Beyond Carry Trades: Tax-Induced FX Overhedging and Macroprudential Responses in Brazil

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Abstract

We examine a critical case of regulatory arbitrage in the Brazilian banking sector, where a tax asymmetry created incentives for overhedging foreign currency risk. We demonstrate how this tax distortion, which exempted foreign investments from taxation while taxing the financial hedge, led banks to take on excessive hedge positions. The overhedge is a form of carry trade. Therefore, it influenced foreign exchange (FX) market dynamics and posed a significant challenge to financial stability. Our empirical analysis reveals that banks exploited this regulatory loophole to generate near-risk-free profits, contributing to heightened systemic risk.

To explore the broader macroeconomic consequences, we develop a two-country, open-economy model that integrates financial frictions and the observed tax distortion. The model shows that such overhedging activities amplify macroeconomic volatility, intensify the impact of financial shocks, and worsen exchange rate depreciations during crises.

We also use the model to assess the effectiveness of policy responses, such as FX interventions and macroprudential measures. Our results indicate that central bank interventions in the FX market can mitigate the adverse effects of overhedging by stabilizing the exchange rate and reducing welfare losses. Therefore, we provide important insights for policymakers regarding the design of prudential regulations and the importance of a coherent tax framework to prevent regulatory arbitrage and safeguard financial stability. The paper contributes to the literature on banking regulation, systemic risk, and the role of policy (FX) interventions in emerging markets.

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1. Introduction

The interaction between financial regulation, exchange rate dynamics, and macroprudential policy has long been a central issue in international finance. In emerging economies, where financial markets are more vulnerable to external shocks, regulatory distortions can create unintended incentives that amplify systemic risk and exchange rate volatility. This paper examines one such case: how a tax-induced asymmetry in Brazil's financial system led domestic banks to engage in excessive foreign exchange hedging (Banks' Overhedge), distorting capital flows and creating systemic risks.

Let us explain the problem. When banks have foreign investments, their values in domestic currency (the BRL, Brazilian real) vary with the exchange rate. Therefore, if a bank wants to stabilize the foreign investments' values in BRL, it must enter into a hedge. In this case, the hedge is a US dollar futures sale, which is a form of carry trade. Of course, what matters is the after-tax result of the hedge, and that is where the tax distortion comes into play.

Until June 2020, changes in the value (denominated in domestic currency, BRL) of net foreign investments in subsidiaries and branches abroad (denominated in USD) due to fluctuations in the exchange rate were not taxed, whereas gains and losses from hedge instruments were subject to taxation and future tax deductions (in the form of tax credits), respectively. As we will carefully show, this differential treatment created the need for banks to establish hedge positions larger than would be necessary under a neutral tax regime, i.e., one that consolidated both positions into one "bundle" and taxed only the variations on the aggregate (zero for a total hedge). Such behavior amplified exchange rate fluctuations and increased systemic risk.

The first contribution of this paper is to document and quantify the extent of overhedging by Brazilian banks. Our empirical results show that banks systematically increase their foreign investments and hedge positions in response to higher interest rate differentials [1] and lower exchange rate

[1] As will be argued below, this enables banks to earn near risk-free profits through carry trades.

volatility. This finding indicates that banks exploit the tax asymmetry for near-risk-free profits. Thus, we provide robust evidence that the overhedge was not just a defensive strategy, but also a financial opportunity leveraged by banks.

We then develop a two-country DSGE model with financial frictions, which captures the overhedging mechanism, to evaluate its effects on the real economy. The model reveals that overhedge not only exacerbates financial instability but also intensifies the effects of external shocks and exchange rate volatility. Regulatory measures that address tax asymmetry can reduce systemic risks and enhance financial stability. Therefore, our paper contributes to the literature on macroprudential policies, exchange rate interventions, and the determination of the exchange rate and its volatility.

The literature on carry trades shows that it is prone to sudden unwinding during periods of reduced risk appetite and funding liquidity, leading to sharp currency depreciations and contributing to systemic instability (Brunnermeier et al. [1], Caballero and Doyle [2]). The overhedge, by enabling banks to accumulate higher carry trade volumes, intensifies those FX movements, amplifying economic downturns and making FX interventions a necessary macroprudential tool. These results contribute to the broader discussion on the unintended consequences of financial regulation and the role of central banks in mitigating systemic risks.

