index
	OIS 1w	20/12/2001 31/12/2019	4704	EUSWE1Z Curncy
	OIS 1m	2/01/2007 31/12/2019	3390	EUSWEA Curncy
GBP	Spot	1/01/2001 31/12/2019	4956	GBP Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	GBP1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	GBP1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	BP0001W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	BP0001M Index
	OIS 1w	6/02/2004 31/12/2019	4148	BPSWS1Z Curncy
JPY	Spot	1/01/2001 31/12/2019	4956	JPY Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	JPY1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	JPY1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	JY0001W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	JY0001M Index
	OIS 1w	15/03/2002 31/12/2019	4643	JYSO1Z Curncy
	OIS 1m	15/03/2002 31/12/2019	4643	JYSOA Curncy

Currency	Item	Period	Observations	Specific Ticker
NOK	Spot	1/01/2001 31/12/2019	4956	NOK Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	NOK1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	NOK1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	NIBOR1W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	NIBOR1M Index
NZD	Spot	1/01/2001 31/12/2019	4956	NZD Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	NZD1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	NZD1M Curncy
	Ibor 1m	1/01/2001 31/12/2019	4956	NDBB1M Curncy
	OIS 1w	12/10/2007 31/12/2019	3188	NDSO1Z Curncy
	OIS 1m	4/09/2002 31/12/2019	4519	NDSOA Curncy
SEK	Spot	1/01/2001 31/12/2019	4956	SEK Curncy
	Forward 1w	1/01/2001 31/12/2019	4956	SEK1W Curncy
	Forward 1m	1/01/2001 31/12/2019	4956	SEK1M Curncy
	Ibor 1w	1/01/2001 31/12/2019	4956	STIB1W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	STIB1M Index
	OIS 1w	15/09/2008 31/12/2019	2946	SKSWTN1Z Curncy
	OIS 1m	3/08/2004 31/12/2019	4020	SKSWTNA Curncy
USD	Ibor 1w	1/01/2001 31/12/2019	4956	US0001W Index
	Ibor 1m	1/01/2001 31/12/2019	4956	US0001M Index
	OIS 1w	20/12/2001 31/12/2019	4704	USSO1Z Curncy
	OIS 1m	4/12/2001 31/12/2019	4715	USSOA Curncy

A.2 FRED

Item	Period	Obs.	Ticker
CBOE Volatility Index (daily)	1/01/2001 31/12/2019	4956	VIXCLS
Total reserve balances maintained with Federal Reserve Banks	1/01/2001 31/12/2019	991	RESBALNSW
Government securities (Treasury and agency) held by commercial banks	1/01/2001 31/12/2019	991	TASACBW 027NBOG
US dollar financial commercial paper	1/01/2001 31/12/2019	991	FINCPN
Demand deposits	1/01/2001 31/12/2019	991	WDDNS

Online supplement (not intended for publication)

Robustness checks on the estimation results:

A. Tables 1 and 3 in the main text do not include control variables (VIX and bid-ask spreads). Tables A1 and A2 below include the control variables.

B. Tables 2, 4 and 5 in the main text include control variables (VIX and bid-ask spreads), whereas tables B1, B2 and B3 below exclude them.

C. Tables C1, C2 and C3 below are variants of tables 2, 4 and 5 in the main text, respectively. They use a balanced sample consisting on observations where both the LIBOR and OIS rates are available, for a given country and a given contract duration.

Table A1. *Regulation and liquidity effects on CIP deviations. One week-contracts, with control variables.*

