NDF and Exchange Rate Volatility*

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Abstract

This paper quantifies the impact of non-resident Non-Deliverable Forward (NDF) flows on the Chilean peso using daily administrative data. Exploiting the structural break caused by the 2020–2021 pension fund withdrawals, we document a critical regime shift. We find that the retrenchment of local institutional investors eroded market depth, leading to a heightened, nonlinear sensitivity to short-term speculative flows. Post-withdrawal, these offshore positions significantly amplify depreciation and volatility. Our findings underscore the financial stability risks arising when domestic liquidity buffers are compromised, presenting key challenges for monetary policy and regulatory design.

JEL codes: F31, G13, G15, G23, E58

Keywords: Non-deliverable forwards; FX volatility; carry trade; speculation

1. Introduction

The rapid deepening of offshore Non-Deliverable Forward (NDF) markets has fundamentally altered the landscape of exchange rate determination in emerging economies. Although these instruments provide essential hedging capabilities for international investors, they also serve as opaque conduits for speculative capital that can bypass domestic macroprudential regulations (McCauley and Shu, 2016). Theoretical models of limits to arbitrage suggest that when these speculative flows are large relative to the absorptive capacity of local intermediaries, they can generate non-fundamental pressure on the spot exchange rate (Gabaix and Maggiori, 2015). Understanding this mechanism is particularly critical during periods of structural stress, where the withdrawal of natural liquidity providers can exacerbate the destabilizing impact of offshore trading strategies.

In this paper, we quantify the impact of non-resident NDF flows on the Chilean peso utilizing administrative data on daily non-resident positions between 2015 and 2024. Exploiting the structural

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break caused by the pension fund withdrawals of 2020-2021, we examine how the erosion of domestic liquidity altered market dynamics. Our results reveal a clear regime shift: following the retrenchment of local institutional investors, the exchange rate developed a heightened, nonlinear sensitivity to short-term speculative flows, driving volatility beyond what fundamentals would predict.

Consequently, these dynamics pose profound challenges for both macroeconomic management and financial stability. On the monetary front, the increased influence of offshore speculation complicates the assessment of exchange rate pass-through (ERPT), forcing central banks to distinguish between fundamental shocks and short-term financial noise when calibrating policy responses. Furthermore, the structural vulnerabilities exposed by this regime shift underscore an urgent need for targeted macroprudential regulation. Addressing these risks requires designing preemptive mechanisms that actively disincentivize speculative offshore flows while preserving the market's essential hedging capabilities, a balance that hinges on leveraging granular transparency and robust institutional frameworks.

We begin our analysis by classifying the strategies driving NDF usage, distinguishing between hedging requirements and investment motives. Within the latter, we further differentiate between carry trade and pure speculation. This framework is essential, as each strategy responds to specific drivers and exerts a distinct impact on exchange rate dynamics.

Turning to the empirical setting, we examine how these forces played out during the structural transformation of the Chilean foreign exchange (FX) market. Chile offers an interesting setting to examine these dynamics, given its expanding derivatives market and regulatory changes that have facilitated non-resident participation.

This evolution took a leap with a series of liberalization measures around 2017, including the possibility of settling local bonds through Euroclear, currently a key custodian, and reforms to pension fund investment limits. The former was accompanied by partial hedging of these instruments, while the latter deepened the NDF market, establishing a stable equilibrium where non-residents acted as net buyers, effectively absorbing the structural short positions of pension funds through the intermediation of local banks due to the attractive implicit yields implied by the forward points. However, this liquidity ecosystem was disrupted by the COVID-19 pandemic and the subsequent pension fund withdrawals. As pension funds liquidated foreign assets and reduced their hedging needs, the market lost its primary counterparty for offshore flows. Concurrently, divergent monetary policy cycles heightened incentives for carry trade strategies; lacking the natural buffer provided by pension funds, local banks —due to their natural FX-neutral position— were forced to close their positions directly in the spot market. This structural decoupling amplified exchange rate sensitivity, culminating in episodes of excessive volatility such as the one triggering the FX intervention in July 2022.

To quantify the dynamic impact of non-resident NDF flows on exchange rate dynamics, we estimate impulse response functions via the local projections technique. We consider FX depreciation and different measures of FX volatility as dependent variables, including realized volatility (exponentially weighted moving average, intraday standard deviation, bid-ask spread) and implied

volatility (derived from options). Our baseline models condition these estimates on a comprehensive set of local and external drivers relevant to the Chilean market. Crucially, we explicitly test for structural breaks in the effect of interest surrounding the three pension fund withdrawals between 2020 and 2021. Finally, we analyze the heterogeneity of these effects by analyzing the sensitivity of the exchange rate to different contract maturities and the nonlinear responses associated with flow size.

Our results show a marked increase in the effect of NDF flows on exchange rate dynamics following pension fund withdrawals. The average cumulative impulse response function (CIRF) over 30 days on exchange rate depreciation doubles after the third withdrawal (April 2021), increasing from 0.3% to 0.6% in response to a USD 1 billion shock in NDF purchases by non-residents. Regarding the realized volatility measures, the CIRFs after April 2021 are larger for horizons of up to 3-5 days. One day after the USD 1 billion shock in NDF purchases by non-residents, the cumulative effects are approximately 4% for the bid-ask spread and 3% for the intraday standard deviation. While for the implied volatility in short-term options (3 and 6 months), the post–April 2021 CIRFs one day after the shock are on the order of 1% and 0.5%, respectively, whereas in the pre-period these effects were practically zero.

Decomposing flows by contractual maturity reveals distinct transmission channels: exchange rate depreciation is driven primarily by flows with maturities between 8 and 35 days, whereas volatility effects stem largely from the 36-to-95-day segment. Consequently, the effects documented in this paper are predominantly explained by short-term positioning.

We also find that the functional form of this impact has changed. The full sample exhibits clear nonlinearities implying that, historically, flows of considerable magnitude were required to alter exchange rate dynamics. However, this feature disappears in the post-April 2021 period. We interpret this linearization as a symptom of reduced market depth. In the absence of the buffer provided by pension funds, the natural counterparty is missing, which allows even moderate non-resident flows to transmit directly to both the exchange rate level and its volatility.

Our work contributes to the literature analyzing the cross-market transmission between offshore derivatives and onshore spot rates in emerging economies. Seminal studies on Asian currencies, such as Park (2001) for the Korean won and Colavecchio and Funke (2009) for the renminbi, established early evidence of unidirectional causality flowing from NDFs to spot prices during periods of turbulence. More recently, Patel and Xia (2019) generalized these findings, demonstrating that while domestic markets dominate in calm times, offshore centers often lead price discovery during global stress. This decoupling is theoretically grounded in the presence of persistent arbitrage frictions (Du et al., 2018), yet recent evidence suggests the transmission mechanism is state-dependent. Katusiime (2025) highlights that the impact of FX derivatives on spot dynamics is not uniform across developing nations but is conditional on financial depth and market microstructure; essentially, the stabilizing or destabilizing nature of these flows hinges on the capacity of local markets to absorb order flow.

Regarding the specific case of Chile, our findings complement recent evidence linking financial flows to exchange rate instability. Cox and Carreño (2016) document that speculative carry trade

positions in the derivatives market are significantly associated with exchange rate "turbulence" and negative skewness. Conversely, Aldunate et al. (2025) focus on the role of domestic institutional investors, finding that pension fund flows exert pressure on spot rates and generate CIP deviations, which are then propagated to the forward market through bank hedging. Crucially, Okuda (2025) provides a macroeconomic assessment of the post-pandemic landscape, confirming that the massive pension fund withdrawals significantly diminished Chile's financial depth, rendering local markets structurally more volatile and sensitive to external shocks. We bridge these strands of literature by isolating the specific role of non-resident NDF flows, showing how their interaction with these local frictions becomes a primary source of nonlinear instability precisely when the liquidity provided by institutional investors retracts.

Finally, our findings carry direct implications for both monetary policy and the design of regulatory frameworks. On the monetary front, the literature indicates that the magnitude and persistence of exchange rate pass-through (ERPT) depend on the nature of the shock triggering the depreciation (cf. Forbes et al. (2018); García-Cicco and García-Schmidt (2020)). As the appropriate policy response hinges on these specific pass-through characteristics, our results underscore the necessity of treating non-resident NDF flows as an additional transmission channel.

Regarding measures to curb speculative pressures, international evidence presents a mixed landscape. The Brazilian experience with the Financial Operations Tax (IOF) serves as a cautionary tale regarding unintended market distortions and liquidity costs. In contrast, the macroprudential approach adopted by South Korea and other Asian economies illustrates that it is feasible to design regulations that effectively correct incentives, successfully mitigating speculative activity and its destabilizing consequences without impairing market functionality.

Looking ahead, further research is required to analyze the specific microstructure of the Chilean market in greater detail, with the objective of devising proposals to disincentivize speculative positioning, particularly by non-resident agents. Such efforts should capitalize on Chile's robust institutional framework and recent advancements in transparency—specifically the granular reporting of derivative transactions—to implement precise mechanisms that enhance stability while preserving financial openness.

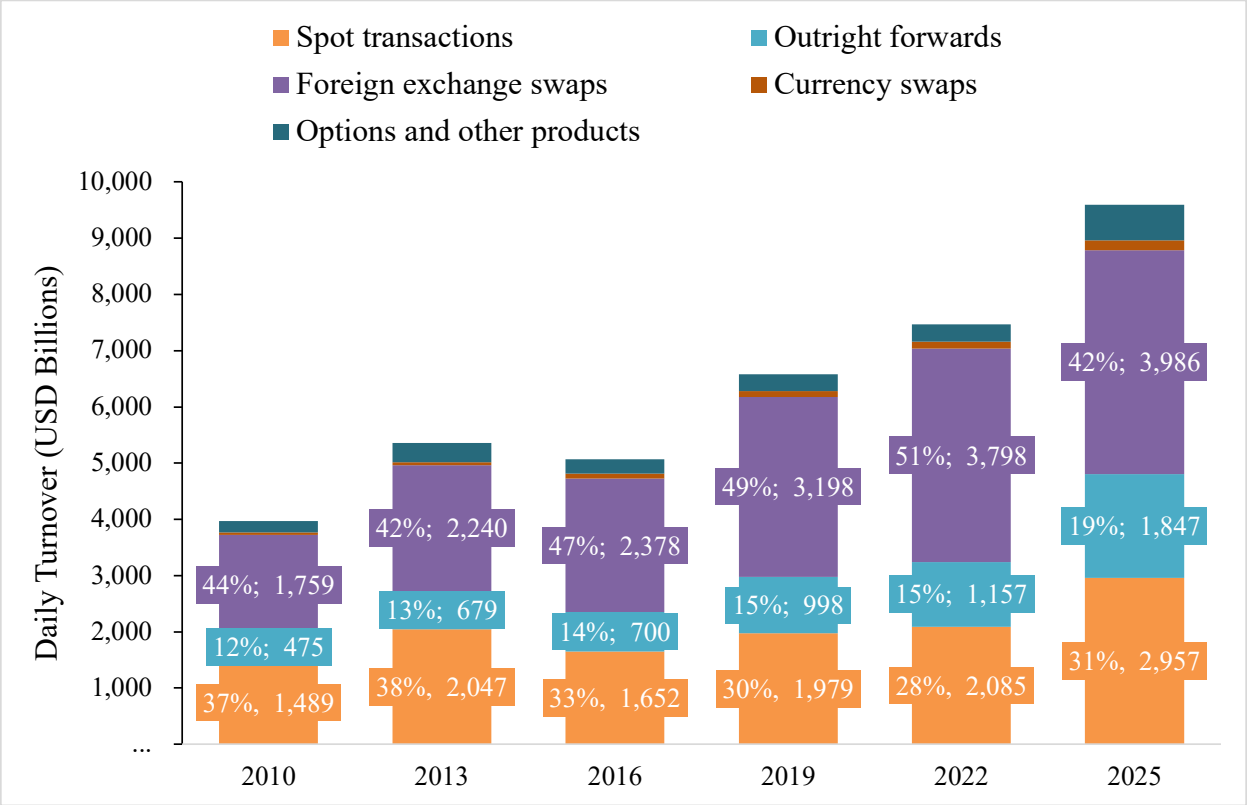
The remainder of this paper is organized as follows. Section 2 provides a global overview of FX markets, while Section 3 outlines the theoretical framework and strategic motivations underlying NDF usage. Section 4 presents the Chilean case in detail, documenting the market's evolution and the pivotal episodes that have shaped its recent trajectory. Section 5 describes the econometric methodology employed to quantify the dynamic effects of NDF flows. Section 6 reports empirical results, and Section 7 discusses their implications for monetary policy and regulatory design. Finally, Section 8 concludes.

2. FX Markets in the Global Economy

Global FX turnover reached approximately USD 9.6 trillion per day in April 2025, nearly 90% higher than in 2013 (BIS, 2025). Much of this growth reflects the rapid expansion of outright forwards

and non-deliverable forwards (NDFs),[1] whose daily volumes rose from roughly USD 475 billion in 2010 to around USD 1.8 trillion in 2025, pushing their share of global FX trading to nearly 20% (Figure 1). While spot trading still exceeds forward volumes in major financial hubs like the United Kingdom and the United States, the gap has narrowed significantly. In contrast, smaller centers and Emerging Markets (EMs) often report forward turnover that rivals or exceeds spot activity. This shift suggests a market structure where derivative instruments used for hedging and positioning play a relatively larger role than underlying cash transactions.

Figure 1: Global FX Market Turnover by Instrument (2010–2025)



Notes: The figure displays the daily average foreign exchange turnover by instrument, adjusted for local and cross-border inter-dealer double-counting. Outright forwards include non-deliverable forwards (NDFs). The category Options and other products includes currency swaps, FX options, and other derivatives. Source: Bank for International Settlements (BIS), Triennial Central Bank Survey of Foreign Exchange and Over the Counter (OTC) Derivatives Markets (2025).

In terms of currency composition, outright forwards remain heavily concentrated in US dollar pairs, which account for close to 90% of turnover, according to the BIS data (Table 1). The euro, yen, and pound sterling follow, alongside other advanced economy currencies. Within the EM sphere, the renminbi, Indian rupee, and Korean won represent the largest absolute forward volumes, while the Taiwan dollar and Brazilian real stand out for their high ratio of forwards to total trading.

[1] Outright forwards include both deliverable contracts and NDFs—cash-settled instruments widely used in markets with capital controls or settlement restrictions.

NDF markets show a similar dollar-centric pattern. NDF activity is dominated by the Indian rupee, Korean won, New Taiwan dollar, and Brazilian real. Conversely, renminbi NDFs have declined in relative importance due to the rise of deliverable offshore markets, and trading in ruble NDFs has effectively ceased since 2019.

Table 1: Evolution of Forward and NDF Markets: Turnover by center and Currency Composition (2010–2025)

	Forwards turnover			Forwards / Spot ratio 2025
Center	2010	2025	Ratio 2025 / 2010	
United Kingdom	228	1,081	4.7	0.8
United States	116	546	4.7	0.5
Singapore	36	208	5.8	0.6
Hong Kong SAR	32	91	2.8	0.5
Japan	32	49	1.5	0.4
Switzerland	11	37	3.4	0.4
Brazil	4	12	3.0	1.0
Chile	2	6	3.0	1.5
India	5	12	2.4	0.3
Korea	6	17	2.8	0.5

	NDF turnover vs USD			Share of global NDFs (%)	
Currency	2013	2025	Ratio 2025 / 2013	2023	2025
Indian rupee	17	71	4.2	14.4	21.2
Korean won	20	69	3.5	16.4	20.4
New Taiwan dollar	9	66	7.4	7.4	19.6
Brazilian real	16	47	3.0	13.3	14.0
Renminbi	17	12	0.7	14.3	3.6
Russian rouble	4	0	0.0	3.5	0.0

Notes: Daily average turnover in billions of US dollars, unless otherwise indicated. Top panel: Forwards comprises outright forwards and non-deliverable forwards (NDFs). The Forwards / Spot ratio measures the relative depth of the derivatives market versus the cash market; a ratio greater than 1.0 (e.g., Chile at 1.5) indicates a market structure dominated by hedging and positioning rather than underlying commercial cash transactions. Bottom panel: NDF turnover data refers specifically to non-deliverable contracts settled in US dollars. The decline in the Renminbi's share reflects the shift toward deliverable offshore forwards, while the collapse of the Russian Rouble reflects geopolitical sanctions. The comparison base year is 2010 for Centers (Panel A) and 2013 for NDF Currencies (Panel B) due to data availability in disaggregated NDF statistics. Source: Bank for International Settlements (BIS), Triennial Central Bank Survey (2025). Data adjusted for local and cross-border inter-dealer double-counting.

Emerging market activity has accelerated even more sharply, expanding faster in EM currencies than in advanced economies. Average daily turnover increased by almost 60% between 2016 and 2019 alone (Patel and Xia, 2019). This trend is supported by domestic financial deepening and growing portfolio investment into EM assets (Caballero et al., 2022). A defining feature of this growth is the dominance of derivatives. For many currencies, turnover in forwards, swaps, and NDFs is roughly twice that of spot transactions (Patel and Xia, 2019). Schmittmann and Chua (2020) note that for the Korean won and Indian rupee, NDF volumes frequently exceed those of other FX instruments and often surpass onshore trading. The evolution of these markets varies by capital account regime, as demonstrated by the gradual displacement of renminbi NDFs by offshore deliverable forwards reported by McCauley and Shu (2016).