A well-developed branch of the literature studies the role of macroprudential regulation in mitigating systemic risks in the financial sector. Surveys such as Brunnermeier et al. [3] highlight how financial institutions engage in risk taking beyond what is socially optimal, often exacerbated by regulatory loopholes and incentive misalignments. Adrian and Shin [4] demonstrated theoretically how financial intermediaries' balance-sheet dynamics amplify systemic risk and, complementing these insights, Borio [5] and Farhi and Tirole [6] emphasize the need for regulatory frameworks that explicitly account for the endogenous nature of financial instability.

This paper contributes to this literature by showing how a tax asymmetry, rather than traditional credit supply frictions, led to an increase in aggregate banking risk. This mechanism is closely related to the literature on regulatory arbitrage Acharya et al. [7] and complements the findings of Hanson et al. [8], who argue that capital regulation alone may not sufficiently mitigate risk if institutions find alternative channels to engage in risk taking.

A growing literature assesses how foreign-exchange (FX) interventions stabilize exchange rates and financial markets, especially in emerging economies.

Most empirical studies have found that central bank interventions are somewhat effective in influencing the level of the dollar (Chamon et al. [9]; Kohlscheen and Andrade [10]; Nedeljkovic and Saborowski [11]), although estimates of their impacts vary considerably. For instance, after an intervention of USD 1.0 billion by the BCB, the estimated effect on the dollar exchange rate ranges from 0.3 p.p. (Walker et al. [12]) to 1.5 p.p. (Nedeljkovic and Saborowski [11], Ferreira et al. [13]).

Consistent with this evidence, Fratzscher et al. [14] show, using data for 33 countries, that FX interventions tend to be effective in smoothing exchange-rate fluctuations across a wide range of regimes. However, other papers employing different empirical strategies have not found a significant impact of such interventions, as documented by Meurer et al. [15].

With regard to the effects on the volatility of the exchange rate, the empirical findings are less consistent. Oliveira and Plaga [16] and Nogueira [17] suggest that foreign exchange interventions may reduce volatility, while Chamon et al. [9] provide inconclusive evidence. In contrast, Moura et al. [18] conclude that interventions tend to increase exchange rate volatility.

Recent studies by Gabaix and Maggiori [19] and Itskhoki and Mukhin [20] built theoretical models showing that interventions can be effective when financial frictions prevent markets from fully arbitraging currency movements. Our paper contributes to this discussion by analyzing a unique case where FX interventions were used not just for short-term exchange rate stabilization but as a tool to mitigate the unwinding of a tax-induced distortion in banks' hedge positions.

The theoretical underpinnings of exchange rate determination date back to the Mundell-Fleming model (Mundell [21]; Fleming [22]) and its modern extensions incorporating uncovered interest parity (UIP) deviations (Fama [23]; Engel [24]). More recent models, such as Gabaix and Maggiori [19], emphasize the role of financial intermediaries in shaping exchange rate dynamics, challenging the traditional view that currency movements are purely driven by fundamentals.

We contribute to this literature by introducing a financial-sector-specific friction — limited FX risk taking and the overhedge induced by tax asymmetries — into an open-economy DSGE model. This aligns with the work of Bruno and Shin [25] that presented empirical evidence linking monetary policy, capital flows, and risk-taking behavior by financial intermediaries to increased exchange rate volatility and Devereux et al. [26], who show that collateral constraints can significantly impact exchange rate movements. Our model demonstrates how the presence of overhedging increases exchange rate volatility by magnifying the response of financial institutions to carry trade incentives and how the excessive overhedging in the financial sector can amplify external shocks.

By combining a DSGE model with empirical analysis, our study highlights how financial-sector policies and tax rules interact with exchange rate dynamics, shaping monetary and macroprudential outcomes. These insights are critical for policymakers designing regulatory frameworks that minimize systemic risk while ensuring exchange rate stability.

The structure of this paper is as follows. Section 2 provides an institutional background on the Brazilian banking sector and the regulatory framework governing FX operations. Section 3 presents empirical evidence on the prevalence and determinants of overhedge, using data on Brazilian banks' foreign investments and derivative positions. Section 4 develops the theoretical model and explores its implications for exchange rate dynamics and macroeconomic stability. Section 5 presents stylized facts and shock simulations and Section 6 concludes.

2. Regulatory Framework

Foreign investments are inherently exposed to exchange rate fluctuations, as they must be converted into domestic currency for financial reporting. As a result, such movements create balance sheet gains or losses, prompting institutions to adopt hedging strategies to mitigate these effects.