	LIBOR (one week)					OIS (one week)				
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation
Panel A: Regulation only ($\beta_i = 0$ for $i = 0, 1, \ldots, m$)										
Regulation β_R	1.114***	0.023	1.429***	0.319***	2.390***	1.185***	0.173**	1.120***	0.205***	1.913***
	(0.052)	(0.039)	(0.065)	(0.041)	(0.111)	(0.070)	(0.069)	(0.059)	(0.039)	(0.102)
Observations	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
Adjusted R^2	0.373	0.378	0.323	0.538	0.317	0.350	0.309	0.394	0.591	0.403
Panel B: Liquidity only ($\beta_R = 0$)										
Liquidity β_0	−1.934***	0.048	−3.036***	−0.986***	−5.063***	−1.308***	−0.121	−2.344***	−0.672***	−4.010***
	(0.138)	(0.082)	(0.200)	(0.116)	(0.406)	(0.179)	(0.159)	(0.185)	(0.114)	(0.372)
β_1	−1.448***	−0.145*	−1.894***	−0.761***	−3.036***	−1.494***	−0.273	−1.438***	−0.462***	−2.508***
	(0.133)	(0.084)	(0.196)	(0.110)	(0.460)	(0.171)	(0.169)	(0.182)	(0.110)	(0.424)
β_2	−1.423***	−0.013	−1.566***	−0.837***	−2.375***	−1.815***	−0.175	−1.058***	−0.461***	−1.839***
	(0.161)	(0.095)	(0.248)	(0.141)	(0.627)	(0.213)	(0.215)	(0.233)	(0.144)	(0.579)
β_3	−2.296***	−0.068	−2.539***	−1.027***	−4.024***	−2.883***	−0.303	−1.760***	−0.502***	−3.179***
	(0.196)	(0.115)	(0.309)	(0.171)	(0.817)	(0.261)	(0.277)	(0.292)	(0.176)	(0.755)
Liquidity β_L	−1.878***	−0.079	−0.849***	−0.591***	−0.885	−3.426***	−0.381	−0.376	−0.091	−0.691
	(0.154)	(0.100)	(0.297)	(0.159)	(0.873)	(0.213)	(0.286)	(0.283)	(0.168)	(0.810)
	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
	0.375	0.378	0.309	0.546	0.269	0.382	0.307	0.386	0.593	0.372

Notes: Fixed-effects estimation of restricted variants of equation (4). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table A2. *Regulation and liquidity effects on CIP deviations. One month-contracts, with control variables.*

	LIBOR (one month)			OIS (one month)		
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis
	Panel A: Regulation only ($\beta_i = 0$ for $i = 0, 1, \ldots, m$)					
Regulation β_R	0.939^{***}	-0.064	1.161^{***}	1.022^{***}	0.179	1.113^{***}
	(0.066)	(0.048)	(0.073)	(0.106)	(0.114)	(0.078)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.500	0.246	0.583	0.578	0.448	0.647
	Panel B: Liquidity only ($\beta_R = 0$)					
Liquidity β_0	-0.579^{***}	-0.169^{***}	-0.656^{***}	-0.015	-0.353^{***}	-0.552^{***}
	(0.086)	(0.054)	(0.110)	(0.120)	(0.130)	(0.116)
β_1	-0.571^{***}	-0.215^{***}	-0.363^{***}	-0.560^{***}	-0.323^{**}	-0.221^{*}
	(0.083)	(0.055)	(0.112)	(0.114)	(0.139)	(0.118)
β_2	-0.770^{***}	-0.277^{***}	-0.615^{***}	-1.279^{***}	-0.474^{***}	-0.406^{**}
	(0.104)	(0.063)	(0.153)	(0.144)	(0.182)	(0.162)
β_3	-0.850^{***}	-0.229^{***}	-0.501^{**}	-1.555^{***}	-0.476^{**}	-0.236
	(0.130)	(0.080)	(0.197)	(0.181)	(0.242)	(0.208)
Liquidity β_L	-0.704^{***}	-0.169^{**}	-0.278	-2.660^{***}	-0.240	0.006
	(0.112)	(0.071)	(0.201)	(0.153)	(0.257)	(0.212)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.488	0.252	0.552	0.613	0.449	0.620

Notes: Fixed-effects estimation of restricted variants of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table B1. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One week-contracts, without control variables.*