Non-resident participation has become central to these markets. For the median EM currency, the share of trading involving at least one non-resident counterparty rose from 53% in 2007 to 83% in 2022 (Caballero et al., 2022). Consequently, most EM currencies are traded predominantly outside their issuing country. This offshore liquidity is a key venue for price discovery. Patel and Xia (2019) find that while onshore and offshore markets are cointegrated, offshore prices often lead during episodes of global stress. Schmittmann and Chua (2020) highlight similar patterns for Asian NDFs. They note that while NDFs provide valuable hedging instruments, their volatility can complicate exchange rate management and prompt diverse policy responses ranging from tighter integration to strict limits on offshore trading.

Overall, global FX markets have become larger, more derivative-intensive, and increasingly centered on the US dollar. EM currencies are now deeply integrated into this offshore system where forwards and NDFs play a central role in risk-taking and price discovery. The following section examines this segment in detail to understand how NDF and forward markets shape exchange rate dynamics and volatility.

3. NDF, Speculation and Carry Trade

This section establishes the theoretical framework linking interest rates and exchange rates through covered and uncovered interest parity while highlighting how market frictions generate persistent deviations from these benchmarks. It subsequently analyzes the NDF market within this context to distinguish between the primary motives driving activity. Specifically, we differentiate between hedging flows and speculative strategies designed to exploit the pricing anomalies inherent to segmented offshore markets.

Non-deliverable forwards (NDFs) are over-the-counter FX commitment derivatives where two parties agree on a forward exchange rate for a notional amount. Unlike deliverable contracts, settlement occurs purely on a net basis without the physical exchange of the principal. In offshore markets, this settlement typically takes place in a hard currency such as the US dollar.[2] This

[2]A critical distinction exists regarding onshore non-delivery forwards often employed by monetary authorities like the Central Bank of Chile. In these local interventions, settlement is frequently executed in domestic currency based on the spot rate differential. Since these specific central bank operations are settled in local currency, they function as

mechanism allows international investors to hedge exposures or speculate on currency movements without accessing the local onshore banking system or navigating complex capital controls. The resulting separation between markets creates a diverse ecosystem where liquidity is driven by multinational firms hedging cash flows, non-resident speculators avoiding settlement frictions, and arbitrageurs seeking to exploit pricing wedges between the onshore and offshore segments (Doukas and Zhang, 2013).

Theoretically, NDF pricing is anchored by the Covered Interest Parity (CIP) condition. In a frictionless setting, the forward rate (F_t^{DF}) is determined by the spot rate (S_t) and the interest rate differential between the domestic (i_t) and foreign (i_t^*) currencies:

$$F_t^{DF} = S_t \cdot \frac{1 + i_t}{1 + i_t^*}$$

In practice, offshore investors frequently face constraints that prevent direct or frictionless access to onshore interest rates. These limitations often stem from capital controls such as withholding taxes or repatriation limits, among others. Alternatively, they may arise from market segmentation caused by operational barriers that force investors to operate solely in the offshore market. Consequently, an offshore interest rate is implied directly from NDF prices (Doukas and Zhang, 2013). The difference between the onshore rate (i_t^{on}) and the NDF-implied domestic rate (i_t^{off}) constitutes the Covered Interest Differential (CID):

$$CID_t = \underbrace{(i_t + s_t - f_t)}_{\text{USD (foreign) implied}} - i_t^*$$

$$CID_t = i_t - \underbrace{(i_t^* - s_t + f_t)}_{\text{CLP (domestic) implied}} = i_t^{on} - i_t^{off}$$

In these equations, f_t and s_t represent the logarithms of the forward and spot rates. While theoretical arbitrage arguments suggest CID_t should be zero, evidence since the 2008 Global Financial Crisis documents persistent non-zero deviations even in the most liquid currency pairs (Du et al., 2018). Modern literature suggests these deviations are no longer driven solely by simple transaction frictions. Instead, they are strongly linked to intermediary balance sheet constraints, regulatory costs, and a structural demand for safe dollar assets (Du et al., 2018; Cerutti et al., 2021). These anomalies are especially pronounced in emerging markets where capital account regulations play a central role in asset pricing (Doukas and Zhang, 2013).

From an expectations perspective, the Uncovered Interest Parity (UIP) condition suggests that the forward premium should reflect the expected depreciation of the currency plus a risk premium. The reality that NDFs often trade at sizable premia or discounts makes them natural vehicles for speculative strategies in partially convertible currencies (Aliber, 1973; Frankel, 1991; Burnside et al., 2007; Doukas and Zhang, 2013). Empirical literature consistently contradicts the standard UIP prediction and finds that high-yield currencies tend to offer positive excess returns rather than depreciating. This phenomenon is known as the forward premium puzzle (Boudoukh et al., 2016;

a dollar-indexed liability rather than a direct spot sale and do not deplete international reserves at maturity.

Engel, 2016). These excess returns are systematically harvested by carry-trade strategies that either do or mimic borrowing in low-yield currencies to invest in high-yield targets (Menkhoff et al., 2012). Risk-based explanations emphasize that these returns are not risk-free arbitrage but rather compensation for exposure to global FX volatility and crash risk. This implies that UIP violations reflect time-varying risk premia ingrained in the market structure (Menkhoff et al., 2012).

3.1. Strategies with NDF

Trading activity in the NDF market is driven primarily by two motives: hedging and investment strategies. Distinguishing between these motives is critical because they exert different and often asymmetric effects on spot and forward rate dynamics. Table A1 presents a detailed overview of these motives and outlines their respective implications for markets.

On the hedging side, domestic market participants use NDF contracts to manage FX exposures arising from trade, investment, and financing activities. Real sector firms, including importers and exporters, use NDFs to hedge cash-flow risks associated with their international operations, while financial institutions and hedge funds hedge currency exposures on foreign asset portfolios. Corporates may also hedge external debt issuance denominated in foreign currency. In parallel, non-resident investors may hedge their exposures to the domestic currency by taking positions in NDFs against their holdings of local financial assets such as government bonds, exchange-traded funds (ETFs), or equities.

Hedging flows can affect spot and forward pricing in heterogeneous ways, depending on how these transactions interact with and offset the FX balance-sheet exposures of local banks. The direction and magnitude of these effects ultimately depend on factors such as the maturity structure of hedges, the timing of flows, and the hedge ratios applied.

Regarding speculative positions in the NDF market, investors seek exposure to different maturities of the domestic currency based on their expectations about underlying currency fundamentals, such as terms-of-trade fluctuations, monetary policy expectations, broader macroeconomic conditions, and idiosyncratic risk factors. Investors also account for institutional and market-specific dynamics, such as hedging activity by local hedge funds, government foreign-currency issuance and associated spot market operations, as well as central bank FX interventions. Together, these elements shape the perceived trajectory of the exchange rate and motivate speculative positioning across the NDF curve.

Moreover, investors also pursue carry-trade strategies, going long high-yielding currencies and funding positions in low-yielding ones in response to divergences in monetary policy stances. Depending on their ability to access local currency markets, investors may implement either hedged or unhedged carry-trade strategies, thereby exposing themselves to both spot FX returns and forward point differentials. For unhedged strategies, investors must account not only for the forward points premium but also for future exchange rate fluctuations, which reflect the underlying currency fundamentals discussed above.

From a portfolio perspective, the FX exposure embedded in unhedged returns can be optimized

through diversification across multiple economies, considering not only cross-currency correlations and volatility, but also regional idiosyncrasies and structural linkages. These include, for example, shared exposure to global demand factors, similarities in export composition, and differentiated sensitivities to major economic blocs such as China and the United States. As a result, currencies of economies with comparable trade patterns, regional supply chain integration, or exposure to commodity price cycles may exhibit correlated dynamics, shaping the risk adjusted performance of multicurrency carry portfolios.

Finally, investors may implement strategies aimed at arbitraging deviations from covered interest parity (CIP). These strategies typically involve synthesizing exposure to local or foreign interest rates using alternative fixed-income instruments, such as bonds or interest-rate swaps, to replicate the theoretical rate to then gain the spread implied by NDF pricing. When forward rates diverge from the synthetic rates implied by these instruments, investors can exploit the resulting misalignment. Additionally, investors may arbitrage mispricing along the NDF curve itself, taking positions that exploit maturity specific basis disparities and inconsistencies across the term structure.

CIP deviations can also stimulate speculative, carry trade, and hedging activity by creating misalignments in forward pricing. For hedgers, deviations from covered interest parity may raise or lower the effective cost of hedging, thereby influencing the hedge demand. For investors, these distortions embed an additional premium in forward rates, potentially increasing expected returns and incentivizing positions that capitalize the mispricing.

Together, these strategies highlight the diverse channels through which market participants use NDFs for hedging, speculation, and arbitrage. Their implementation, however, is highly sensitive to prevailing financial conditions, including liquidity in the onshore and offshore markets, regulatory frameworks governing capital flows, and shifts in global risk appetite.

4. The Chilean Experience

Chile presents a relevant case study for examining the evolution of FX derivatives markets in an emerging economy. In the region, while Brazil and Mexico have the highest traded volume, Chile leads the FX derivatives market in relation to the size of its economy (see BIS (2025)). Over the past decade, the market has expanded following regulatory adjustments that modified the incentives and balance sheet constraints of key domestic players, primarily pension fund managers. These developments effectively altered the local liquidity conditions and facilitated a broader participation of non-resident investors in the local market.

This evolving structure faced specific challenges during the Covid-19 period. The authorization of pension fund withdrawals prompted asset liquidations by institutional investors and shifted the demand for FX hedging. Concurrently, the central bank executed a monetary policy cycle characterized by its anticipatory timing. The authority-initiated interest rate hikes early to address inflationary pressures and subsequently became one of the first in the region to begin the easing phase once prices stabilized.

These conditions influenced, among other things, the attractiveness of NDF-based investment

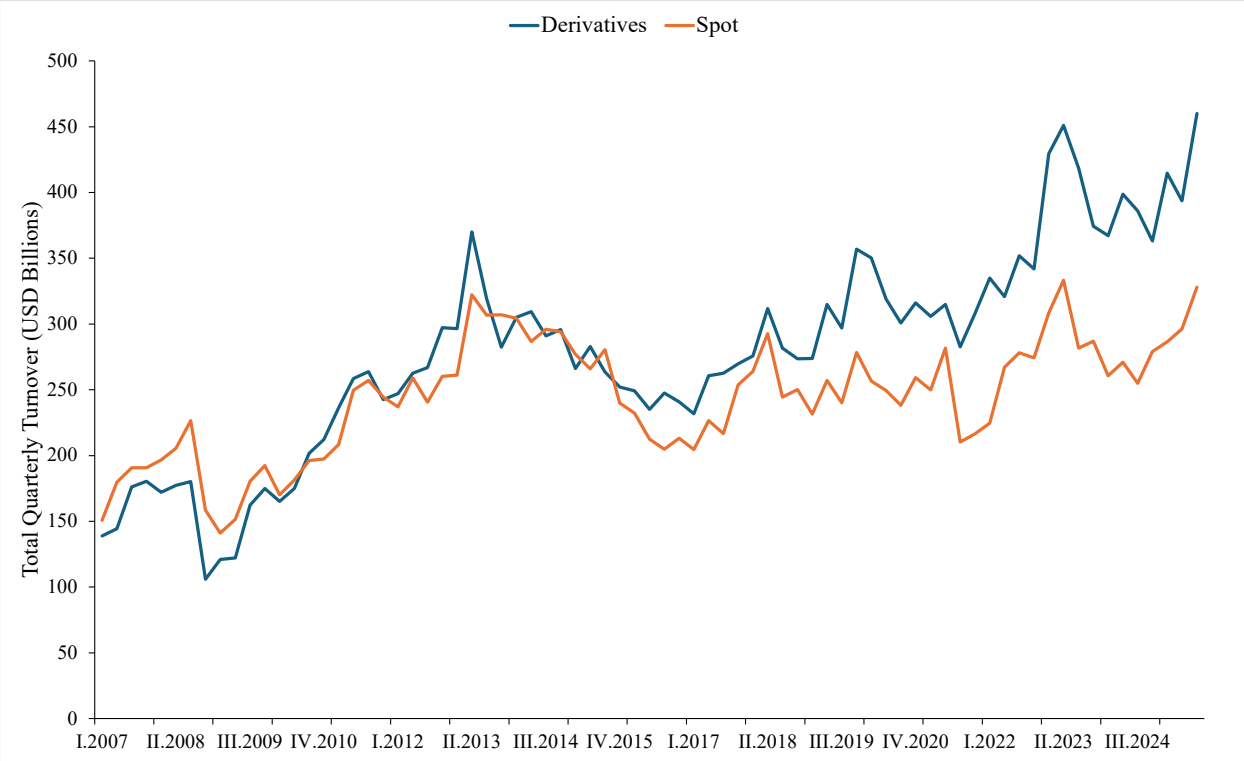
strategies, particularly carry and directional trades. Taken together, these factors make the Chilean experience particularly suitable for analyzing the interaction between domestic institutional shifts and global investor positioning. Most importantly, this context provides a clear opportunity to study how non-resident NDF flows can impact exchange rate dynamics.

The remainder of this section describes the Chilean FX market and the events that influenced non-resident NDF flows and the exchange rate.

4.1. Chilean FX Market

Chile operates an inflation-targeting regime, used partially since its announcement in 1990 and adopted in full in 1999, in conjunction with a freely floating exchange rate, with the central bank reserving the option to intervene only to safeguard market functioning and monetary transmission. Local banks are the primary market makers and intermediate roughly USD 10 billion per day (USD 6 billion FX derivatives + USD 4 billion spot) (Figure 2). Trading is predominantly over the counter (OTC), with the private platform DATATEC handling around USD 1.3 billion per day, currently being the platform of choice for interbank FX market.

Figure 2: Evolution of Chilean FX Trading Volumes: Spot vs. Derivatives



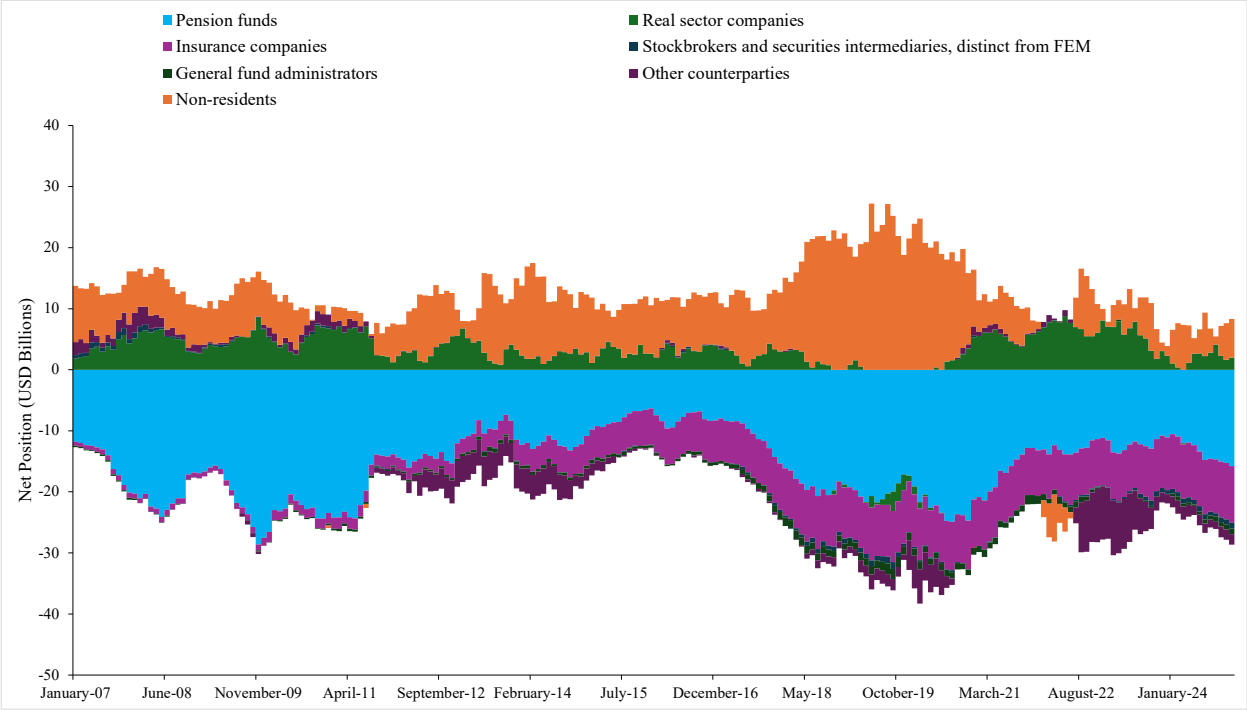
Notes: The figure displays the total quarterly turnover in the Formal Exchange Market. Derivatives comprise forwards (both deliverable and non-deliverable), FX swaps, and cross-currency swaps. Spot refers to cash transactions. Source: Central Bank of Chile, Statistical Database (BDE).