Until June 2020, Brazilian tax regulations treated net foreign investments [2] differently from their associated hedging instruments. Specifically, exchange rate variations in these foreign investments were exempted from taxation, whereas losses (gains) of the hedging instrument were deductible (taxed). This asymmetric tax treatment incentivized Brazilian banks to adopt a practice known as "*overhedge*", where hedging volumes exceeded their foreign investment exposure, as it is explained in the next Section.

[2] Investments abroad, according to the definition of CMN Resolution 4.817, dated May 29, 2020, include holdings abroad in controlled entities, affiliates, and jointly controlled entities with other entities. This concept includes investments in overseas branches (agencies), which are treated, both from an accounting and tax perspective, as holdings.

2.1. Illustration of the Tax Distortion

Consider a simplified scenario where a domestic bank initially holds R$900 in household deposits, has a net worth of R$100, and invests R$1000 in a foreign branch at an exchange rate of R$2 per USD. Table 1 summarizes this initial situation on a fictitious balance sheet:

Domestic Bank Balance Sheet			
Assets		**Liabilities & Equity**	
Foreign Investments	R$ 1000	Deposits	R$ 900
		Net worth	R$ 100
Hedge Volume: R$1000 (Off-balance)			

Table 1: Simulated initial balance sheet.

In each case, we will consider a case in which the Brazilian exchange rate depreciates to R$ 4.00 and another in which it appreciates to R$ 1.00 for each US dollar. We first assume that there are no taxes (Table 2). As there is no distortion, the bank follows one of the main premises of a hedge structure: the value equivalence between the foreign investment and the hedge instrument.

Under depreciation, the value of the foreign investment increases by R$1000, offset by an equivalent loss on the hedge. Under appreciation, the value of the foreign investment decreases by half, offset by a corresponding gain on the hedge instrument. In both scenarios, the bank's net worth remains unaffected, exemplifying the mechanism by which hedge strategies operate.

Now, suppose that the hedge result is taxed by 50% but the bank does not adapt its hedging strategy (Table 3). In the scenario in which the BRL appreciates, the bank loses R$ 500 with its foreign investment, but gains R$ 500 with the hedge instrument. However, it must pay R$ 250 in taxes, meaning that its net worth would even become negative. The depreciation scenario shows a similar logic, but instead of a tax to be paid, the bank earns a tax credit to be deducted from future profits. This case illustrates the necessity for the bank to adjust its hedge strategy due to the tax distortion: if it does not, it is not fully protected against FX movements and can even become insolvent.

Now, suppose that the bank adjusts its hedging strategy and doubles its volume. This adjustment is sufficient to ensure that the bank is fully protected against FX variations, as shown in Table 4.

Domestic Bank Balance Sheet			
BRL Appreciates 50%			
Assets		**Liabilities & Equity**	
Foreign Investments	R$ 500	Deposits	R$ 900
Tax Credit	-	Taxes due	-
Hedging Gains	R$ 500	Hedging Losses	-
		Net worth	R$ 100
BRL Depreciates 100%			
Foreign Investments	R$ 2000	Deposits	R$ 900
Tax Credit	-	Taxes due	-
Hedging Gains	-	Hedging Losses	R$ 1000
		Net worth	R$ 100

Hedge Volume: R$1000 (Off-balance)

Table 2: FX Scenarios without taxes.

It is possible to show this dynamic algebraically. Suppose τ_h and τ_f is the tax rate levied on gains or losses in the hedge and the foreign investment respectively. The objective is to both tax adjusted results offset each other:

$$(1-\tau_h)\Delta(\text{Hedge Volume}) \approx (1-\tau_f)\Delta(\text{Foreign Inv Value})$$

Supposing that the all the variation from one period to the other is related to exchange rate movements, its possible to approximate the previous equation as follows:

$$\text{Hedge Volume} \approx \frac{(1-\tau_f)}{(1-\tau_h)} \text{ Foreign Inv Value} \tag{1}$$

If we consider, as the example above, that $\tau_f = 0$ and $\tau_h \approx 0.5$, the hedge volume must be equivalent to twice the foreign branch value.

Finally, Table 5 shows how the simulated balance must behave with both the hedge instrument and the foreign investment being taxed. Any tax credit in the foreign investment or in the hedge instrument is perfectly balanced by a tax due, meaning that doing the same hedge volume as the foreign investment is enough to fully protect the balance sheet from exchange rate variations. This is easily seen in Equation (1) by setting $\tau_f = \tau_h = 0.5$.