	LIBOR (one week)					OIS (one week)				
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation
Liquidity β_0	-1.258^{***}	0.035	-1.967^{***}	-0.786^{***}	-2.878^{***}	-0.433^{**}	-0.037	-1.540^{***}	-0.585^{***}	-2.298^{***}
	(0.136)	(0.083)	(0.197)	(0.119)	(0.386)	(0.178)	(0.166)	(0.185)	(0.117)	(0.361)
β_1	-0.916^{***}	-0.148^{*}	-1.116^{***}	-0.630^{***}	-1.234^{***}	-0.857^{***}	-0.253	-0.865^{***}	-0.404^{***}	-1.103^{***}
	(0.131)	(0.086)	(0.193)	(0.112)	(0.440)	(0.169)	(0.173)	(0.182)	(0.111)	(0.414)
β_2	-1.149^{***}	-0.023	-1.272^{***}	-0.802^{***}	-1.073^{*}	-1.425^{***}	-0.121	-0.831^{***}	-0.445^{***}	-0.811
	(0.156)	(0.095)	(0.240)	(0.140)	(0.588)	(0.207)	(0.219)	(0.229)	(0.143)	(0.555)
β_3	-2.003^{***}	-0.074	-2.091^{***}	-0.984^{***}	-2.251^{***}	-2.442^{***}	-0.332	-1.440^{***}	-0.498^{***}	-1.797^{**}
	(0.190)	(0.115)	(0.301)	(0.171)	(0.770)	(0.253)	(0.279)	(0.288)	(0.176)	(0.728)
Liquidity β_L	-1.771^{***}	-0.096	-1.014^{***}	-0.654^{***}	-0.042	-3.244^{***}	-0.377	-0.500^{*}	-0.117	-0.021
	(0.149)	(0.100)	(0.290)	(0.160)	(0.821)	(0.206)	(0.287)	(0.280)	(0.168)	(0.778)
Regulation β_R	0.994^{***}	0.006	1.153^{***}	0.213^{***}	1.992^{***}	1.214^{***}	0.165^{**}	0.882^{***}	0.102^{**}	1.573^{***}
	(0.055)	(0.043)	(0.069)	(0.045)	(0.118)	(0.073)	(0.078)	(0.063)	(0.043)	(0.109)
Observations	7,672	2,248	4,584	2,504	2,080	6,029	0,869	4,584	2,504	2,080
Adjusted R^2	0.397	0.377	0.343	0.547	0.348	0.402	0.309	0.403	0.593	0.421

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table B2. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One month-contracts, without control variables.*

	LIBOR (one month)			OIS (one month)		
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis
Liquidity β_0	-0.487^{***}	-0.173^{***}	-0.453^{***}	0.151	-0.358^{***}	-0.382^{***}
	(0.083)	(0.054)	(0.103)	(0.114)	(0.132)	(0.110)
β_1	-0.646^{***}	-0.204^{***}	-0.559^{***}	-0.644^{***}	-0.376^{***}	-0.422^{***}
	(0.080)	(0.056)	(0.108)	(0.109)	(0.144)	(0.115)
β_2	-0.891^{***}	-0.262^{***}	-0.923^{***}	-1.393^{***}	-0.528^{***}	-0.711^{***}
	(0.102)	(0.064)	(0.149)	(0.139)	(0.189)	(0.159)
β_3	-1.091^{***}	-0.203^{**}	-1.066^{***}	-1.825^{***}	-0.564^{**}	-0.782^{***}
	(0.129)	(0.083)	(0.193)	(0.175)	(0.254)	(0.206)
Liquidity β_L	-1.012^{***}	-0.139^{*}	-1.113^{***}	-3.020^{***}	-0.349	-0.783^{***}
	(0.112)	(0.076)	(0.200)	(0.149)	(0.275)	(0.212)
Regulation β_R	1.083^{***}	-0.051	1.281^{***}	1.513^{***}	0.237^{*}	1.195^{***}
	(0.067)	(0.052)	(0.076)	(0.096)	(0.122)	(0.081)
Observations	9,860	3,080	5,730	7,066	1,642	4,584
Adjusted R^2	0.507	0.251	0.588	0.634	0.450	0.647

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table B3. *Funding liquidity effects, regulations effects and their interactions on CIP deviations, without control variables.*