On the participant side, the key players are local banks, local firms, pension funds and offshore

investors. Spot FX is used mainly to finance domestic investments and trade, whereas forwards and NDFs are the workhorse instruments for hedging, carry and speculative strategies. Banks sit at the center of this network, taking the opposite side of both resident and non-resident demand. Pension funds are particularly important because regulation requires them to hedge a fraction of their foreign-currency assets, especially in fixed income, which has helped deepen both the forward and spot markets. Offshore investors, in turn, hold a sizable market share in derivatives (especially NDFs) and are more concentrated in speculative, hedging and carry-trade activity.

The stock of FX derivatives also reveals a persistent reallocation of risk across sectors over time (Figure 3). Pension funds, insurance companies and other domestic institutional investors appear as persistent net selling in FX derivatives, reflecting their need to hedge sizeable foreign-currency asset positions. Non-residents take the opposite side, holding sizable net USD-receivable that fluctuate with global risk appetite and carry opportunities, while real-sector firms and brokers play a comparatively smaller role.

Figure 3: Net FX Derivative Positions by Institutional Sector (2007–2024)



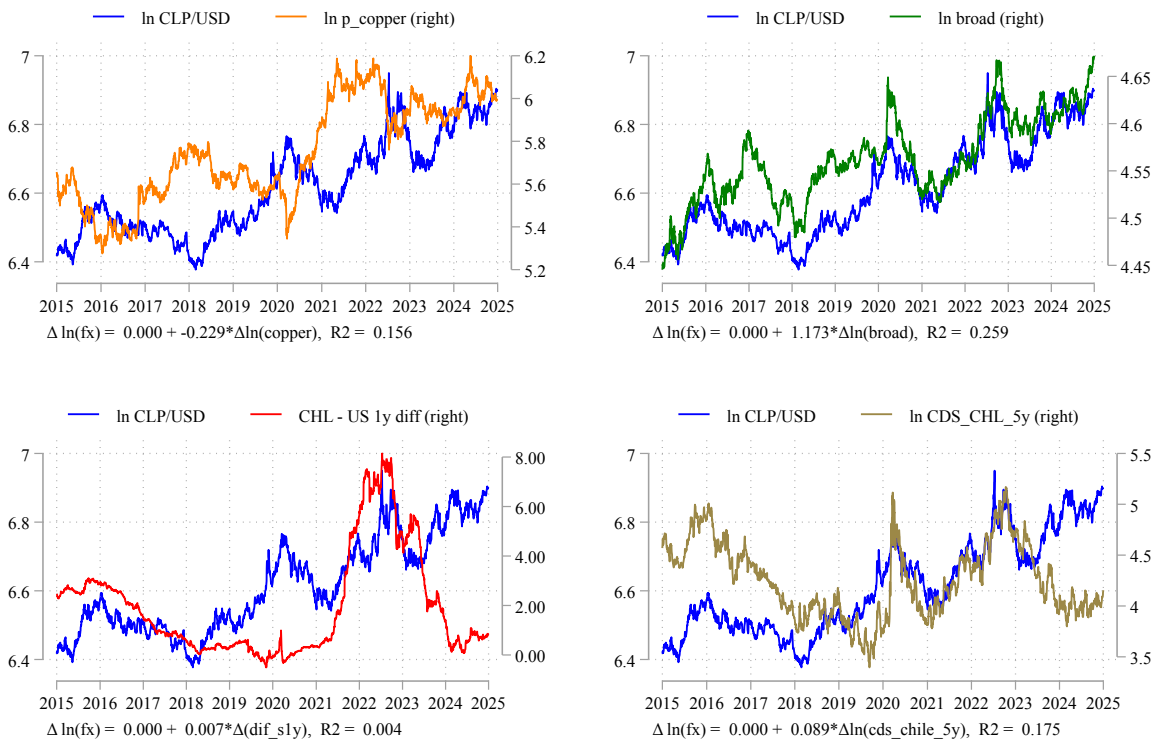
Notes: The figure displays the monthly stock of net outstanding FX derivative positions (Forwards and Swaps) of the Formal Exchange Market's counterparties. Positive values indicate a net long position in USD (the sector buys USD to local banks). Negative values indicate a net short position in USD (the sector sells USD from local banks). Source: Central Bank of Chile, Statistical Database (BDE).

According to the official data from SIID-TR (Chilean trade repository), the outstanding stock of FX derivatives is highly concentrated in the USD–CLP pair. By December 2024, around 85% of local banks' FX derivatives were against the US dollar, and about half of that notional was held between local banks and non-resident investors. The remaining positions were split between

non-bank residents and interbank trades. Within USD–CLP instruments, forwards and FX swaps account for roughly 60% of amounts outstanding, cross-currency swaps for close to 40%, and options for only a small fraction. This composition underscores both the central role of the USD in Chile's FX market and the importance of banks as hubs linking local balance sheets with global investors.

The Chilean Peso (CLP, nominal bilateral exchange rate between Chile and US: USDCLP) is shaped by a combination of global and country-specific factors (Figure 4). On the external side, broad US dollar trends and the interest rate differential between Chile and the United States are key: periods of a strong dollar or narrow CLP–USD rate spreads tend to weigh on the peso, while wide positive differentials support carry-trade and hedging demand for CLP assets. Commodity prices, especially copper, are another central driver, given Chile's role as a major exporter; improvements in terms of trade typically go hand in hand with CLP appreciation. On the domestic side, changes in perceived country risk and sociopolitical uncertainty have become more important in recent years.

Figure 4: The Chilean Peso and Key Fundamental Drivers: Co-movements and Correlations (2015–2025)



Notes: The figure displays the daily evolution of the nominal exchange rate (CLP/USD, blue line, left axis) against four key fundamental drivers (right axis). All variables are expressed in logarithms, except for the interest rate differential. Top-Left: Copper price (LME, spot). Top-Right: Broad Dollar Index (DXY/Broad), representing global dollar strength. Bottom-Left: The 1-year onshore-offshore interest rate differential (CLP Swap rate minus USD Swap rate). Bottom-Right: 5-Year Sovereign Credit Default Swap (CDS) for Chile, as a proxy for idiosyncratic country risk. The equation at the bottom of each panel reports the results of a univariate regression of daily exchange rate returns on the daily changes of the respective driver, indicating the sign of the relationship and the goodness of fit (R2). Source: Central Bank of Chile and Bloomberg.

Over the past six years, the Central Bank of Chile has intervened twice to counter excessive FX volatility, in 2019 and 2022, its first such interventions since 2002. Arenas and Griffith-Jones (2024) find that these FX interventions were effective in reducing volatility, and suggest that, in both episodes, spot dollar sales and NDF sales appear to have been similar in their effectiveness.

4.2. Euroclearability and Changes in Pension Funds' Investments and Hedging

The structural transformation of the Chilean FX market progressed in 2017 with the modernization of the sovereign debt market. The Ministry of Finance promoted several measures to attract foreign investment in local bonds: it enabled the settlement of these instruments through Euroclear, which simplified international custody and reduced operational frictions; amended Article 104 of the

Income Tax Law to grant tax benefits to public offering debt; and developed an issuance and exchange strategy aimed at increasing outstanding volume and meeting the requirements of JP Morgan's GBI-EM Index, which requires a minimum of USD 1 billion per series and sufficient residual term. Notably, the weight of Chile in the J.P. Morgan Government Bond Index–Emerging Markets (GBI-EM) index surged from a marginal 0.1% to 2.0% by mid-2017 (Euroclear, 2018), compelling passive funds to rebalance their portfolios toward CLP assets.

This was a pioneering move for the region: Chile became the first Latin American country to make its local-currency bonds *Euroclearable*, granting direct access to International Central Securities Depositories (ICSD) such as Euroclear. This measure was part of broader initiatives that aligned Chilean debt instruments with global standards by removing operational barriers that had historically limited offshore participation.

This structural change triggered a rapid increase in non-resident participation. The inaugural Euroclearable issuance in January 2017 was a watershed moment that recorded foreign allocation levels above 20%, which stands in sharp contrast to historical participation rates of around 5% (Euroclear, 2018). This shift was reinforced by the inclusion of Chilean bonds in global benchmarks. While the primary objective was to enhance liquidity and reduce sovereign financing costs, which are estimated to have fallen by approximately 28 basis points due to the Euroclearability premium (PwC, 2019), the secondary effect was a surge in the stock of CLP assets held by offshore entities. Since these international investors typically mandate strict risk management, their entry generated a corresponding structural demand for FX hedging. Consequently, the Euroclearability of the bond market acted as a catalyst for the deepening of the NDF market. This is evidenced by data showing that NDF trading volumes for the Chilean peso nearly doubled between 2016 and 2019 (Schrimpf and Sushko, 2019).

Complementing the opening of the sovereign debt market, the NDF market infrastructure underwent a parallel modernization. Although central clearing services for Chilean peso NDFs were introduced earlier (by CME in 2011 and LCH in 2012), their adoption accelerated significantly around 2017 due to new global margin regulations for non-centrally cleared derivatives. Consequently, trading increasingly migrated from bilateral OTC agreements, governed by the standard International Swaps and Derivatives Association (ISDA) master agreement and its Credit Support Annex (CSA) for collateral, to Central Counterparties (CCPs) such as CME (Chicago Mercantile Exchange) and LCH (London Clearing House). This shift toward centralized clearing significantly reduced capital requirements for dealer banks and standardized the execution process for offshore investors. By lowering the operational and credit barriers-of-entry, the migration to CCPs attracted a wider range of participants, including algorithmic traders and high-frequency funds, thereby boosting liquidity and further tightening the link between offshore NDF flows and high-frequency exchange rate dynamics.

Simultaneously, the domestic investor base experienced a regulatory watershed in November 2017,[3] authorizing pension funds to invest in "alternative assets", a category that encompasses

[3]Resolution No. 88 by the Superintendence of Pensions (*Superintendencia de Pensiones*) and operationalized by

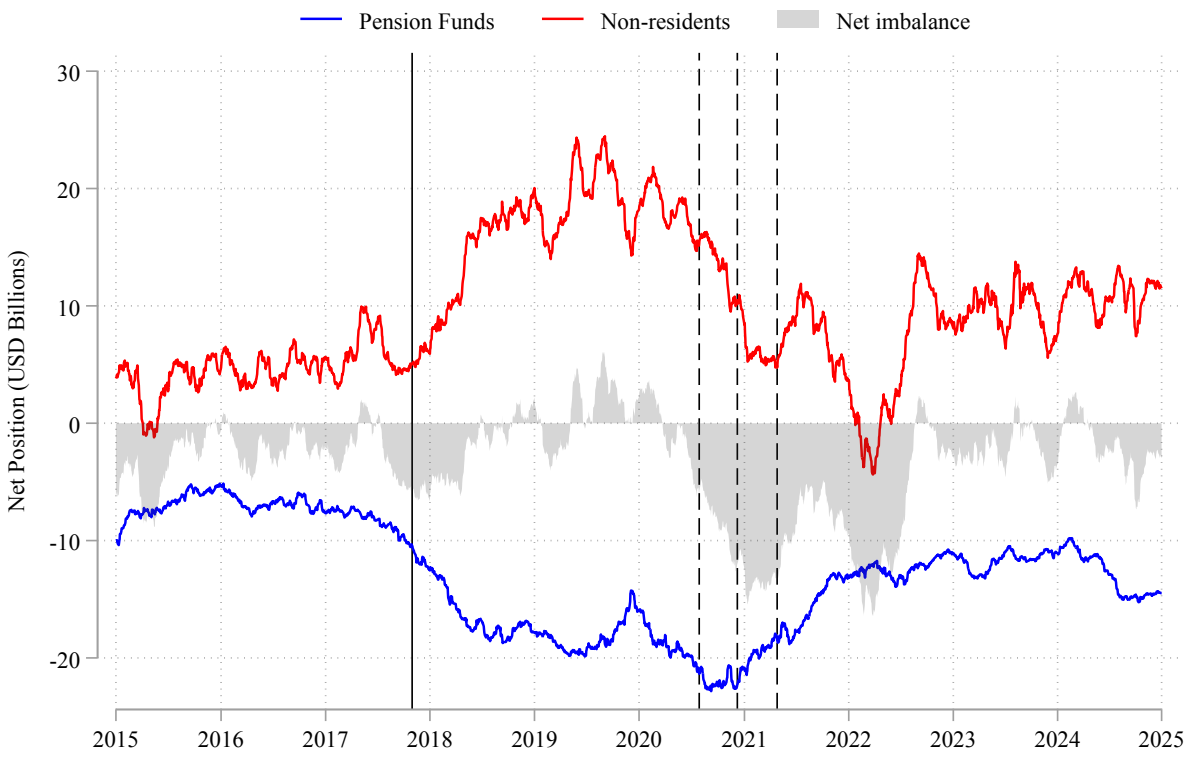
vehicles for private equity, private debt, real estate, and infrastructure projects. Prior to this change, pension portfolios were largely constrained to traditional public securities. The new regime allowed funds to seek higher returns and diversification through private markets, both domestic and international. This structural shift incentivized a reallocation of capital toward foreign-denominated assets, thereby increasing the funds' gross exposure to foreign currency risk.

Crucially for FX dynamics, this expansion into foreign markets was accompanied by a strict regulatory framework for currency hedging. The pension funds regime established that for alternative assets and variable income denominated in foreign currency, pension funds could hedge up to 50% of the investment value, for high-yield debt the limit was set between 0% and 70%, while for investment grade foreign debt the limits are set to hedge between 50% - 100%. By mandating these specific coverage ratios, the regulation effectively institutionalized a structural demand for FX derivatives. This shift is clearly visible in aggregate market data: as shown in Figure 2, starting in late 2017, a persistent divergence emerges between derivatives and spot trading volumes. While both segments grew, derivatives' turnover outpaced spot transactions significantly, with greater hedging from pension funds and an increasing interest from non-residents due to a more standardized market, creating a widening gap that reflects the relative increasing interest in operating in the derivative market.

Figure 5 provides compelling evidence of this structural break. Following the implementation of the 2017 reforms, the net NDF positions of non-residents and pension funds exhibit a striking "mirror image" pattern. Pension funds, incentivized by the new alternative asset regime, increased their foreign investments and the associated currency hedges, resulting in a structural net short NDF position. The structural movement of investing abroad made by the pension funds, created a squeeze in the local US funding market which made the local funding cost in USD to increase, reflected in the implied rates in the FX forward, which gave an attractive opportunity for non-residents to enter the market through NDF operations finding relatively cheap funding and started to build a structural position in the Chilean market, which was accompanied by their increased participation in the local bond market, their demand for hedging led to a structural net long NDF position, effectively buying USD to hedge their CLP exposure. The stability of the net difference during this period suggests that pension funds acted as the natural liquidity providers for offshore investors, absorbing the structural buying pressure from non-residents and keeping the market relatively balanced until the onset of the idiosyncratic shocks of 2019 and onwards.

Law No. 20.956.

Figure 5: Evolution of Net NDF Positions: Pension Funds vs. Non-Residents



Notes: The figure displays the daily net outstanding NDF positions of the two main market participants. Positive values indicate a net long USD position (buying USD forward), characteristic of non-residents (red line) hedging CLP assets or speculating against the peso. Negative values indicate a net short USD position (selling USD forward), characteristic of pension funds (blue line) hedging their foreign currency portfolio. The grey area represents the net imbalance between these two sectors. A smaller area indicates a high degree of liquidity provision between them. Vertical lines: The solid line marks the regulatory reform of November 2017 (Euroclearability and Alternative Assets). The three dashed lines correspond to the legislative approvals of pension fund withdrawals (July 2020, December 2020, and April 2021). Source: Central Bank of Chile, Integrated Derivatives Information System (SIID-TR).

4.3. Social Unrest and Policy Response: First Time Intervening the NDF Market

In October 2019, financial stability faced significant challenges due to a domestic crisis triggered by social unrest. This turmoil sharply increased political and economic uncertainty, deteriorating local financial conditions. Sovereign spreads widened notably, local financial assets were sold off massively, and the FX market experienced extreme stress, with sharp exchange rate volatility, a rapid depreciation of the Chilean peso to historic highs, and liquidity disruptions as market infrastructure struggled to absorb one-way flows. On one side, local players sought safety, driving significant outflows in the FX spot market; on the other, non-residents heavily bet on further depreciation, adding pressure on the market and straining local banks' capacity to absorb these flows. To stabilize conditions, the Central Bank intervened in the FX market for the first time in nearly two decades. Moreover, for the first time, it complemented USD sales in the spot market with an NDF program,

targeting both markets simultaneously without further depleting FX reserves.

4.4. Covid-19 and Policy Response: Pension Fund Withdrawals

As financial turbulence from the social unrest was still unfolding, the COVID-19 pandemic hit in March 2020, worsening market dysfunction. Liquidity dried up, exchange rate pressures increased, and expectations deteriorated sharply. Lockdowns caused a sudden drop-in economic activity and household and corporate income, while uncertainty about the crisis's duration amplified risk aversion. Banks raised liquidity requirements amid higher funding costs and credit risk, and financial institutions sold assets—even traditionally safe ones—in a global "dash-for-cash". This environment disrupted key monetary policy transmission channels, creating distortions in fixed-income markets and prompting central banks worldwide, including Chile's, to implement large-scale measures to support market functioning.