Domestic Bank Balance Sheet			
BRL Appreciates 50%			
Assets		**Liabilities & Equity**	
Foreign Investments	R$ 500	Deposits	R$ 900
Tax Credit	-	Taxes due	R$ 250
Hedging Gains	R$ 500	Hedging Losses	-
		Net worth	-R$ 150
BRL Depreciates 100%			
Foreign Investments	R$ 2000	Deposits	R$ 900
Tax Credit	R$ 500	Taxes due	-
Hedging Gains	-	Hedging Losses	R$ 1000
		Net worth	R$ 600

Hedge Volume: R$1000 (Off-balance)

Table 3: FX scenarios with hedge being taxed but the bank does not adjust its hedge structure.

Domestic Bank Balance Sheet			
BRL Appreciates 50%			
Assets		**Liabilities & Equity**	
Foreign Investments	R$ 500	Deposits	R$ 900
Tax Credit	-	Taxes due	R$ 500
Hedging Gains	R$ 1000	Hedging Losses	-
		Net worth	R$ 100
BRL Depreciates 100%			
Foreign Investments	R$ 2000	Deposits	R$ 900
Tax Credit	R$ 1000	Taxes due	-
Hedging Gains	-	Hedging Losses	R$ 2000
		Net worth	R$ 100

Hedge Volume: R$2000 (Off-balance)

Table 4: FX scenarios with hedge being taxed and the bank adjusting its hedge structure.

In summary, the overhedge arises from the different tax rates on the two components of the "bundle": the foreign investment and the offsetting FX hedge. If both legs were taxed at the same rate, the overhedge, a carry trade, would not exist.

Domestic Bank Balance Sheet			
BRL Appreciates 50%			
Assets		**Liabilities & Equity**	
Foreign Investments	R$ 500	Deposits	R$ 900
Tax Credit	R$ 250	Taxes due	R$ 250
Hedging Gains	R$ 500	Hedging Losses	-
		Net worth	R$ 100
BRL Depreciates 100%			
Foreign Investments	R$ 2000	Deposits	R$ 900
Tax Credit	R$ 500	Taxes due	R$ 500
Hedging Gains	-	Hedging Losses	R$ 1000
		Net worth	R$ 100

Hedge Volume: R$1000 (Off-balance)

Table 5: FX scenarios with hedge being taxed and the bank adjusting its hedge structure.

2.2. Carry Trade and Other Risks

So far, we have ignored one important facet of the overhedge: As the bank needs to be protected against variations in foreign currencies, it borrows externally (to short-sell the US dollar) and invests domestically, i.e., it does the carry trade. This is actually done through the sale of US dollar futures in the domestic exchange B3.[3] If the domestic interest rate is higher than the foreign interest rate, the banks earn the interest rate differential. Due to its foreign investment, the bank is fully protected against FX variations. This

[3]B3 S.A. – Brasil, Bolsa, Balcão is the main stock and derivatives exchange and fixed-income and OTC clearing/depository system in Brazil. The referred contract can be found in the link https://www.b3.com.br/en_us/products-and-services/trading/exchange-rates/u-s-dollar-futures.htmhttps://www.b3.com.br/en_us/products-and-services/trading/exchange-rates/u-s-dollar-futures.htm.

means that the overhedge allows banks to conduct a carry-trade operation without incurring additional FX risk.

Suppose that there is an equivalence between the foreign investment and hedge volume. Although the bank can earn the interest rate differential in the hedge, it lost an equivalent value in the foreign investment (the bank borrowed domestically to invest abroad, so it pays the interest rate differential in this side of the operation). As shown in the Table 4, the tax distortion allows the bank to double its carry trade volume without incurring any FX risk, generating an almost risk-free profit.

However, the overhedge creates other risks. The first significant risk is that, in the event of a strong depreciation, it might generate tax credits exceeding the bank's recurring profits, which means it cannot be immediately utilized. Consequently, these credits must be carried forward and realized in future periods - just like an illiquid asset.

The second issue arises from a mismatch between the liquidity of foreign investments and their corresponding hedging instruments. If the exchange rate depreciates sharply, banks may face liquidity constraints when required to cover losses on their hedging instruments. This is particularly relevant because most banks use derivative contracts, i.e., they sell USD futures at the B3 exchange, that require daily settlement, whereas foreign investments, such as overseas branches, cannot be liquidated immediately.