	One-week contracts		One-month contracts	
	(1) LIBOR	(2) OIS	(1) LIBOR	(2) OIS
Liquidity β_0	-1.327^{***}	-1.017^{***}	-0.204^{*}	-0.081
	(0.191)	(0.182)	(0.122)	(0.130)
β_1	-0.528^{***}	-0.391^{**}	-0.417^{***}	-0.246^{*}
	(0.188)	(0.181)	(0.125)	(0.132)
β_2	-0.290	-0.035	-0.564^{***}	-0.349^{**}
	(0.239)	(0.232)	(0.161)	(0.170)
β_3	-0.781^{***}	-0.377	-0.685^{***}	-0.355
	(0.294)	(0.287)	(0.209)	(0.222)
Liquidity β_L	0.187	0.461^{*}	-0.925^{***}	-0.592^{***}
	(0.281)	(0.279)	(0.201)	(0.213)
Regulation β_R	1.876^{**}	2.403^{***}	3.528^{***}	4.512^{***}
	(0.729)	(0.687)	(0.705)	(0.752)
Interaction α_0	-0.527^{***}	-0.419^{***}	-0.093^{***}	-0.101^{***}
	(0.027)	(0.026)	(0.021)	(0.022)
α_1	-0.340^{***}	-0.266^{***}	-0.054^{***}	-0.061^{***}
	(0.041)	(0.039)	(0.018)	(0.019)
α_2	0.014	-0.005	-0.132^{***}	-0.130^{***}
	(0.023)	(0.022)	(0.021)	(0.023)
α_3	-0.075^{*}	-0.072^{*}	-0.130^{***}	-0.144^{***}
	(0.039)	(0.037)	(0.024)	(0.026)
Interaction α_L	-0.056^{***}	-0.054^{***}	-0.025^{***}	-0.037^{***}
	(0.008)	(0.007)	(0.008)	(0.008)
Observations	4,584	4,584	5,730	4,584
Adjusted R^2	0.410	0.448	0.592	0.652

Notes: Fixed-effects estimation of equation (5). Newey-West standard errors (with a 12-week lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include currency fixed-effects and quarterly dummies for time-effects.The sample runs from 2009 to 2019.

Table C1. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One week-contracts, balanced samples.*

	LIBOR (one week)					OIS (one week)				
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(4) Pre-Regulation	(5) Regulation
Liquidity β_0	-1.486^{***}	0.012	-2.006^{***}	-0.727^{***}	-2.971^{***}	-0.899^{***}	-0.041	-2.060^{***}	-0.717^{***}	-3.098^{***}
	(0.176)	(0.103)	(0.223)	(0.125)	(0.442)	(0.218)	(0.165)	(0.234)	(0.141)	(0.459)
β_1	-1.083^{***}	-0.021	-1.152^{***}	-0.579^{***}	-1.398^{***}	-1.228^{***}	-0.237	-1.096^{***}	-0.465^{***}	-1.439^{***}
	(0.168)	(0.102)	(0.217)	(0.118)	(0.501)	(0.207)	(0.172)	(0.229)	(0.134)	(0.521)
β_2	-1.210^{***}	0.046	-1.265^{***}	-0.718^{***}	-1.161^{*}	-1.914^{***}	-0.128	-1.131^{***}	-0.553^{***}	-1.138
	(0.202)	(0.120)	(0.270)	(0.150)	(0.666)	(0.253)	(0.219)	(0.288)	(0.175)	(0.694)
β_3	-2.133^{***}	-0.006	-2.061^{***}	-0.847^{***}	-2.400^{***}	-3.254^{***}	-0.344	-1.877^{***}	-0.634^{***}	-2.352^{***}
	(0.245)	(0.144)	(0.337)	(0.182)	(0.872)	(0.310)	(0.279)	(0.360)	(0.213)	(0.909)
Liquidity β_L	-1.594^{***}	-0.061	-0.908^{***}	-0.510^{***}	-0.082	-3.891^{***}	-0.401	-0.618^{*}	-0.161	0.026
	(0.193)	(0.130)	(0.324)	(0.172)	(0.926)	(0.254)	(0.287)	(0.349)	(0.205)	(0.968)
Regulation β_R	0.995^{***}	0.033	1.087^{***}	0.169^{***}	1.912^{***}	1.248^{***}	0.148^{**}	1.071^{***}	0.169^{***}	1.884^{***}
	(0.068)	(0.049)	(0.078)	(0.047)	(0.136)	(0.081)	(0.072)	(0.082)	(0.052)	(0.140)
Observations	4,748	0,865	3,438	1,878	1,560	4,748	0,865	3,438	1,878	1,560
Adjusted R^2	0.405	0.460	0.373	0.604	0.363	0.406	0.306	0.381	0.554	0.413

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table C2. *Joint estimation of funding liquidity and regulation effects on CIP deviations. One month-contracts, balanced samples.*