Additionally, the Chilean Congress approved three pension fund withdrawals (June 2020, December 2020, and April 2021), totaling over USD 48 billion—about 23% of 2020 assets or nearly 20% of GDP (IMF, 2023) (Table 2). Part of these withdrawals were financed by selling foreign investments, creating inflows and unwinding hedging positions. This significantly reduced pension funds' derivatives exposure and broke the mirror-like pattern they shared with non-resident players.

Table 2: Key Characteristics of Pension Fund Withdrawals

Feature	**1st Withdrawal**	**2nd Withdrawal**	**3rd Withdrawal**
Approval Date	July 23, 2020	December 19, 2020	April 27, 2021
Total Amount Withdrawn	USD 20,828 million	USD 14,186 million	USD 13,408 million
Eligibility	Universal (active affiliated and Programmed Withdrawal pensioners)	Universal (active and Programmed Withdrawal pensioners)	Universal (active and Programmed Withdrawal pensioners), Life Annuity pensioners
Authorized Amounts	10% with a cap of USD 6,000 and floor of USD 3,400 (or low-available balance)	10% with a cap of USD 6,000 and floor of USD 1,400	10% with a cap of USD 6,000 and floor of USD 1,400
Tax Status	Tax-exempt	Taxed (income tax for monthly exiting > USD 2,100)	Tax-exempt
Repayment Terms	None. Except alimony debt. Up to 2 installments (10 and 30 business days)	None. Except alimony debt. Up to 2 installments (10 and 20 business days)	None. Except alimony debt. Single installment (15 business days)

Notes: Amounts in USD are approximate, calculated using a conversion rate of 1 UF = USD 40.
Source: Superintendence of Pensions.

The imbalance among market participants created new challenges for local banks, which lost counterparties for hedging. This became critical in 2022, when the FX market faced high volatility and financial stress driven by internal uncertainty and external factors such as global monetary tightening, a strong U.S. dollar, and geopolitical tensions. These shocks led to sharp peso depreciation and increased volatility, threatening monetary policy transmission and financial stability. Non-residents played a key role in amplifying pressures when they unwound positions, placed speculative

bets on further depreciation, and withdrew portfolio flows, consistent with global trends. Using NDFs against local banks, non-residents exerted additional depreciation pressure, leaving local agents temporarily unhedged. To compensate, banks sought other counterparties, but as more domestic actors entered the intermediation chain, premiums for bearing FX risk increased, further amplifying peso depreciation—exacerbated by the lack of willing counterparties.

4.5. Arbitrage Opportunities: The Recovery of Pension Funds and its Effects on Prices

After the significant moves by offshore agents in 2022, their positions have stabilized, maintaining a structural funding base for carry trade opportunities and tactical bets on currency appreciation or depreciation. Since mid-2024, non-resident investors have increasingly favored CLP funding as forward points turned negative, while other Latin American currencies like BRL and COP offered positive returns due to diverging monetary policies. This has enabled profitable cross-currency trades to leverage regional correlations.

Carry trade activity has been reinforced by structural flows from pension funds, which regained momentum as contributors shifted to riskier funds seeking higher returns. These funds require hedging, driving persistent USD selling through derivatives and exerting downward pressure on forward points. This dynamic pushed implied CLP rates below U.S. rates, creating arbitrage opportunities alongside carry trades. In 2025, AFP hedging flows have induced distortions in the 6M tenor, further enabling CIP arbitrage strategies. Local banks act as market makers, absorbing these flows and hedging through forwards and spot transactions.

CLP remains highly correlated with other EM currencies, though imperfectly, offering diversification benefits for global investors. The ability of local banks to absorb NDF flows is critical: when capacity is limited, spot volatility rises, and the exchange rate becomes more sensitive to NDF activity.

5. Quantifying the Effects

This section quantifies the dynamic impact of non-resident NDF flows on FX volatility metrics using administrative data, conditioning results on the events discussed in the previous section. Furthermore, we analyze the drivers of these flows across maturities to distinguish distinct trading strategies.

5.1. Data

The primary data on NDF flows utilized in this study are sourced from the Integrated Derivatives Information System (SIID-TR), the official trade repository of the Central Bank of Chile. Established in response to the G20 recommendations following the 2008 Global Financial Crisis, the SIID was designed to enhance transparency in OTC derivatives markets and promote financial stability through better risk monitoring. Unlike survey-based datasets commonly used in the literature, such as the BIS Triennial Survey, the SIID provides a comprehensive, mandatory administrative registry

of all daily derivative transactions reported by banks and other regulated entities in Chile. This high-frequency, census-like nature of the data ensures a superior level of accuracy and granularity, allowing for a precise identification of daily non-resident NDF positions without the sampling errors inherent in survey data.

The NDF series represents the net outstanding amount of USD/CLP non-deliverable forwards held by non-residents, defined as the difference between notional buy and sell positions at period end. A positive value indicates a net long position in US dollars, while a negative value denotes a net short position. Since these data reflect stock levels, daily flows are derived by taking the first difference of the net position. Although the series is available from 2012, our sample begins in January 2015 to ensure temporal consistency with other variables.

The remaining macroeconomic and financial variables are obtained from standard information providers including Bloomberg, the Statistical Database of the Central Bank of Chile, and DATATEC (an electronic FX trading platform), while specific indicators were constructed directly by the authors.

Regarding the determinants of the exchange rate, we select the set of explanatory variables following the framework established by the Central Bank of Chile (2020). These drivers include the Broad Dollar Index to capture global currency trends, the price of copper on the London Metal Exchange (LME), and the price of Brent oil. We also incorporate financial variables such as the interest rate differential between Chile and the United States and the 5-year sovereign Credit Default Swap (CDS) for Chile. Finally, the dataset accounts for macroeconomic adjustments via the Consumer Price Indices (CPI) of both the United States and Chile, as well as dummy variables to control for episodes of FX Intervention.

The final sample employed in the subsequent sections consists of daily data spanning from January 2, 2015, to December 30, 2024. A detailed description of each variable, including its unit of measurement, original source, and summary statistics, is provided in Table A2.

5.2. Determinants of Offshore NDF Positioning

In this part we analyze the determinants of non-resident NDF flows, examining both the aggregate position and flows disaggregated by contract maturity. We estimate a model that incorporates a comprehensive set of global and domestic factors to isolate the drivers of offshore positioning across short, medium, and long-term horizons. The primary objective is to identify the specific variables driving flows in each maturity segment, allowing us to empirically link the distinct trading strategies discussed in previous sections to the term structure of NDF contracts.

To characterize the behavior of non-resident investors, we estimate a linear regression model, defined in equation (1), that regresses net NDF flows on a comprehensive vector of global and domestic fundamentals.

$$\Delta NDF_t = \sum_{i=1}^{k_{NDF}} \Delta NDF_{t-i} + \Gamma_1' G_t + \Gamma_2' D_t + \Gamma_3' Z_t + u_t \tag{1}$$

To ensure stationarity, all continuous explanatory variables enter the equation as log-differences,

except for the 1-year interest rate differential which enters as a simple daily change. The external block (G_t) captures global push factors and includes the Broad Dollar Index, copper and oil prices, the US CPI, and the VIX index. Additionally, to isolate the shared sentiment toward commodity and emerging market assets, we incorporate a common factor extracted via Principal Component Analysis (PCA) from the daily returns of a basket of seven peer currencies: AUD, MXN, BRL, NZD, CAD, COP, and ZAR. On the domestic front (D_t), the specification controls for the Chilean CPI, the 5-year sovereign CDS spread, the interest rate differential, and the Economic Policy Uncertainty (DEPU) index (Becerra and Sagner, 2023).

Crucially, the specification accounts for the strong persistence inherent in flow data by including an autoregressive component of the NDF flows. Based on a visual inspection of the partial autocorrelation functions presented in Figure A1, we fix the autoregressive structure at six lags. We further control for market microstructure effects and feedback trading (Z_t) by including the lagged daily exchange rate return, lagged intraday volatility, and dummy variables for Foreign Exchange Intervention (FXI) episodes. This model is estimated for both the aggregate NDF position and for flows disaggregated by contract maturity to uncover horizon-specific drivers. Finally, to facilitate the comparison of relative economic magnitude across these diverse determinants, all continuous variables are standardized, allowing us to report beta coefficients.

The standardized estimation results reported in Table 3 highlight the hierarchy of drivers determining aggregate non-resident NDF flows. The analysis reveals that global factors, particularly the Broad Dollar Index, exert the strongest economic influence on offshore positioning, with a beta coefficient of 0.23. This dominance suggests that aggregate flows toward the Chilean peso are largely a vehicle for expressing views on the global USD cycle, significantly outweighing the impact of idiosyncratic fundamentals such as the copper price (-0.09) or the onshore-offshore interest rate differential (-0.04). While these fundamental variables remain statistically significant and exhibit the theoretically expected signs, with higher copper prices and local rates reducing net USD buying pressure, their relative economic magnitude is secondary. Additionally, the results point to substantial inertia in trading behavior, as evidenced by the high economic significance of the autoregressive terms, which likely reflects the persistence of large institutional order execution strategies.

Table 3: Relative Importance of Drivers of Non-Resident NDF Flows across Maturities: Standardized Beta Coefficients.

Driver	NDF Contract Maturity						
	Total Flows	**1–7 days**	**8–35 days**	**36–95 days**	**96–185 days**	**186–370 days**	**> 370 days**
Δ ln(Broad)	**0.2334**	0.0236	**0.1562**	0.0145	-0.0350	0.0067	0.0072
ΔNDF(−2)	**0.1695**	**-0.3214**	-0.0134	**0.0379**	0.0305	0.0262	0.0131
ΔNDF(−1)	**0.0934**	**-0.1082**	**0.0804**	**0.1253**	**0.0604**	**0.0713**	**0.0578**
Δ ln(CPI_CL)	**0.0621**	-0.0230	0.0298	0.0271	-0.0359	0.0395	-0.0056
PCA_CCY	**0.0620**	0.0255	0.0154	-0.0052	-0.0062	**-0.0546**	**0.0435**
ΔNDF(−4)	**0.0558**	**-0.1684**	**0.0410**	**0.0695**	0.0268	0.0252	-0.0096
Δ ln(CDS_CL_5Y)	**0.0488**	0.0173	-0.0074	0.0011	**0.0610**	0.0238	0.0033
ΔNDF(−3)	**0.0466**	**-0.2109**	**0.0336**	**0.0405**	0.0202	0.0209	**0.0551**
Δ ln(FX(−1))	**0.0395**	**-0.0469**	**0.0757**	0.0119	0.0247	-0.0030	-0.0034
ΔNDF(−5)	**0.0349**	**-0.0614**	**0.0628**	**0.0957**	0.0112	-0.0005	**0.0442**
FXI_2019	0.0316	-0.0006	**0.0490**	0.0175	**-0.0523**	-0.0124	-0.0324
Δ ln(VIX)	0.0286	-0.0188	0.0289	0.0079	0.0125	**0.0370**	**-0.0607**
FXI_2022	0.0278	-0.0062	0.0187	0.0090	0.0207	0.0053	**0.0423**
Δ ln(Oil)	0.0122	0.0304	-0.0158	-0.0128	0.0270	0.0278	-0.0064
FXI_2021	0.0105	-0.0151	**0.0324**	0.0008	**-0.0403**	-0.0022	-0.0151
FXI_2023	0.0051	-0.0045	-0.0031	**0.0385**	-0.0070	-0.0303	-0.0225
ΔNDF(−6)	-0.0026	**-0.1108**	-0.0191	0.0030	-0.0129	**0.0547**	0.0310
Δ ln(DEPU)	-0.0043	-0.0130	0.0165	0.0004	-0.0056	-0.0207	0.0075
Δ ln(CPI_US)	-0.0171	0.0105	-0.0091	0.0020	0.0237	-0.0274	0.0206
Δ ln(DIF_S1Y)	**-0.0445**	0.0239	**-0.0405**	-0.0018	-0.0008	-0.0143	0.0297
Δ ln(SD_FX)	**-0.0532**	**0.0400**	**-0.0694**	-0.0253	0.0123	-0.0082	0.0116
Δ ln(Copper)	**-0.0912**	0.0156	**-0.0648**	**-0.0365**	-0.0015	-0.0028	-0.0024

Notes: The table reports the standardized beta coefficients estimated from equation (1), illustrating the relative economic significance of global, domestic, and microstructure determinants on non-resident net NDF flows across different contract maturities. The dependent variable is the daily net flow in each specified maturity bucket, while the explanatory variables include the full set of drivers defined in the text, standardized to allow for direct comparison. Coefficients represent the standard deviation change in the dependent variable associated with a one-standard-deviation increase in the regressor, effectively ranking the drivers by their explanatory power. Values in bold denote statistical significance at the 10% level or better. The background color scale reflects the magnitude and direction of the standardized effect, ranging from dark green (strong positive association) to dark red (strong negative association).

The results for short-term maturities presented in the second and third columns of Table 3 reveal a stark contrast in drivers depending on the specific time horizon. For the shortest maturity bracket of 1 to 7 days, the estimated coefficients are dominated by negative autoregressive terms, indicating a strong pattern of mean reversion where recent buying pressure is quickly followed by selling flows. Conversely, flows with maturities between 8 and 35 days exhibit positive persistence and are primarily driven by external factors, with the Broad Dollar Index having the largest standardized impact. Furthermore, this segment shows a significant positive sensitivity to past exchange rate depreciation and a negative response to copper prices and interest rate differentials, suggesting that these positions are responsive to both global trends and domestic price signals.

As we extend the analysis to longer-term maturities, the drivers shift decisively toward fundamental risk metrics. For contracts with maturities between 96 and 185 days, the Chilean sovereign CDS

spread emerges as a statistically significant determinant, indicating that medium-term positioning is sensitive to perceptions of local creditworthiness. At the longest end of the curve, for maturities exceeding one year, global risk aversion becomes the dominant driver, evidenced by the significant negative coefficient on the VIX index. This negative association suggests that periods of heightened global volatility lead to a reduction in net USD positions in this segment, consistent with the unwinding of long-term exposures or carry trades during stress episodes (Brunnermeier et al., 2009; Bruno and Shin, 2015), as high global volatility triggers deleveraging and capital retrenchment (Forbes and Warnock, 2012; Menkhoff et al., 2012). Furthermore, this maturity bracket shows sensitivity to the common currency factor, reinforcing the link between long-term flows and broader trends in commodity-linked currencies.

Overall, these findings provide empirical evidence that the NDF market is highly segmented by investment horizon. The shifting significance of drivers from microstructure variables at the very short end to global push factors in the medium term and fundamental risk metrics at the long end confirms that contract maturity serves as a reliable proxy for the underlying trading motives. This distinction allows us to map aggregate flows into specific behaviors and effectively separates high-frequency liquidity provision and tactical speculation from structural hedging strategies.

5.3. Empirical Strategy

We are interested in estimating the cumulative impulse response functions (CIRFs) of a USD 1 billion shock to NDF purchases on different measures of FX volatility,

$$\mathcal{R}_y(h) = \sum_{j=0}^{h} \mathbb{E}\left[y_{t+j} | \Delta NDF_t = 1, \mathbf{w_t}\right] - \mathbb{E}\left[y_{t+j} | \Delta NDF_t = 0, \mathbf{w_t}\right],$$

for horizons $h \in \{0, 1, 2, ..., H\}$, where y_t is the outcome variable at day t, ΔNDF_t is the daily change in the net NDF position of non-resident (in billions of USD), and $\mathbf{w_t}$ is the vector of predetermined variables. To estimate these CIRFs we use the local projections technique (Jordà, 2005), and our baseline specification is the following:

$$\Delta^h y_t \equiv \ln(y_{t+h}) - \ln(y_{t-1}) = \alpha_h + \tau_h \Delta NDF_t + \gamma_h' \mathbf{w_t} + \nu_{\mathbf{t+h}} \tag{2}$$

Defining ν_{t+h} such that $\mathbb{E}\left[\nu_{t+h} | \Delta NDF_t, \mathbf{w_t}\right] = 0$ for all $h \in \{1, 2, ..., H\}$, we can recover the CIRFs of interest by estimating the parameters τ_h from equation (2), that is, $\hat{\mathcal{R}}_y(h) = \hat{\tau}_h$.[4]

As outcome variables, we consider several high-frequency measures of FX volatility. The first one is the daily FX depreciation $\Delta \ln(e_t)$, where e_t is the nominal exchange rate (CLP per USD). To capture autoregressive heteroskedasticity, we also compute an exponentially weighted moving

[4]To be precise, the vector of predetermined variables and their coefficients are given by $\sum_{i=1}^{k_y+1} (\gamma_{1,h,i} \Delta y_{t-i} + \gamma_{2,h,i} \Delta NDF_{t-i}) + \sum_{i=0}^{k_y+1} \gamma_{3,h,i}' \mathbf{x_{t-i}}$, here $\mathbf{x_t}$ contains the main drivers and fundamentals variables of the Chilean FX market (presented in Table A2), as well as linear and quadratic time trends. For each model (i.e., each outcome variable), we select the number of lags k_y that minimizes the Akaike Information Criteria (AIC) for horizon $h = 0$.

average (EWMA) volatility $\sigma_t = \sqrt{\lambda\sigma_{t-1}^2 + (1-\lambda)(\Delta \ln(e_t))^2}$, with a weight of $\lambda = 0.94$, as is standard in the literature (J.P. Morgan and Reuters, 1996). Using intraday transaction data, we further consider the standard deviation of intraday CLP returns (scaled by 1,000), and the bid-ask spread (measured as a percentage of the exchange rate). Lastly, we use implied volatility from at-the-money options on the CLP for maturities $m \in \{3, 6, 9, 12, 24\}$ months (in CLP per USD).