There is also a macroprudential dimension related to this liquidity risk. During periods of high market stress, a bank may be forced to divest from its foreign branches at a loss to meet capital requirements or to meet margin calls on other investments. With the overhedge, the bank also needs to unwind it by buying dollars in the open market[4]. This increased demand for foreign currency places additional pressure on the FX market, potentially creating a negative feedback loop that exacerbates currency depreciation, increases market volatility and margin calls.

In summary, through the act of overhedging, banks significantly amplifies the risks of the carry trade, resulting in an exaggerated impact on market behavior.

[4]The central portion of the hedge is offset by the USD proceeds from the divestment of the overseas branch.

2.3. Overhedge Correction

This scenario unfolded precisely in the aftermath of the 2020 pandemic. The Brazilian exchange rate depreciated sharply as investors sought safer assets - an effect linked to the concept of "exorbitant duty" described by ([27]) - and the interest rate differential between Brazil and the United States reached historically low levels, reducing the attractiveness of carry-trade operations. Consequently, Brazilian banks rapidly began to disinvest in their foreign branches. According to the Central Bank of Brazil's report ([28]), there was a 28.9% reduction in such investments in the second quarter of 2020 alone.

Recognizing the overhedge harmful consequences, the Brazilian government issued Provisional Measure (MP) 930 on March 30, 2020 to rectify this imbalance. This measure, later converted into law, progressively aligned the fiscal treatment of foreign investment exchange rate fluctuations with their corresponding hedging instruments. The adjustment was gradually implemented, with half of the correction applied at the end of 2020 and the remainder by the end of 2021.

The main reason behind this staggered implementation was the concern that immediate unwinding of excessive hedging positions by banks would precipitate substantial dollar purchases in both spot and futures markets, intensifying pressure on an already strained foreign exchange market, particularly during year-end dividend repatriation periods.

The implications of this unwind sparked significant concern among Brazilian Central Bank (BCB) officials. For instance, on November 18, 2020, the BCB's Director of Monetary Policy, Bruno Serra, explicitly stated: "The Central Bank has never denied that this volume—approximately USD 15 billion, scheduled for execution at year's end—is substantial. There exists a genuine risk that the market lacks the depth or capacity to absorb it adequately. [...] If we perceive market functionality to be compromised due to insufficient absorption capacity, the Central Bank will intervene to ensure stability. Such an intervention should be anticipated and is consistent with our mandate."

These concerns were materialized into concrete actions. In December 2020, the Central Bank intervened significantly by offering approximately USD 10 billion in exchange rate swap contracts, effectively absorbing two-thirds of the excess demand originated from closing the short USD positions necessary to undo the overhedge.. A similar intervention occurred at the end of 2021, supplemented by additional direct spot market sales totaling USD 4.8 billion.

In the empirical analysis that follows, we demonstrate how banks responded directly to incentives arising from the overhedge phenomenon that affected their foreign investment strategies. Subsequently, our theoretical model further elucidates the interconnectedness of regulatory frameworks, financial incentives, and macroeconomic factors, illustrating how these dimensions collectively influence conditions in Brazil's foreign exchange market.

3. Empirical Evidence

Understanding the impact of the overhedge on financial markets and the economy requires an empirical investigation into how banks adjust their foreign investment and how large is the overhedge compared to the whole market. This section presents key stylized facts and supporting evidence that illustrate the role of overhedge in exchange rate dynamics.

The first fact regarding the overhedge is the increase in size over time, shown in Figure 1. According to [28], "Brazilian financial institutions (IFs), aiming to serve their clients with global financial products and services, expand their international presence, and access new markets, make investments in international financial centers through the establishment of branches, subsidiaries, and equity participations in other companies.".

At the end of 2019, this foreign investment was close to USD 60 billion, but rapidly fell by a third as the 2020 pandemic hit, triggering a significant market disruption (risk off) known as the dash for cash, which negatively affected all risky investors. The BRL had a major depreciation. Contrasting this with the exchange rate open contracts in the spot and future markets shows its importance: in March of 2020, this total volume was close to USD 200 billion. In a first glimpse, the overhedge might not be so representative. However, any strategic repositioning of the banks opens up large contracts in a highly sensitive market.