	LIBOR (one month)			OIS (one month)		
	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis	(1) Full Sample	(2) Pre-crisis	(3) Post-crisis
Liquidity β_0	-0.553^{***}	-0.393^{***}	-0.425^{***}	0.043	-0.337^{***}	-0.424^{***}
	(0.101)	(0.080)	(0.109)	(0.114)	(0.129)	(0.109)
β_1	-0.692^{***}	-0.282^{***}	-0.528^{***}	-0.721^{***}	-0.341^{**}	-0.440^{***}
	(0.097)	(0.080)	(0.116)	(0.110)	(0.140)	(0.115)
β_2	-0.917^{***}	-0.480^{***}	-0.854^{***}	-1.462^{***}	-0.517^{***}	-0.724^{***}
	(0.124)	(0.095)	(0.160)	(0.139)	(0.185)	(0.158)
β_3	-1.145^{***}	-0.417^{***}	-0.995^{***}	-1.929^{***}	-0.521^{**}	-0.801^{***}
	(0.155)	(0.123)	(0.207)	(0.175)	(0.250)	(0.204)
Liquidity β_L	-0.971^{***}	-0.247^{**}	-1.023^{***}	-3.054^{***}	-0.323	-0.770^{***}
	(0.134)	(0.114)	(0.215)	(0.150)	(0.272)	(0.211)
Regulation β_R	1.079^{***}	0.010	1.200^{***}	1.434^{***}	0.180	1.190^{***}
	(0.077)	(0.068)	(0.081)	(0.092)	(0.113)	(0.081)
Observations	7,064	1,640	4,584	7,064	1,640	4,584
Adjusted R^2	0.502	0.199	0.627	0.636	0.452	0.650

Notes: Fixed-effects estimation of equation (4). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.

Samples: (1) Full: 2001-2019; (2) Pre-Crisis: 2001-2006; (3) Post-Crisis: 2009-2019; (4) Pre-Regulation: 2009-2014; and (5) Regulation: 2015-2019.

Table C3. *Funding liquidity effects, regulations effects and their interactions on CIP deviations. Balanced samples.*

	One-week contracts		One-month contracts	
	(1) LIBOR	(2) OIS	(1) LIBOR	(2) OIS
Liquidity β_0	-1.411^{***}	-1.431^{***}	-0.189	-0.110
	(0.217)	(0.227)	(0.129)	(0.128)
β_1	-0.616^{***}	-0.559^{**}	-0.392^{***}	-0.251^{*}
	(0.213)	(0.225)	(0.133)	(0.131)
β_2	-0.350	-0.165	-0.509^{***}	-0.343^{**}
	(0.269)	(0.288)	(0.172)	(0.169)
β_3	-0.836^{**}	-0.629^{*}	-0.619^{***}	-0.346
	(0.331)	(0.355)	(0.223)	(0.220)
Liquidity β_L	0.222	0.542	-0.838^{***}	-0.563^{***}
	(0.316)	(0.343)	(0.216)	(0.212)
Regulation β_R	1.541^{*}	1.976^{**}	3.489^{***}	4.626^{***}
	(0.826)	(0.862)	(0.750)	(0.749)
Interaction α_0	-0.509^{***}	-0.526^{***}	-0.092^{***}	-0.108^{***}
	(0.031)	(0.033)	(0.022)	(0.022)
α_1	-0.313^{***}	-0.306^{***}	-0.054^{***}	-0.067^{***}
	(0.047)	(0.049)	(0.019)	(0.019)
α_2	0.021	0.010	-0.128^{***}	-0.137^{***}
	(0.026)	(0.028)	(0.023)	(0.023)
α_3	-0.058	-0.050	-0.131^{***}	-0.154^{***}
	(0.045)	(0.047)	(0.026)	(0.026)
Interaction α_L	-0.052^{***}	-0.058^{***}	-0.025^{***}	-0.038^{***}
	(0.009)	(0.009)	(0.008)	(0.008)
Observations	3,438	3,438	4,584	4,584
Adjusted R^2	0.434	0.439	0.631	0.656

Notes: Fixed-effects estimation of equation (5). Newey-West standard errors (with a 12-lag window) in parenthesis. The symbol * [**] *** denotes statistical significance at the 10% [5%] 1% confidence level. All the estimations include the following controls: VIX Index one-week lag and its variation, bid-ask spread one-week lag and its variation, currency fixed-effects, and quarterly dummies for time-effects.The sample runs from 2009 to 2019.