Each of these volatility measures captures a different aspect of FX risk, so the interpretation of the results must take this into account. The most direct measure is the magnitude (and sign) of the daily exchange rate change. In addition, we use realized volatility measures, either based on the weighted history of past returns (EWMA) or on the intraday behavior of the FX market (standard deviation or bid-ask spread), which reflect the dynamics of price formation. Finally, implied volatility measures summarize market participants' expectations about the future exchange rate movements.

The local projection technique has a particular advantage for our approach. In addition to being asymptotically equivalent to vector autoregressions (VARs) when the VAR is sufficiently lag-augmented (Plagborg-Møller and Wolf, 2021), and to lying on the low-bias/high-variance side of the usual bias–variance trade-off (Li et al., 2024; Montiel Olea et al., 2025), local projections are very flexible for testing nonlinearities in the effect of interest. This is useful for us because we evaluate how the impact of NDF flows varies with the occurrence of different exogenous events that, as discussed in Section 4, change the incentives of agents taking NDF positions. These events correspond to the regulatory reform of pension funds' investment and hedging rules in November 2017, and to the three pension fund withdrawals that took place in July 2020, December 2020 and April 2021. Denoting these events by $z_{j,t} = \mathbf{1}\{t \geq \bar{t}_j\}$, where $\mathbf{1}\{\cdot\}$ is the indicator function and $\bar{t}_j$ are the corresponding dates, we estimate the following specification

$$\Delta^h y_t = \alpha_h + \tau_h \Delta NDF_t + \sum_{j=1}^{4} \beta_{j,h} \left(\Delta NDF_t \cdot z_{j,t}\right) + \delta_h' \mathbf{z_t} + \gamma_{\mathbf{h}}' \mathbf{w_t} + \nu_{\mathbf{t+h}}, \tag{3}$$

in which CIRFs take the form $\hat{\mathcal{R}}_{y,j}(h) = \hat{\tau}_h + \hat{\beta}_{j,h}$.[5]

Finally, for inference we follow Jordà and Taylor (2025) (cf. Montiel Olea and Plagborg-Møller (2021); Inoue et al. (2025)), estimating standard errors that are robust to autocorrelation and allow for lag augmentation. In addition, to test the presence of heterogeneities, we simply test the significance of $\{\hat{\beta}_{j,h}\}_{j\in\{1,2,3,4\}}$ for a given horizon h, according to equation (3).

6. Results

This section presents the estimation results of the previous equations. We first report the baseline specification in equation (2) and then, in the heterogeneity subsection, the results from equation (3).

[5]Sometimes, along with the CIRF for each horizon, we present the average CIRF for all horizons. The estimation of this average CIRF considers the average of the cumulative changes over the entire horizon as the dependent variable; that is, it uses expression $\frac{1}{H+1}\sum_{h=0}^{H} \Delta^h y_t$ in equations (2) and (3).

We also analyze which NDF maturities drive the estimated effects by grouping NDF flows by maturity and re-estimating equations (2) and (3) for each group.

Table 4 reports the estimates of the baseline specification at horizon 0 (immediate effect). A shock of USD 1 billion in NDF purchases is associated with an average depreciation of 0.9%, which falls to 0.5% once we condition on FX market drivers. For the realized volatility measures (EWMA, intraday standard deviation and bid–ask spread), no significant effects are found at this horizon. By contrast, implied volatility at the 3-month maturity increases by about 0.5% in response to a USD 1 billion NDF purchase, although this effect loses statistical significance once control variables are included.

Table 4: Contemporaneous Effect of Non-Resident NDF Flows on Exchange Rate Dynamics: Local Projections Estimates ($h = 0$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	FX depreciation		FX EWMA vol.		FX bid–ask spread		FX SD intraday		FX implied vol. 3M	
d_ndf	0.00908***	0.00476***	-0.00446	-0.00636	-0.00767	-0.0121	-0.00950	-0.00907	0.00473***	0.000437
	(0.000528)	(0.000469)	(0.00541)	(0.00591)	(0.00982)	(0.0111)	(0.0112)	(0.0124)	(0.00152)	(0.00166)
Observations	2,481	2,481	2,482	2,482	2,478	2,478	2,478	2,478	2,481	2,481
Lags	5	5	4	4	9	9	9	9	6	6
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports the estimated coefficients for the contemporaneous impact ($\hat{\tau}_0$) from the local projections model defined in equation (2). Sample: Daily data from January 2015 to December 2024. Independent Variable ($d_n df$): Daily flow (variation) of the net NDF position of non-residents, measured in billions of USD. A positive value indicates a net purchase of USD (long position against the CLP). Dependent Variables: (1)-(2) FX depreciation: Daily log-difference of the nominal USD/CLP exchange rate. (3)-(4) FX EWMA vol: Exponentially Weighted Moving Average volatility. (5)-(6) FX bid-ask spread: Daily average bid-ask spread. (7)-(8) FX SD intraday: Standard deviation of intraday exchange rate movements. (9)-(10) FX implied vol 3M: 3-Month At-The-Money implied volatility. Controls: Columns with "Yes" include the following drivers: Broad Dollar Index, copper price, oil price, Chile CPI, US CPI, and Chile 5-Year CDS (all entered as log-differences), and the 1-year onshore-offshore interest rate differential (entered as a simple difference). The specification also includes linear and quadratic trends, and dummy variables for FX intervention episodes (2019, 2021, 2022, and 2023). The optimal lag length for autoregressive terms was selected by minimizing the Akaike Information Criterion (AIC). Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

In terms of dynamic effects, Figure A2 reports the estimated CIRFs for FX depreciation and the realized volatility measures. The impact on the exchange rate is persistent and remains significant for up to 30 days after the shock, with an average depreciation of around 0.5% in response to a USD 1 billion NDF purchase. The effects on EWMA volatility and the bid–ask spread are essentially zero at all horizons, and although the intraday standard deviation rises by about 0.6%, this increase is not statistically significant. Regarding implied volatility, the results presented in Figure A3 show that the CIRFs for 3-month maturities are mostly positive, with an average effect of about 0.4%, but not statistically different from zero. Moreover, the average impact declines with the maturity over which implied volatility is measured and becomes virtually nil on the 24-month horizon.

As discussed in Section 3.1, the maturity of NDF contracts can be informative about the

strategies underlying these positions.[6] In the results above, the USD 1 billion NDF shock refers to the aggregate position. However, each NDF-based strategy has different drivers and may therefore affect the volatility measures in different ways. To explore this, we re-estimate the baseline specification separately for NDF contracts in the following maturity buckets (in days): $[1, 7], [8, 35], [36, 95], [96, 185], [186, 369], [370, \infty]$.

Figure 6 reports the average CIRFs of the baseline specification by NDF maturity. For FX depreciation, NDF contracts with maturities between 8 and 35 days have a significant effect, of about 0.4% for every USD 1 billion purchased. For the EWMA volatility measure, positions with maturities between 36 and 95 days also have a significant positive impact, and of considerable magnitude: around 5.4% per USD 1 billion purchased. For intraday measures (bid–ask spread and standard deviation), NDF positions between 36 and 95 days likewise have a positive effect, on the order of 2.0 – 2.4%, although imprecisely estimated.

Overall, a shock to NDF positions appears to have a depreciating effect on the exchange rate, of around 0.5% per USD 1 billion, and this effect persists for up to 30 days. Examining the maturity structure of NDF positions shows that short-term contracts (less than 35 days), and typically associated with speculative strategies, account for this exchange rate response.

Although the total NDF position does not have a statistically significant impact on FX volatility measures in this full sample, a shock to NDF positions with maturities between one and three months raises EWMA volatility by about 5%. For the other realized volatility measures, the positive effects for these maturities are of similar magnitude but only slightly below conventional significance levels.

6.1. Post-PFs withdrawals effects

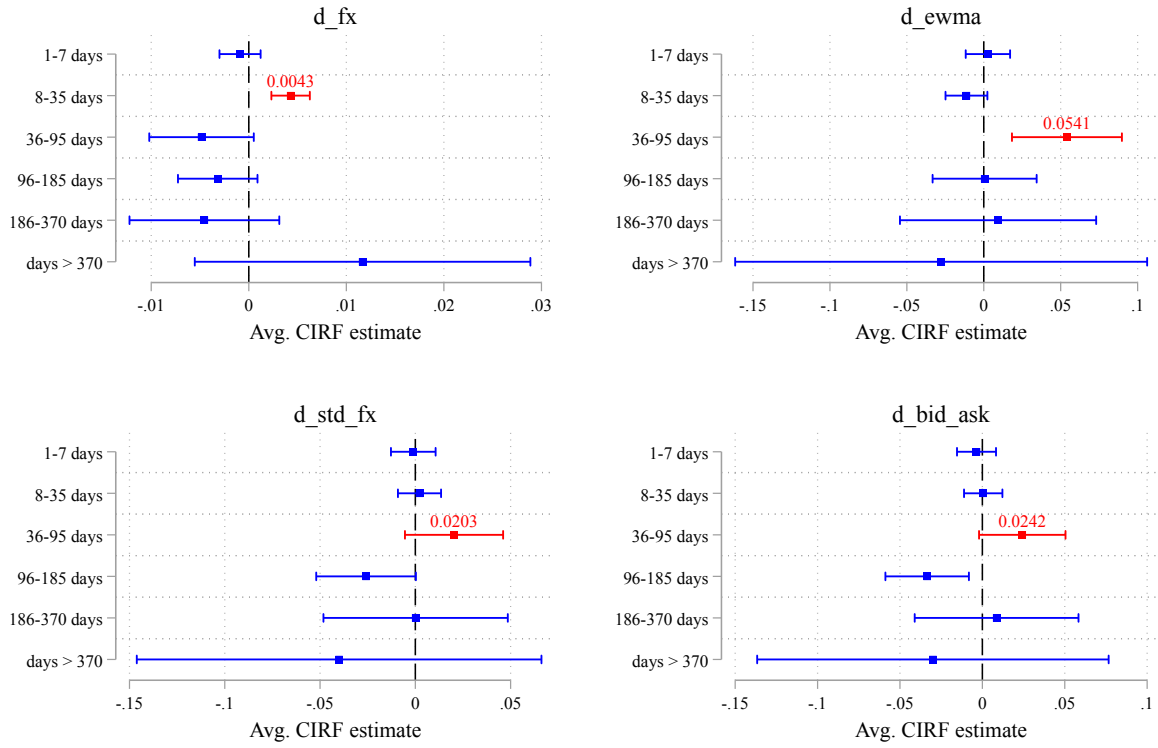
As discussed in Section 3.1, the Chilean NDF market underwent significant structural changes starting in 2017, driven by reforms to pension fund investment regulations and the enhancement of international standards for public debt. These developments initially fostered a structural increase in non-resident NDF positions, which subsequently unwound and exhibited heightened volatility following the legislative approval of pension fund withdrawals. Given that these events fundamentally altered the incentives and behavior of non-resident agents in the derivatives market, this section empirically tests whether the impact of NDF flows on FX dynamics changed significantly after these structural breaks.

To this end, we estimate equation (3), which augments the baseline specification with dummy variables for each event and their interaction with NDF flows.[7] The dummies are defined so that they switch on at the event date and remain active thereafter, so the periods overlap. Each

[6] It is worth noting that this relationship has a dynamic component. Strategies may use multiple maturities simultaneously or change them over time. However, the maturity remains an informative indicator of the strategy.

[7] For the construction of the dummy variables, we used the dates described in Table 2 for pension fund withdrawals. For the dummy variable that reflects the 2017 changes, we activated it starting November 1, 2017, the date the law (Resolution No. 88 by the Superintendence of Pensions (*Superintendencia de Pensiones*)) modifying the pension fund investment and coverage system came into effect.

Figure 6: Average Cumulative Impact of Non-Resident NDF Flows on FX Dynamics Across NDF Maturities



Notes: The figure displays the estimated dynamic response coefficients obtained from local projections for different NDF maturities to a shock to net non-resident NDF flows, according to equation (2). The panels illustrate the response of four exchange rate metrics: daily depreciation (d_fx), EWMA volatility (d_ewma), intraday standard deviation (d_std_fx), and bid-ask spread (d_bid_ask). In each panel, the blue dots represent the average estimated coefficient for the specified NDF maturity (e.g., 1-7 days, 8-35 days), while the horizontal blue bars indicate the 90% confidence intervals based on robust standard errors.

interaction coefficient thus captures the incremental change in the CIRF relative to the pre-event period (pre-Nov 2017). The effective CIRF after each event is given by the cumulative sum of these coefficients up to that event.

Table 5 reports the estimation of equation (3) for horizon $h = 0$. The results show that the impact of NDF flows increases after the regulatory and withdrawal events, both for FX depreciation and for realized volatility measures. The change in slope is particularly pronounced after the third pension withdrawal in April 2021.

Table 5: Heterogeneous Impact of Non-Resident NDF Flows on Exchange Rate Dynamics across Structural Periods (at $h = 0$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	FX depreciation		FX EWMA vol.		FX bid–ask spread		FX SD intraday		FX implied vol. 3M	
d_ndf	0.00489***	0.00326***	-0.0171	-0.0218**	-0.0796***	-0.0401**	-0.0846***	-0.0474***	-0.00136	-0.00168
	(0.000665)	(0.000530)	(0.0109)	(0.00853)	(0.0226)	(0.0158)	(0.0258)	(0.0172)	(0.00251)	(0.00247)
d_ndf_z_pf_Nov2017	-0.00188**		-0.00697		0.0685**		0.0551		0.000952	
	(0.000958)		(0.0170)		(0.0322)		(0.0346)		(0.00452)	
d_ndf_z_pfw_Jul2020	-0.00374*		0.0258		-0.0822*		-0.0298		-0.0197	
	(0.00227)		(0.0284)		(0.0483)		(0.0545)		(0.0128)	
d_ndf_z_pfw_Dec2020	-0.000259		-0.0583		0.122**		0.115		0.0249	
	(0.00354)		(0.0422)		(0.0620)		(0.0800)		(0.0155)	
d_ndf_z_pfw_Apr2021	0.00746**	0.00316***	0.0675*	0.0325***	-0.0101	0.0592***	-0.0227	0.0809***	-0.00192	0.00443
	(0.00290)	(0.000842)	(0.0347)	(0.0105)	(0.0474)	(0.0201)	(0.0651)	(0.0228)	(0.00976)	(0.00285)
CIRF per event										
Pre-Nov. 2017	0.0049***		-0.0171		-0.0796***		-0.0846***		-0.0014	
Nov. 2017 – Jul. 2020	0.0030***		-0.0241*		-0.0111		-0.0295		-0.0004	
Jul. 2020 – Dec. 2020	-0.0007		0.0018		-0.0933**		-0.0594		-0.0201*	
Dec. 2020 – Apr. 2021	-0.0010		-0.0566*		0.0289		0.0557		0.0048	
Post-Apr. 2021	0.0065***	0.0064***	0.0109	0.0107	0.0188	0.0190	0.0330**	0.0335**	0.0029	0.0028
Observations	2,481	2,481	2,482	2,482	2,478	2,478	2,478	2,478	2,481	2,481
Lags	5	5	4	4	9	9	9	9	6	6
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