For example, according to the COSIF database, Bradesco Bank reduced its foreign investment by 6 billion dollars in April 2020 and by 7 billion dollars during May 2020. This implies that it should have bought a similar amount of US dollars to reduce the extra hedge volume. To put this into perspective, the literature found that a 1 billion USD intervention by the Brazilian Central Bank leads to a range of 30bps-150bps appreciation in the Brazilian exchange rate; assuming a symmetric effect is enough to highlight

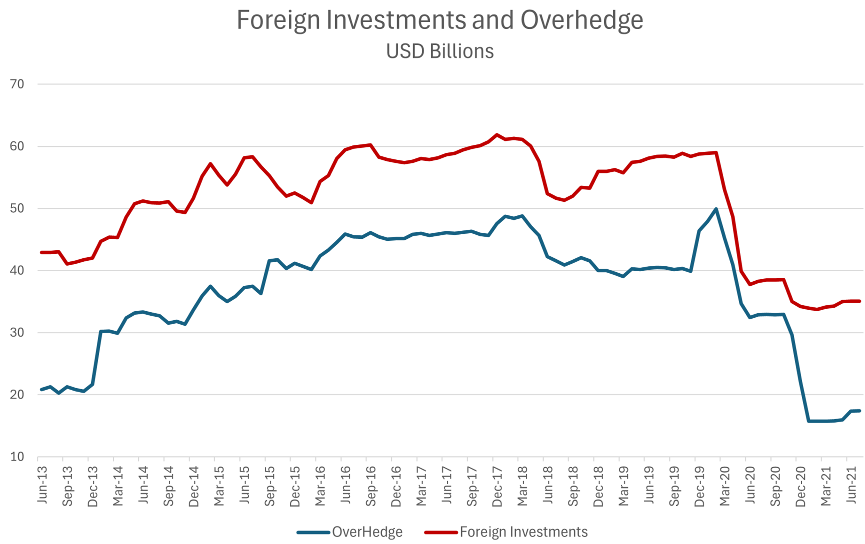

Figure 1: Aggregate foreign investments of Brazilian financial institutions (USD billions). The figure highlights the steady expansion of banks' international presence prior to 2020 and the sharp contraction during the COVID-19 crisis, reflecting a rapid unwinding of foreign positions amid heightened financial stress. Source: *Central Bank of Brazil, Financial Stability Report.*

the important role the overhedge could play in determining the exchange rate. [5]

3.1. Overhedging as a Profitable Strategy for Banks

We want to investigate if banks actually strategically use the overhedge to collect extra profits, instead of just to hedge their foreign investments. If banks act strategically, they would increase their equity position in their branches abroad, only to ship the funds back to Brazil and make use of the overhedge to double the amount of the carry trade, without being penalized by the FX gap. To show that the banks actually exploit the overhedge to make an almost risk-free profit, we estimate a panel with monthly data for

[5] As one might imagine, there is little reason to the Central Bank to buy foreign exchange rate if the markets are tight, as it were during the COVID crisis. Thus, there is no better estimate for this effect. However, it is not absurd to assume that buying dollars in moment of stress could depreciate the exchange rate more than the appreciation caused by selling dollars by a Central Bank.

foreign investments from the BCB's COSIF database. We cover the period from August 2006 to September 2024 and limit our sample to banks with more than 1 billion BRL invested abroad [6] This is assumed to include a good sample while keeping the panel balanced.

We employ two key explanatory variables: the interest rate differential and the one-year implied volatility derived from the USD dollar futures market at the B3 exchange. Our identification strategy exploits variation in these variables to distinguish between competing hypotheses regarding banks' foreign investment behavior. Under the hypothesis that banks strategically exploit overhedging positions to engage in carry trade activities, we expect the interest rate differential to exert a positive and statistically significant effect on foreign investments. Conversely, if banks' foreign asset allocations are instead driven by client preferences and long-term strategic considerations—rather than opportunistic carry trade motives—the interest rate differential should exhibit no systematic relationship with foreign investment positions, conditional on our control variables.

Without overhedge, as the bank hedges its foreign investments, we should also expect no significant effect from the volatility of the FX, for the same reason expressed above. However, with the risks associated with the overhedge, this should not be the case.

To show robustness to our result, we use some common controls found in the literature, such as the VIX index, the relative strength of the US dollar, measured by the Broad Dollar Index, and the 5-year Brazilian CDS. We also add banks' fixed effects to capture inherent differences (a bank might have a higher-profile clients such that they demand a foreign branch instead of only the desire to exploit the overhedge) and quarter FE and year FE to capture macroeconomic shocks, trends, and policy changes.

Thus, we estimate Equation (2), where ΔFI_{it} is the log-variation of the foreign investment, $\Delta(i - i^{*})_t$ is the variation of the interest rate, ΔFXVol_t is the variation in the one-year exchange rate volatility, Overhedge_t is the overhedge implicit volume given by $\frac{1}{1-TaxRateDiff_t} - 1$, where $TaxRateDiff$ is the tax rate differencial between the hedge instrument and the foreign investment. For example, if the hedge is taxed by 50% and the FI is not

[6] The selected banks are Santander (Brasil) S.A., Bradesco S.A., Banco do Brasil S.A., BTG Pactual, Banco ABC Brasil S.A., Banco Votorantim S.A., Credit Suisse (Brasil), Banco Safra S.A., Banco BBM S.A. and Banco Itau.

Table 6: Regressions to model the rate of change of the Brazilian Banks' foreign investment (denominated in US Dollars).

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0053**	0.0219*	0.0080	0.1849***	0.0083	0.1928***
	(2.093)	(1.904)	(1.339)	(2.752)	(1.373)	(2.833)
$\Delta(i_t - i_t^*)$	0.0236	0.0091	-0.1000*	-0.0942	-0.0991*	-0.0892
	(0.903)	(0.274)	(-1.809)	(-1.532)	(-1.791)	(-1.446)
Δ FX Volatility	-0.0963***	-0.0983***	-0.0068	-0.0296	-0.0078	-0.0300
	(-13.079)	(-12.655)	(-0.188)	(-0.756)	(-0.215)	(-0.763)
Overhedge (%)	-	-	-0.0030	-0.2796**	-0.0034	-0.2929**
	-	-	(-0.352)	(-2.449)	(-0.401)	(-2.525)
Δ $(i_t - i_t^*)$ x Overhedge	-	-	0.2053**	0.1849*	0.1943**	0.1722*
	-	-	(2.45)	(1.9)	(2.29)	(1.741)
Δ FX Volatility x Overhedge (%)	-	-	-0.1201**	-0.0903*	-0.1209**	-0.0927*
	-	-	(-2.545)	(-1.781)	(-2.539)	(-1.818)
Δ Log VIX	-	-	-	-	-0.0008	-0.0089
	-	-	-	-	(-0.051)	(-0.533)
Δ Log Broad Dollar	-	-	-	-	-0.0223	0.0107
	-	-	-	-	(-0.094)	(0.042)
Δ Log CDS	-	-	-	-	0.0187	0.0247
	-	-	-	-	(0.693)	(0.87)
Bank Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Fixed Effect	No	Yes	No	Yes	No	Yes
Observations	2130	2130	2130	2130	2130	2130
R-squared	0.075	0.087	0.08	0.093	0.08	0.094

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
t-stats are reported in parentheses.

taxed at all, the overhedge volume is equal to 1, meaning the bank needs to make the double volume of hedge to be fully protected. We also add the interactions between the overhedge volume and both the interest rate differential and FX volatility. Z_t is a set of controllers, μ_i is the bank FE, $YEAR_t$ is the year FE and $QUARTER_t$ is the quarter FE.

$$\begin{aligned}\Delta FI_{it} = \beta_0 + \beta_1 \Delta(i - i^*)_t + \beta_2 \Delta\text{FXVol}_t + \beta_3 \text{Overhedge}_t \\ + \beta_4 [\Delta(i - i^*)_t \times \text{Overhedge}_t] + \beta_5 [\Delta\text{FXVol}_t \times \text{Overhedge}_t] \\ + Z_t + \mu_i + YEAR_t + QUARTER_t + \varepsilon_{it}\end{aligned} \quad (2)$$

The first notable result is that the coefficient associated with FX volatility is significant across all specifications. However, when interacted with the overhedge volume, the interaction term becomes significant, while the standalone FX volatility loses significance. This suggests that higher FX volatility is associated with lower foreign investment only when there is a positive level of overhedging.

This provides strong evidence that, although banks are fully hedged against FX fluctuations, they remain exposed - and responsive - to the risks and rewards associated with overhedging. When the FX future contracts becomes more volatile, the risk of accumulating large tax credits increases, prompting banks to reduce their exposure. In addition, heightened volatility of FX contracts raises the margin requirements in futures markets, increasing the liquidity needed for operations. This second channel reveals how macroprudential risk emerges. As a bank reduces its foreign investments, it adds further volatility to FX markets by creating pricing pressure (BRL depreciation), amplifying the original effect.