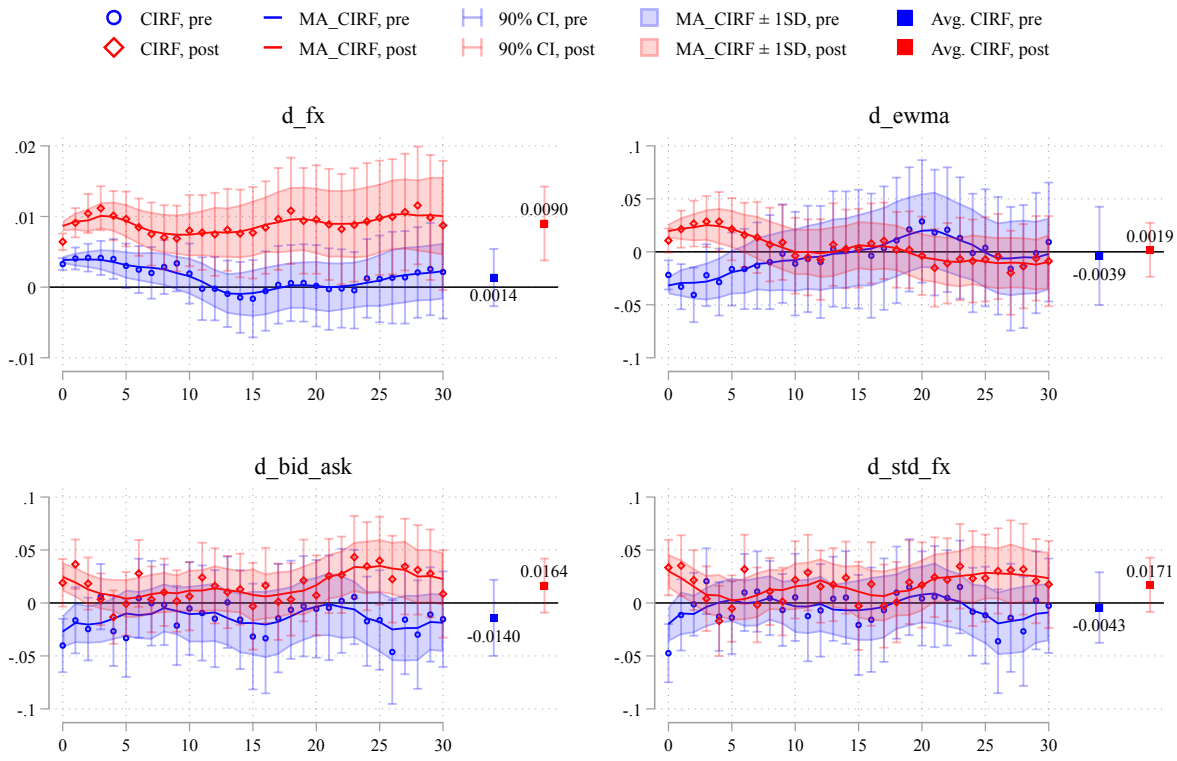
Notes: The table reports the estimated coefficients for the contemporaneous impact ($h = 0$) derived from the local projections model specified in equation (3). The independent variable *d_ndf* represents the daily net NDF flow of non-residents in billions of USD. The model allows for heterogeneity in the estimated impact by interacting the flow variable with dummy variables representing distinct structural periods starting in November 2017 (financial modernization), July 2020 (first pension fund withdrawal), December 2020 (second withdrawal), and April 2021 (third withdrawal). Odd-numbered columns present the full specification including interactions for all structural breaks, while even-numbered columns display a parsimonious specification focusing on the regime following the third pension withdrawal. The lower panel reports the total estimated marginal effect of NDF flows within each specific time window, calculated as the linear combination of the baseline coefficient and the active interaction terms. All specifications include the full set of control variables described in Table A2, with optimal lag length selected via the Akaike Information Criterion (AIC). Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

In terms of dynamic effects, Figure 7 shows that the CIRF of the FX depreciation is larger after the third pension withdrawal (April 2021) throughout the whole horizon: the average impact of a USD 1 billion NDF purchase rises from 0.1% (not statistically significant) to 0.9%. For the realized volatility measures, the post-April 2021 CIRFs are higher only at short horizons, up to three days for the intraday standard deviation and bid–ask spread, and up to five days for EWMA volatility. At horizon $h = 1$ (one day after the shock), the cumulative effects are about 4% for the bid–ask spread, 3% for the intraday standard deviation and 2% for EWMA volatility, all statistically significant.

The reversal in the intraday volatility coefficient likely reflects the breakdown of the liquidity provision mechanism illustrated in Figure 5. Prior to the withdrawals, pension funds acted as natural counterparties to non-residents, stabilizing price formation. The loss of this buffering role implies that NDF flows now encounter shallower liquidity, thereby amplifying intraday noise rather

than absorbing it.

Figure 7: Heterogeneous Dynamics Impact of Non-Resident NDF Flows on Exchange Rate Dynamics: Pre- and Post-Third Pension Fund Withdrawal



Notes: The figure displays the cumulative impulse response functions (CIRFs) estimated from the state-dependent local projections model (equation (3)) over a 30-day horizon following a shock to net non-resident NDF flows. The estimation distinguishes between two structural regimes: the period prior to the third pension fund withdrawal approval in April 2021 (blue series) and the period following it (red series). The panels illustrate the dynamic response of daily depreciation (d_fx), EWMA volatility (d_ewma), bid-ask spread (d_bid_ask), and intraday standard deviation (d_std_fx). In each panel, the hollow blue circles and red diamonds represent the point estimates for each horizon for the pre- and post-event periods respectively, with vertical bars indicating the 90% confidence intervals based on robust standard errors. The solid lines depict the centered 5-day moving average of the coefficients to highlight the trend in each regime, while the surrounding shaded areas indicate the moving average plus/minus one standard deviation. The numeric values reported on the right correspond to the average cumulative effect over the full 30-day period for each regime.

The estimates also indicate higher CIRFs after April 2021 for short-term (3- and 6-month) implied volatility, but only at short horizons. Figure A4 shows cumulative effects of about 1% for 3-month implied volatility and 0.5% for the 6-month measure, both statistically significant, whereas the corresponding pre-April 2021 CIRFs are not significantly different from zero.

We also find that, after April 2021, short-term NDF flows drive these aggregate effects. To show this, we re-estimate equation (3) by grouping NDF flows by maturity. The results, presented in Figure A5, indicate that flows with maturities between 8 and 35 days are the primary drivers of the exchange rate level, generating an average depreciation of roughly 0.6% per USD 1 billion purchased

in the post-April 2021 period.

For EWMA volatility, intraday standard deviation and bid–ask spread, NDF flows with maturities between 36 and 95 days are the most relevant. Before April 2021, the corresponding average CIRFs were not statistically different from zero. After April 2021, however, a USD 1 billion increase in purchases of 1- to 3-month NDFs generate average cumulative effects of about 9.8% for EWMA volatility, 3.4% for intraday standard deviation and 4.3% for the bid–ask spread.

These results support the hypothesis that, following the post-2017 deepening of the NDF market and the subsequent pension fund withdrawals, NDF flows by non-resident investors have had a stronger impact on several measures of exchange rate volatility.

6.2. Nonlinearities

In this subsection, we extend our baseline analysis to explore potential nonlinearities in the relationship between non-resident NDF flows and exchange rate dynamics. To do so, we augment equation (2) to test whether the estimated CIRFs are conditional on the magnitude of the flows. Specifically, we introduce a quadratic term of the net NDF flows to assess if larger flow volumes exert a disproportionate impact on the FX variables compared to smaller ones.

The results presented in Table 6 indicate a significant nonlinear relationship between non-resident NDF flows and FX depreciation over the full sample period. Specifically, the impact of these flows intensifies as the magnitude of the net flow increases. For instance, evaluating the effect on the median daily flow of USD 9 million yields an estimated depreciation of 0.5% for every USD 1 billion purchased. However, when evaluated at the 95th percentile, corresponding to a daily flow of approximately USD 500 million, this effect rises to 1.4%. Conversely, when restricting the analysis to the period following the third pension fund withdrawal in April 2021, we find no statistically significant evidence of such nonlinearities.

Table 6: Nonlinear Average Cumulative Impact of Non-Resident NDF Flows on Exchange Rate Metrics (30-Day Horizon)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FX depreciation		FX EWMA vol.		FX bid–ask spread		FX SD intraday	
d_ndf	0.00518***	0.00829***	0.00114	0.0133	0.00189	0.0211*	0.00703	0.0227*
	(0.00162)	(0.00297)	(0.0141)	(0.0124)	(0.0117)	(0.0123)	(0.0114)	(0.0129)
d_ndf_2	0.00874**	0.00754	0.0735***	0.0371	0.0481**	0.0234	0.0372*	0.0139
	(0.00363)	(0.00546)	(0.0254)	(0.0256)	(0.0213)	(0.0236)	(0.0210)	(0.0243)
d_ndf Pct 5	-0.5059	-0.5845	-0.5059	-0.5845	-0.5059	-0.5845	-0.5059	-0.5845
d_ndf Pct 25	-0.1812	-0.1931	-0.1812	-0.1931	-0.1816	-0.1931	-0.1816	-0.1931
d_ndf Pct 50	0.0090	0.0112	0.0086	0.0110	0.0081	0.0110	0.0081	0.0110
d_ndf Pct 75	0.1881	0.2214	0.1874	0.2213	0.1874	0.2213	0.1874	0.2213
d_ndf Pct 95	0.4811	0.5662	0.4811	0.5662	0.4811	0.5662	0.4811	0.5662
CIRF Pct 5	-0.0037	-0.0005	-0.0733***	-0.0300	-0.0467**	-0.0063	-0.0307	0.0064
CIRF Pct 25	0.0020	0.0054*	-0.0255	-0.0010	-0.0156	0.0120	-0.0065	0.0173
CIRF Pct 50	0.0053***	0.0085***	0.0024	0.0141	0.0027	0.0216*	0.0076	0.0230*
CIRF Pct 75	0.0085***	0.0116***	0.0287	0.0297	0.0199	0.0314*	0.0210	0.0289*
CIRF Pct 95	0.0136***	0.0168**	0.0719**	0.0553	0.0481**	0.0475	0.0429*	0.0385
Sample	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021
Observations	2,451	884	2,452	885	2,448	885	2,448	885
Lags	5	5	4	4	9	9	9	9
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports the estimated coefficients for the average cumulative impulse response function (CIRF) over a 0 to 30-day horizon, derived from the nonlinear local projections model (augmented equation (2)). The independent variables include the daily net NDF flow of non-residents (*d_ndf*) and its quadratic term (*d_ndf_2*), both measured in billions of USD. Odd-numbered columns present estimates for the full sample period, while even-numbered columns restrict the sample to the period following the third pension fund withdrawal (post-April 2021). The middle panel displays the distribution of the daily net NDF flow variable at selected percentiles. The lower panel reports the estimated average cumulative response evaluated at each of these flow percentiles. All specifications include the full set of control variables detailed in Table A2. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Regarding the realized volatility measures, the full sample estimation presented in Table 6 reveals that only the quadratic term of the NDF flows is statistically significant, whereas the linear term is not. This suggests that substantial fluctuations in NDF flow volumes are required to drive increases in these volatility metrics. Consequently, statistical significance in the average CIRFs emerges only at the upper tail of the distribution, specifically at the 95th percentile. At this level of activity, the economic impact is considerable, with estimated increases of 7.2% for EWMA volatility, 4.8% for the bid-ask spread, and 4.3% for the intraday standard deviation.

However, in the estimates restricted to the post-April 2021 sample, the quadratic term of NDF flows loses its statistical significance. Given that the linear term remains significant, this shows that, following these structural events, a high volume of flows is no longer a prerequisite for a shock to generate significant market repercussions; rather, the impact remains constant across the entire distribution of the variable.

This shift from nonlinear to linear sensitivity signals a structural loss of market depth. Previously, abundant liquidity from pension funds acted as a buffer, absorbing standard flows so that only extreme shocks triggered disproportionate price responses. The retrenchment of these institutional

players have diluted this cushion, exposing a structurally more fragile market where, in the absence of deep natural counterparties, even moderate flows transmit directly to exchange rate dynamics.

Regarding implied volatility metrics, we observe nonlinear effects for option horizons up to 12 months. As shown in Table A3, in both the full sample and the post-April 2021 subsample, only the quadratic term of the NDF flows is statistically significant. Consequently, the impact of these flows on implied volatility becomes statistically significant only for flow volumes exceeding the 75th percentile of the distribution.

7. Discussion

Our findings show that NDF flows exert depreciative pressure on the exchange rate, a dynamic that notably intensified for both returns and volatility following the structural break in April 2021. We document distinct maturity-specific transmission channels, where very short-term flows drive spot depreciation while three-to-six-month tenors primarily impact volatility. Furthermore, the evidence indicates that these market reactions are size-dependent, with larger flow volumes generating stronger effects on both currency depreciation and realized volatility metrics.

In this section, we discuss the implications of these findings for monetary policy and the main challenges for policy responses to speculative flows.

7.1. Interaction with Monetary Policy

In an inflation-targeting regime characterized by exchange rate flexibility, our findings have direct implications for monetary policy on two critical fronts: exchange rate pass-through (ERPT) dynamics and financial stability.

Regarding ERPT, our results indicate that NDF flows drive currency movements independently of macroeconomic fundamentals. Since there is evidence suggesting that the magnitude of ERPT depends on the underlying nature of the shock (cf. Forbes et al. (2018); García-Cicco and García-Schmidt (2020)), a surge in NDF activity can generate a disconnect between the nominal exchange rate and its fundamentals. This disconnect could complicates the monetary authority's ability to distinguish between persistent movements that warrant a monetary reaction to preserve price stability and temporary fluctuations arising from market frictions. Furthermore, the positive relation we document between the magnitude of NDF shocks and their impact on FX dynamics suggests a potential nonlinearity in the transmission mechanism. This creates a risk of amplification, particularly in light of literature indicating that ERPT is heterogeneous and notably higher for large depreciations (Delatte and López-Villavicencio, 2012; Bertinatto and Saravia, 2015; Caselli and Roitman, 2019). Even though the consolidation of inflation targeting has historically attenuated the transmission of currency shocks to domestic prices (cf. Taylor (2000); Mishkin and Schmidt-Hebbel (2007); Caselli and Roitman (2019)), the amplification potential we document suggests that monitoring these flows remains important for preserving price stability.

Concerning financial stability, the evidence of maturity segmentation suggests that volatility

is driven primarily by short-term, speculative flows or those unrelated to "real" hedging needs backed by real-sector investment. Specifically, in the period following April 2021, we observe that these flows exert a positive and significant effect on intraday volatility metrics (bid-ask spreads and standard deviations). Although these effects display low persistence—potentially mitigated by the central bank's policy responses in 2019 and 2022 through FXI—they may justify the deployment of macroprudential or unconventional measures to ensure proper market functioning. Reliance solely on direct FXI to curb such volatility entails a direct cost in terms of international reserves,[8] highlighting the importance of monitoring these non-fundamental flow dynamics.

7.2. Policy Responses to Speculative Flows

Theoretical discussions regarding the management of volatile capital flows often align with the spirit of a Tobin tax, advocating for levies on specific transactions to discourage short-term speculative behavior without penalizing long-term investment. The underlying premise is that by increasing the cost of high-frequency trading, policy can discourage speculative trading, thereby reducing exchange rate volatility and aligning prices closer to fundamentals. However, the practical application of this principle offers contrasting lessons depending on the specific mechanism employed.

The Brazilian experience during the 2011-2013 period illustrates the challenges associated with price-based capital controls directly on transactions. To curb excessive currency appreciation, authorities imposed a 1% Financial Operations Tax (IOF) on the notional increase of short FX positions held by non-residents in the domestic futures market. This mechanism aimed to directly penalize the accumulation of speculative bets favoring the local currency. While aimed at penalizing speculative accumulation, evidence suggests the measure impaired market efficiency more than it contained speculation. Alfaro et al. (2017) and Chamon and García (2016) document that the tax widened bid-ask spreads and reduced liquidity, while financial agents utilized arbitrage strategies and offshore vehicles to circumvent the levy.

In contrast, South Korea implemented a macroprudential approach in 2011 that targeted the funding source of speculative positions rather than the transactions themselves. The policy introduced a stability levy on the stock of non-core foreign currency liabilities held by banks, with rates differentiated by maturity to specifically penalize short-term external funding. Hahm et al. (2013) argue this design addresses the structural vulnerability of banks acting as counterparties to NDFs. Empirically, Bruno and Shin (2014) confirm that by increasing the cost of the balance sheet expansion required to hedge offshore positions, the measure successfully reduced the financial system's sensitivity to global shocks without disrupting daily market liquidity. Conversely, evidence from Southeast Asia highlights that administrative restrictions, such as prohibiting domestic banks from acting as counterparties to offshore NDFs, tend to displace trading volume toward offshore centers beyond local supervision (McCauley and Shu, 2016), exacerbating market opacity.

[8] While addressing these imbalances directly through NDF market intervention is a theoretical possibility, the relative efficiency of such operations compared to traditional spot market intervention remains less established (see, e.g., Nedeljkovic and Saborowski (2019); Arenas and Griffith-Jones (2024)).

It is worth noting that, given the extraterritorial nature of NDF contracts, these interventions rarely targeted the instrument itself. In Brazil, the tax applied to regulated domestic derivatives, whereas the Korean levy targeted bank liabilities used to hedge positions. This distinction underscores the structural challenge of directly taxing NDF flows, as local measures face jurisdictional limitations and the risk of fostering regulatory arbitrage toward opaque financial centers. Nonetheless, these limitations do not preclude the implementation of policies designed to mitigate disruptive effects through enhanced market infrastructure.

In the case of Chile, Dodd and Griffith-Jones (2007) emphasized early on the need to strengthen transparency, recommending reporting systems capable of identifying risk accumulation by large market participants. Contrasting these recommendations with the current landscape reveals substantial institutional progress: the implementation of detailed trade repositories (SIID-TR) and central clearing counterparties have effectively overcome the opacity that historically characterized OTC flows, granting authorities the capacity to observe these flows in real time.

Designing policy responses to these flows requires confronting a fundamental identification problem: distinguishing speculative activity from genuine hedging demand. In practice, the underlying motivation of a given transaction is unobservable. Nonetheless, the maturity structure of positions provides a useful empirical lens, consistent with both the international literature and the evidence presented in Section 5.2. Real-sector agents typically seek risk coverage at longer maturities that align with production, investment, and trade cycles, whereas strategies related to trading, arbitrage, or portfolio reallocation are more frequently implemented over shorter horizons and at higher turnover rates. From this standpoint, analytical frameworks that differentiate flows according to their time horizon are better suited to isolating the most volatile components of capital movements, while remaining relatively neutral with respect to hedging activity. An important qualification to this argument, however, concerns the depth and absorptive capacity of the local market.[9]

Ultimately, the overarching policy goal remains the mitigation of excessive volatility driven by speculative flows that decouple prices from fundamentals. Achieving this requires designing instruments that account for the specific microstructure of the Chilean market, acknowledging the complexity of regulating offshore activities without impairing liquidity. In this context, the local financial environment offers distinct advantages, characterized by strong institutional frameworks and a substantial increase in derivative market transparency. These attributes provide a solid foundation for developing targeted measures that effectively disincentivize destabilizing short-term behavior while preserving the hedging channels necessary for the real economy.

[9] A non-trivial complication arises when the depth of the long-term market is insufficient, compelling firms with genuine long-term hedging needs to take positions in shorter-term contracts and roll them over periodically. This structural constraint poses an additional challenge for policy design, as instruments intended to correct speculative flows could inadvertently penalize agents managing commercial risks due to the lack of available liquidity at longer tenors.

8. Concluding Remarks

Our results indicate that non-resident NDF flows influence Chilean exchange rate dynamics, a relationship that has become more relevant following the structural shifts observed in recent years. Driven mainly by short-term positions, these flows exhibit nonlinear features that are pertinent to financial stability monitoring and exchange rate pass-through assessments.

Future research will explore potential regulatory measures, taking into account the specific microstructure of the Chilean market. The objective is to design policies and regulations aimed at counteracting speculative activity and its distorting effects on exchange rate dynamics.

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Appendix

This appendix presents supplementary figures and tables regarding the data description and descriptive statistics. Additionally, it reports further results related to the econometric exercises discussed in Section 5.

Table A1: Taxonomy of Non-Deliverable Forward (NDF) Trading Strategies

Category	**Main Objective**	**Key Drivers**	**Expected Return Profile**	**Typical FX Impact**
Domestic Hedging	Lock FX cash flows on payables/receivables; hedge FX debt; neutralize foreign exchange currency exposure risk on foreign assets	Cash-flow timing; FX-denominated costs/revenues; hedging and international AUM regulations for institutional investors; domestic and foreign debt cost conditions	Not return-seeking; minimize P&L volatility/hedging cost	Local hedging can move spot depending on hedging ratios and tenors; hedging demand at tenors shifts forward points downward
Non-resident Hedging	Neutralize currency exposure risk on local bonds/equities/ETFs or other domestic assets	Portfolio flows; index rebalancing; global risk appetite	Cost of carry/basis; roll and margin costs	Flows affect on-the-run forwards; inventory hedging may influence spot hedging ratios and tenors
FX Speculation	Profit from the difference between the expected future spot and current forward rate	Terms of trade; macroeconomic conditions; idiosyncratic risk; policy/intervention	P&L from spot rate fluctuations and forward repricing; event risk	Reprices curve slope/level depending on tenors; impact on spot rates by offsetting the FX balance-sheet exposures of local banks
Unhedged Carry Trade	Monetize interest rate differential from NDF implied rates and FX returns	Rate differentials; FX volatility; global and idiosyncratic risk sentiment; macroeconomic conditions; monetary policy expectations; policy/intervention	Forward points differentials + FX returns; FX risk	Long position can support high yield FX and compress forward points; funding position can depreciate low-yield currency and press forward points upwards
Hedged Carry Trade	Access high-yield local assets and fund in low-yield currency while fully hedging FX exposure via NDF	Local-asset yields; hedging cost (forward points/basis); assets liquidity and funding conditions; macroeconomic conditions, monetary policy expectations	Rate differential net of hedging cost; low directional FX risk; rollover/basis-variation risk	FX-neutral strategy if 100% hedged; affects forward curve via hedging demand
Covered Interest Parity Deviation Arbitrage	Lock spread between NDF implied and synthetic rates in interest rate domestic bonds or other domestic instruments	Supply and demand imbalances in FX forwards driving CIP deviations; balance-sheet frictions; funding bases	Mispricing spread capture; low directional FX risk	Convergent pressure on mispriced forwards; limited spot impact
NDF Curve Arbitrage	Take advantage of short-term mispricing along the NDF curve	Supply and demand imbalances at different maturities in FX forwards; hedging seasonality; rolling dynamics	Arbitrage gains with low FX exposure	Smooths forward curve prices; limited spot impact

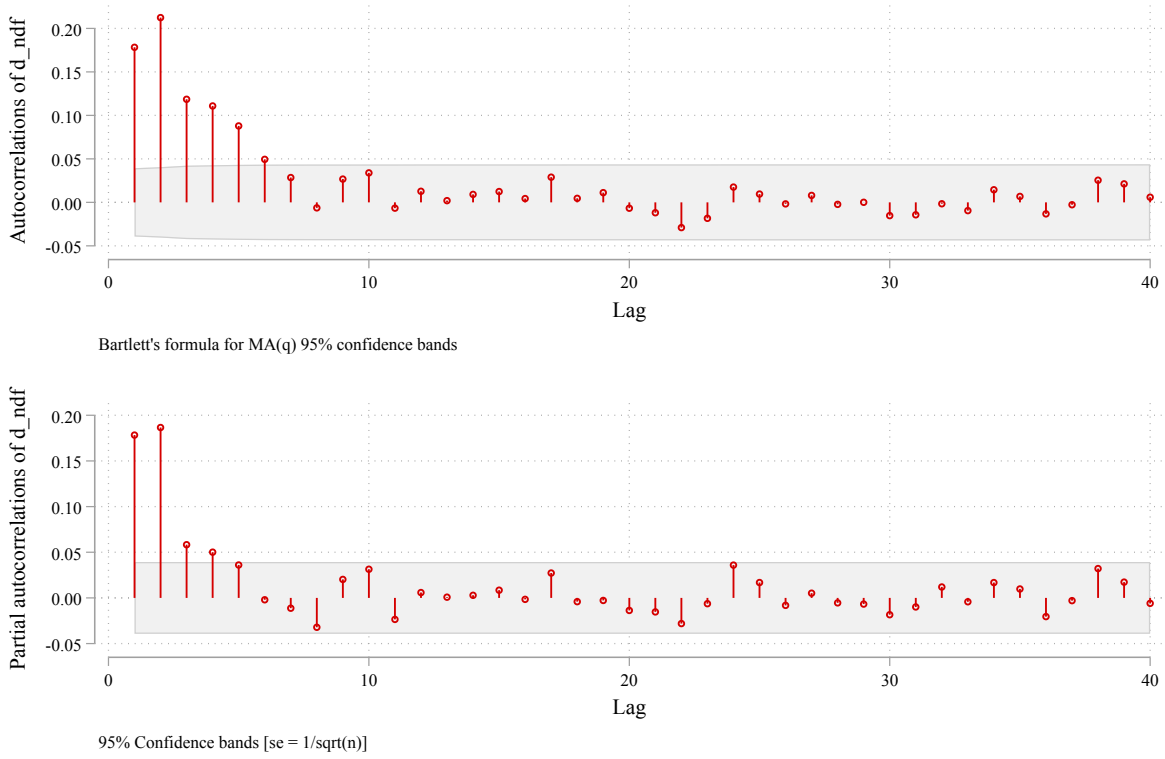
Notes: This table outlines the main uses of NDFs across hedging, speculative, carry trade, and arbitrage strategies.

Table A2: Description of Variables and Summary Statistics

Variable	Source	Unit	Obs	Mean	SD	Min	P25	P50	P75	Max
NDF										
NDF total	SIID-TR	USD Billions	2,489	9.61	5.90	4.36	5.13	8.76	13.57	24.46
NDF 1–7 days	SIID-TR	USD Billions	2,489	-0.18	0.42	-1.80	-0.43	-0.15	0.09	1.46
NDF 8–35 days	SIID-TR	USD Billions	2,489	1.06	2.63	-5.45	-0.53	1.24	2.75	8.11
NDF 36–95 days	SIID-TR	USD Billions	2,489	1.00	2.20	-4.85	-0.43	1.06	2.38	7.03
NDF 96–185 days	SIID-TR	USD Billions	2,489	2.46	2.74	-2.12	0.92	1.38	4.83	9.63
NDF 186–370 days	SIID-TR	USD Billions	2,489	3.36	1.41	0.26	2.29	3.15	4.39	6.94
NDF days > 370	SIID-TR	USD Billions	2,489	1.92	1.67	-0.07	0.31	1.46	3.46	4.97
Δ NDF total	SIID-TR	USD Billions	2,488	0.0001	0.3041	-1.6912	-0.1794	0.0094	0.1834	1.2668
Δ NDF 1–7 days	SIID-TR	USD Billions	2,488	0.0000	0.3081	-1.2453	-0.1995	-0.0095	0.1798	1.6761
Δ NDF 8–35 days	SIID-TR	USD Billions	2,488	-0.0002	0.4125	-2.0160	-0.2465	-0.0010	0.2569	2.7830
Δ NDF 36–95 days	SIID-TR	USD Billions	2,488	0.0002	0.1618	-1.7436	-0.0799	0.0017	0.0852	0.3459
Δ NDF 96–185 days	SIID-TR	USD Billions	2,488	0.0026	0.1681	-2.7695	-0.0415	0.0030	0.0800	1.3628
Δ NDF 186–370 days	SIID-TR	USD Billions	2,488	0.0004	0.0942	-0.7198	-0.0400	0.0000	0.0400	1.4475
Δ NDF days > 370	SIID-TR	USD Billions	2,488	0.0002	0.0392	-0.9500	0.0000	0.0000	0.0000	0.5160
FX outcomes										
FX	BBG	CLP/USD	2,488	753.08	107.11	588.28	665.97	721.83	823.11	1,042.97
EWMA	Constructed	Log points	2,488	0.0070	0.0025	0.0022	0.0053	0.0066	0.0081	0.0264
Bid–Ask spread	DATATEC	Percentage points	2,489	0.4853	0.1869	0.1458	0.3499	0.4460	0.5761	1.6526
SD FX	DATATEC	Log points	2,489	0.1570	0.0597	0.0716	0.1149	0.1440	0.1824	0.6550
Imp. vol. 3M	BBG	CLPUSD	2,489	12.74	3.24	7.44	10.12	12.32	14.26	24.94
Imp. vol. 6M	BBG	CLPUSD	2,489	12.62	3.03	7.87	10.05	12.31	14.18	22.39
Imp. vol. 9M	BBG	CLPUSD	2,489	12.56	2.91	8.12	10.04	12.25	14.14	21.89
Imp. vol. 12M	BBG	CLPUSD	2,489	12.52	2.83	8.32	10.03	12.30	14.01	21.47
Imp. vol. 24M	BBG	CLPUSD	2,489	12.76	2.77	8.72	10.45	12.42	14.29	21.61
Δ Log(FX)	BDE	Log-difference	2,487	0.0002	0.0075	-0.0539	-0.0042	0.0001	0.0045	0.0359
Δ Log(EWMA)	Constructed	Log-difference	2,487	-0.0001	0.0674	-0.0484	-0.0030	-0.0026	0.0156	0.5200
Δ Log(Bid–Ask spread)	DATATEC	Log-difference	2,488	0.0002	0.1652	-0.8327	-0.0973	-0.0061	0.1006	0.6826
Δ Log(SD FX)	DATATEC	Log-difference	2,488	0.0003	0.1859	-1.1195	-0.1036	-0.0073	0.1072	1.3803
Δ Log(Imp. vol. 3M)	BBG	Log-difference	2,488	0.0001	0.0220	-0.1508	-0.0063	0.0000	0.0057	0.3163
Δ Log(Imp. vol. 6M)	BBG	Log-difference	2,488	0.0001	0.0185	-0.1497	-0.0045	0.0000	0.0042	0.2571
Δ Log(Imp. vol. 9M)	BBG	Log-difference	2,488	0.0001	0.0172	-0.1417	-0.0043	0.0000	0.0040	0.2163
Δ Log(Imp. vol. 12M)	BBG	Log-difference	2,488	0.0001	0.0154	-0.1348	-0.0041	0.0000	0.0036	0.1826
Δ Log(Imp. vol. 24M)	BBG	Log-difference	2,488	0.0001	0.0238	-0.2927	-0.0046	0.0000	0.0043	0.3017
FX drivers										
USD broad	BBG	Index	2,489	95.83	4.31	85.24	92.83	95.41	99.15	106.90
Copper	BBG	US cents/lb	2,489	321.97	76.60	195.52	261.73	303.23	388.51	492.47
Oil	BBG	USD/bbl	2,489	66.37	18.49	19.33	51.81	65.42	78.94	127.98
CPI US	BBG	Index	2,489	266.25	26.01	234.75	244.16	257.04	291.30	316.45
CPI CL	BBG	Index	2,489	82.16	11.48	67.43	73.29	78.10	91.48	105.83
CDS CL 5Y	BBG	Basis points	2,489	75.17	24.53	29.86	53.08	67.94	91.76	176.04
Dif S1Y	BBG	Percentage points	2,489	1.96	2.10	-0.50	0.36	0.98	2.71	8.15
FXI 2019	Constructed	Binary	2,489	0.01	0.10	0.00	0.00	0.00	0.00	1.00
FXI 2021	Constructed	Binary	2,489	0.08	0.26	0.00	0.00	0.00	0.00	1.00
FXI 2022	Constructed	Binary	2,489	0.02	0.14	0.00	0.00	0.00	0.00	1.00
FXI 2023	Constructed	Binary	2,489	0.04	0.19	0.00	0.00	0.00	0.00	1.00
Δ Log(USD broad)	BBG	Log-difference	2,488	0.0001	0.0032	-0.0209	-0.0017	0.0000	0.0019	0.0183
Δ Log(Copper)	BBG	Log-difference	2,488	0.0001	0.0128	-0.0585	-0.0070	0.0000	0.0077	0.0589
Δ Log(Oil)	BBG	Log-difference	2,488	0.0001	0.0288	-0.2798	-0.0114	0.0014	0.0129	0.1088
Δ Log(CPI US)	BBG	Log-difference	2,488	0.0001	0.0008	-0.0080	0.0000	0.0000	0.0000	0.0129
Δ Log(CPI CL)	BBG	Log-difference	2,488	0.0002	0.0012	-0.0064	0.0000	0.0000	0.0000	0.0185
Δ Log(CDS CL 5Y)	BBG	Log-difference	2,488	-0.0002	0.0352	-0.3162	-0.0176	-0.0015	0.0147	0.3545
Δ Dif S1Y	BBG	Percentage points	2,488	-0.0007	0.0691	-0.8740	-0.0213	-0.0009	0.0181	0.7166
NDF drivers										
VIX	BBG	Index	2,489	18.28	7.29	9.14	13.34	16.33	21.32	82.69
DEPU	Becerra and Sagner (2023)	Index	2,489	163.47	83.94	54.52	104.01	126.32	218.33	464.41
PCA_CCY	Constructed	Index	2,488	0.00	1.99	-11.91	-1.21	-0.04	1.23	12.42
Δ Log(VIX)	BBG	Log-difference	2,488	0.0000	0.0801	-0.3307	-0.0436	-0.0053	0.0349	0.7683
Δ Log(DEPU)	Becerra and Sagner (2023)	Log-difference	2,488	0.0001	0.0345	-0.1928	-0.0145	0.0010	0.0173	0.2132

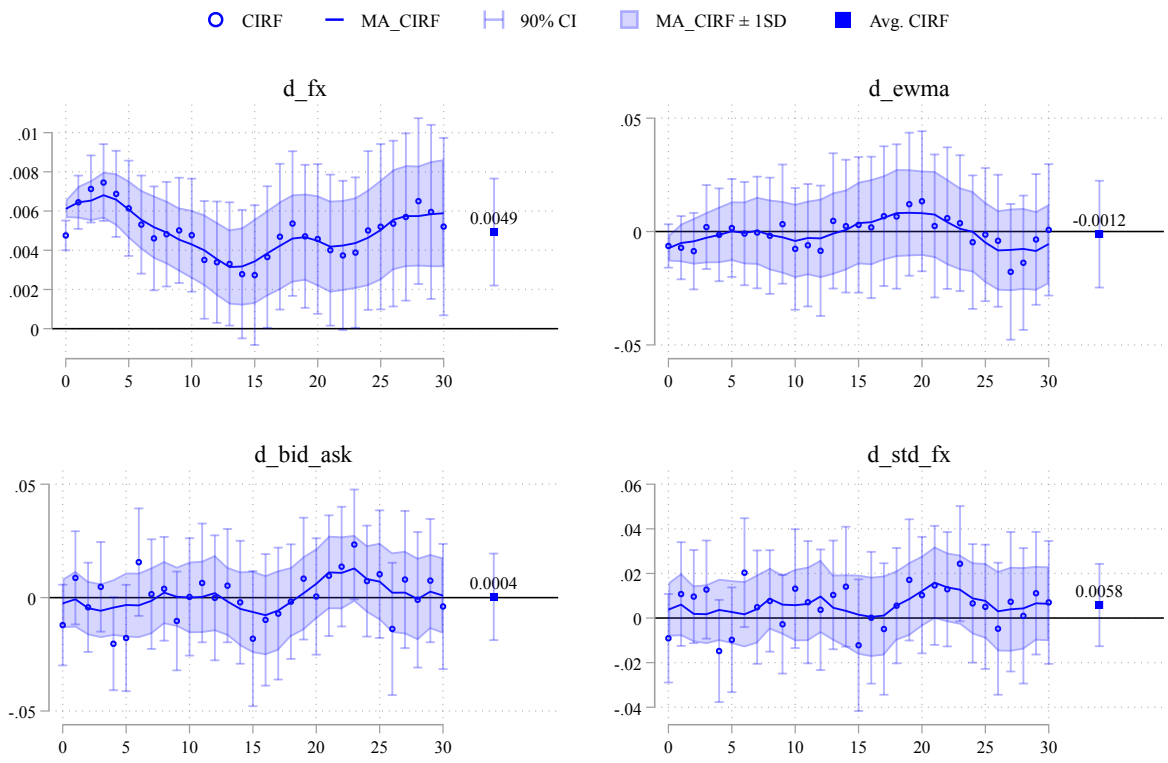
Notes: The table displays the source, unit of measurement, and descriptive statistics for the main variables. SIID-TR stands for the Trade Repository of the Central Bank of Chile. BBG denotes Bloomberg. DEPU refers to the Economic Policy Uncertainty index based on Twitter data from Becerra and Sagner (2023).

Figure A1: Serial Correlation of NDF Flows



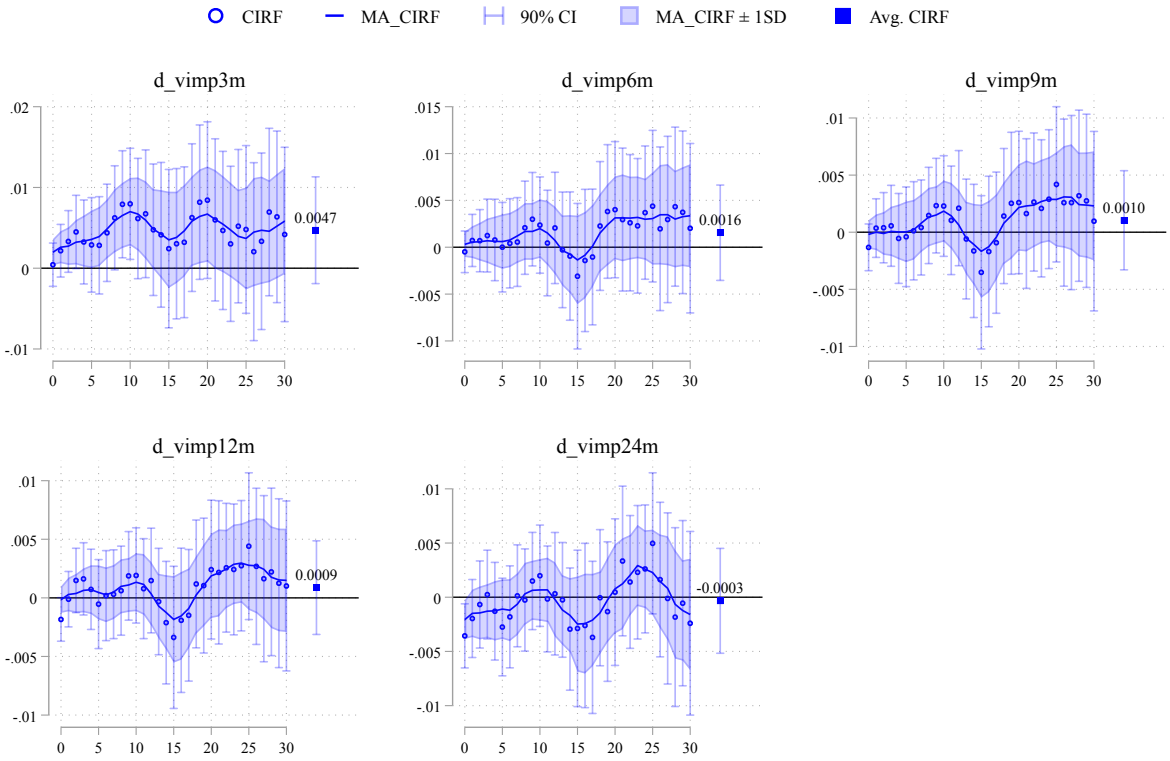
Notes: This figure displays the autocorrelation function (ACF, top panel) and the partial autocorrelation function (PACF, bottom panel) for the daily NDF net flows. The gray shaded areas represent the 95% confidence intervals. The horizontal axis indicates the lag length in days.

Figure A2: Dynamic Impact of Non-Resident NDF Flows on Exchange Rate Dynamics



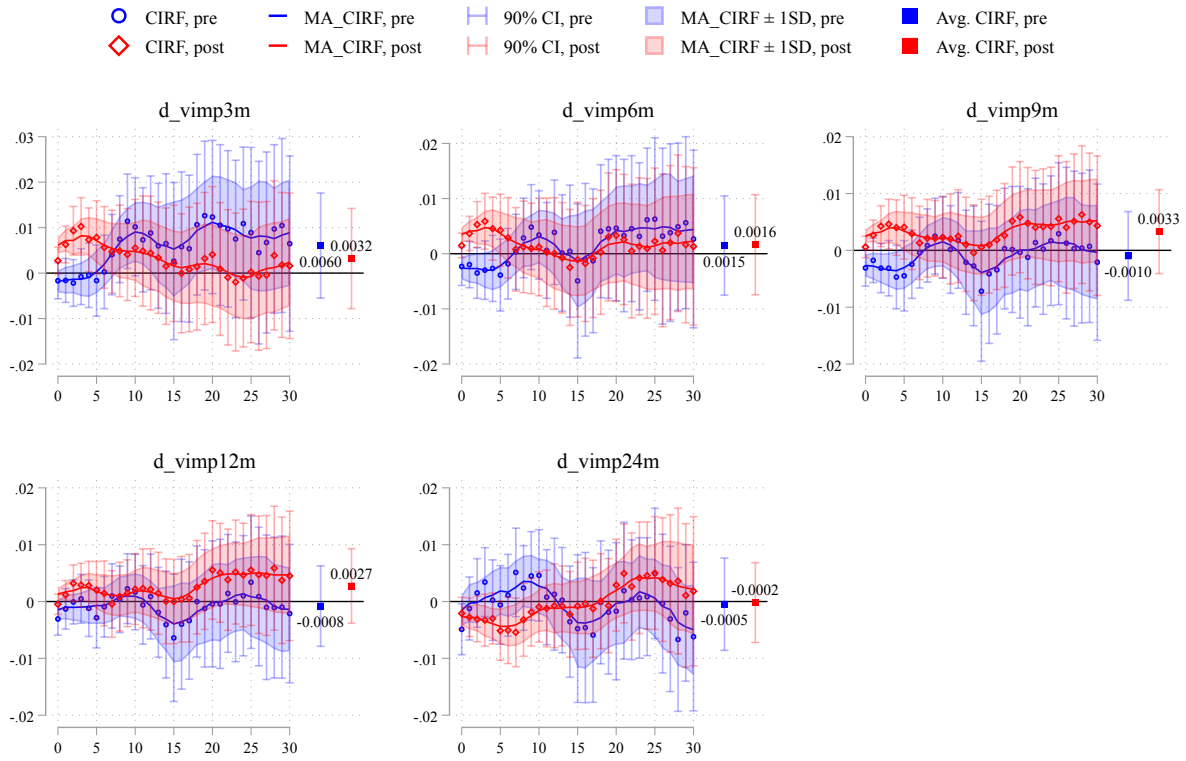
Notes: The figure displays the estimated dynamic response coefficients obtained from local projections for horizons $h = 0$ to $h = 30$ days following a shock to net non-resident NDF flows, according to equation (2). The panels illustrate the response of the daily exchange rate depreciation (d_fx), EWMA volatility (d_ewma), bid-ask spread (d_bid_ask), and intraday standard deviation (d_std_fx). In each panel, blue circles denote the point estimates for each specific horizon, accompanied by vertical bars representing the 90% confidence intervals based on robust standard errors. The solid blue line depicts a centered 5-day moving average of these coefficients to highlight the trend, with the surrounding shaded area indicating the moving average plus/minus one standard deviation. The numeric value reported on the right of each plot corresponds to the average effect over the full 30-day period.

Figure A3: Dynamic Impact of Non-Resident NDF Flows on Implied Volatility Measures



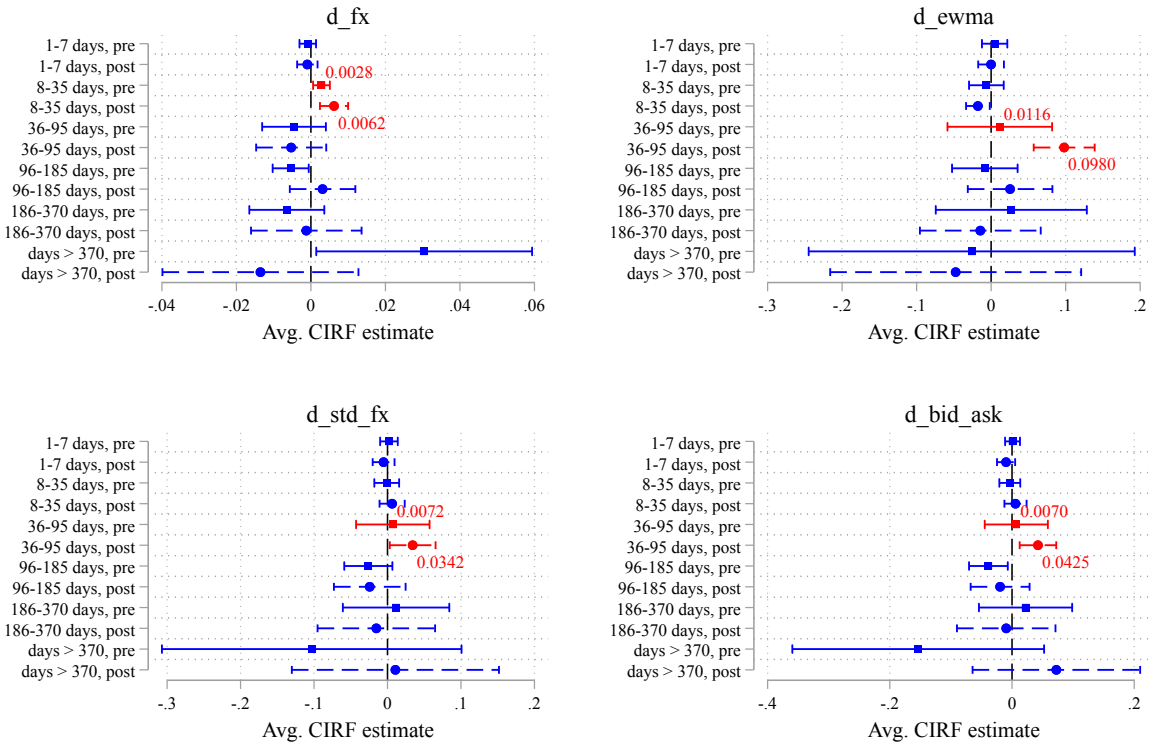
Notes: The figure displays the estimated dynamic response coefficients obtained from local projections for horizons $h = 0$ to $h = 30$ days following a shock to net non-resident NDF flows, according to equation (2). The panels illustrate the dynamic response of FX implied volatility across varying option maturities: 3 months (d_vimp3m), 6 months (d_vimp6m), 9 months (d_vimp9m), 12 months ($d_vimp12m$), and 24 months ($d_vimp24m$). In each panel, blue circles denote the point estimates for each specific horizon, accompanied by vertical bars representing the 90% confidence intervals based on robust standard errors. The solid blue line depicts a centered 5-day moving average of these coefficients to highlight the trend, with the surrounding shaded area indicating the moving average plus/minus one standard deviation. The numeric value reported on the right of each plot corresponds to the average effect over the full 30-day period.

Figure A4: Heterogeneous Dynamics Impact of Non-Resident NDF Flows on FX Implied Volatility: Pre- and Post-Third Pension Fund Withdrawal



Notes: The figure displays the cumulative impulse response functions (CIRFs) estimated from the state-dependent local projections model (equation (3)) over a 30-day horizon following a shock to net non-resident NDF flows. The panels illustrate the dynamic response of FX implied volatility across varying option maturities: 3 months (*d_vimp3m*), 6 months (*d_vimp6m*), 9 months (*d_vimp9m*), 12 months (*d_vimp12m*), and 24 months (*d_vimp24m*). The estimation distinguishes between two structural regimes: the period prior to the third pension fund withdrawal approval in April 2021 (blue series) and the period following it (red series). In each panel, the hollow blue circles and red diamonds represent the point estimates for each horizon for the pre- and post-event periods respectively, with vertical bars indicating the 90% confidence intervals based on robust standard errors. The solid lines depict the centered 5-day moving average of the coefficients to highlight the trend in each regime, while the surrounding shaded areas indicate the moving average plus/minus one standard deviation. The numeric values reported on the right correspond to the average cumulative effect over the full 30-day period for each regime.

Figure A5: Average Cumulative Impact of NDF Flows on FX Dynamics Across Maturities: Pre- and Post-April 2021



Notes: The figure displays the estimated average Cumulative Impulse Response Functions (CIRF) over a 30-day horizon obtained from local projections, according to equation (3). The coefficients are reported for each NDF maturity bucket, distinguishing between the period prior to April 2021 ("pre") and the period starting from April 2021 ("post"). The panels illustrate the response of four exchange rate metrics: daily depreciation (d_fx), EWMA volatility (d_ewma), intraday standard deviation (d_std_fx), and bid-ask spread (d_bid_ask). In each panel, the blue dots represent the point estimates, while the horizontal blue bars indicate the 90% confidence intervals based on robust standard errors.

Table A3: Nonlinear Average Cumulative Impact of Non-Resident NDF Flows on Implied Volatility Metrics (30-Day Horizon)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	d_vimp 3M		*d_vimp* 6M		*d_vimp* 9M		*d_vimp* 12M		*d_vimp* 24M	
d_ndf	0.00519	0.00515	0.00203	0.00427	0.00140	0.00494	0.00113	0.00424	-0.000162	0.00195
	(0.00412)	(0.00598)	(0.00313)	(0.00474)	(0.00267)	(0.00384)	(0.00247)	(0.00341)	(0.00299)	(0.00379)
d_ndf_2	0.0167**	0.0245**	0.0153**	0.0202**	0.0114**	0.0146**	0.00833*	0.00966	0.00562	0.00240
	(0.00827)	(0.0104)	(0.00643)	(0.00793)	(0.00547)	(0.00675)	(0.00489)	(0.00590)	(0.00550)	(0.00727)
d_ndf Pct 5	-0.5059	-0.5845	-0.5059	-0.5845	-0.5059	-0.5845	-0.5059	-0.5845	-0.5059	-0.5845
d_ndf Pct 25	-0.1812	-0.1931	-0.1812	-0.1931	-0.1812	-0.1931	-0.1812	-0.1931	-0.1812	-0.1931
d_ndf Pct 50	0.0082	0.0110	0.0090	0.0110	0.0090	0.0110	0.0090	0.0110	0.0090	0.0110
d_ndf Pct 75	0.1881	0.2213	0.1881	0.2213	0.1881	0.2213	0.1881	0.2213	0.1881	0.2213
d_ndf Pct 95	0.4811	0.5662	0.4811	0.5662	0.4811	0.5662	0.4811	0.5662	0.4811	0.5662
CIRF Pct 5	-0.0117	-0.0235**	-0.0135**	-0.0193**	-0.0101*	-0.0121*	-0.0073	-0.0071	-0.0058	-0.0009
CIRF Pct 25	-0.0009	-0.0043	-0.0035	-0.0035	-0.0027	-0.0007	-0.0019	0.0005	-0.0022	0.0010
CIRF Pct 50	0.0055	0.0057	0.0023	0.0047	0.0016	0.0053	0.0013	0.0045	-0.0001	0.0020
CIRF Pct 75	0.0115**	0.0160*	0.0078*	0.0132*	0.0057	0.0114*	0.0043	0.0085*	0.0020	0.0030
CIRF Pct 95	0.0213**	0.0329**	0.0167**	0.0271**	0.0123**	0.0215**	0.0091*	0.0152*	0.0052	0.0047
Sample	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021	Full	Post PFW Apr 2021
Observations	2,451	885	2,453	885	2,453	885	2,453	885	2,453	885
Lags	6	6	4	4	4	4	4	4	4	4
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports the estimated coefficients for the average cumulative impulse response function (CIRF) over a 0 to 30-day horizon, derived from the nonlinear local projections model (augmented equation (2)). The independent variables include the daily net NDF flow of non-residents (*d_ndf*) and its quadratic term (*d_ndf_2*), both measured in billions of USD. Odd-numbered columns present estimates for the full sample period, while even-numbered columns restrict the sample to the period following the third pension fund withdrawal (post-April 2021). The middle panel displays the distribution of the daily net NDF flow variable at selected percentiles. The lower panel reports the estimated average cumulative response evaluated at each of these flow percentiles. All specifications include the full set of control variables detailed in Table A2. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.