The second important result is that the interest rate differential ($\Delta\ (i_t - i_t^*)$) becomes significant in all specifications when it is interacting with the overhedge volume. This indicates that despite the aforementioned risks, banks do exploit the overhedge channel to enhance profits. If that were not the case, the interest rate differential would not be a significant explanatory variable.

In summary, our empirical results show that the amount of the banks ' foreign investments (and, by consequence, of the overhedge) responds to the determinants of the carry trade, the interest rate differential, and the FX volatility. Such behavior would not have happened had the banks invested abroad solely to serve new clients or to explore new foreign markets.

4. Model

Our model adapts the models proposed by ([19]) and ([26]) to incorporate imperfections in financial markets and the role of banks in both domestic and international markers, and is summarized in Figure 2. We consider a two-country setting with a home country displaying the tax distortions related to the overhedge, like Brazil, and the other country representing the rest of the world. The exchange rate is defined as the number of units of domestic currency per unit of foreign currency, implying that a rise in the exchange rate denotes a depreciation of the domestic currency.

Since our focus is on the financial sector, we do not model production. Instead, we assume that the representative household has a period endowment of tradable and non-tradable goods. The households can trade internationally to smooth or increase consumption according to the relative strength of their own currency. A consequence of the endowment economy is that

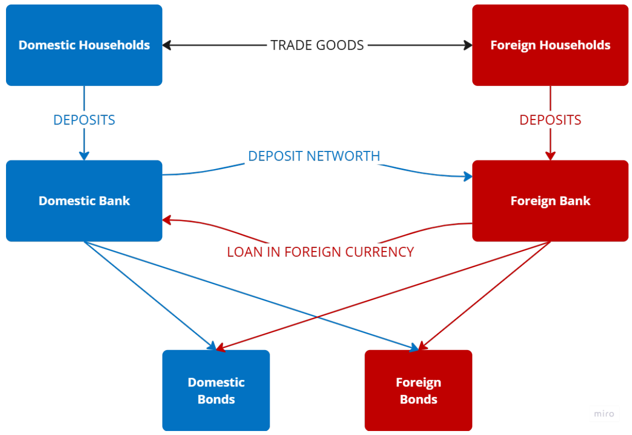

Figure 2: Schematic representation of the model economy, illustrating the interactions between households, domestic and foreign banks, asset markets, and the exchange rate. The model incorporates asymmetric taxation of FX hedging instruments and foreign investments, generating endogenous overhedging and deviations from uncovered interest parity.

an exchange rate depreciation generates a reduction in the amount of goods consumed and consequently a direct loss of welfare.

We assume that the representative households deposit their wealth in the banks of their own country, which in turn allocate their funds across domestic and foreign assets. More specifically, banks can buy domestic and foreign government bonds, while the domestic bank can invest in the equity of the foreign bank, and the foreign bank might lends to the domestic bank.

Our innovation is to introduce a cost for banks that take on exchange-rate risk. Without an institution able to absorb unlimited FX risk, UIP need not hold. However, we show that UIP is recovered under a parameterization in which this risk carries no cost. The model also incorporates the asymmetric tax rates that generates the overhedge.

4.1. Households

We extend the household problem of ([19]) to account for an arbitrary number of periods. The consumption basket is given by

$$C_t = [(C_{NT,t})^{\chi}(C_{H,t})^{a}(C_{F,t})^{\iota}]^{\frac{1}{\chi+a+\iota}}$$

Where C_t is total consumption, $C_{NT,t}$ is the consumption of domestic non-tradables goods, $C_{F,t}$ is the consumption of foreign tradable goods and

$C_{H,t}$ is the consumption of domestic tradable goods. We assume that the non-tradable good is the numeraire of the economy, such that $P_{NT,t} = 1 \ \forall \ t$.

Household solves the following problem:

$$\max_{C_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t ln(C_t)$$

Subject to a sequence of budget constraints:

$$P_{NT,t}Y_{NT,t}+P_{H,t}Y_{H,t}+B_t = R_tB_{t-1}+P_{NT,t}C_{NT,t}+P_{H,t}C_{H,t}+P_{F,t}C_{F,t}+T_t+\Pi_t-T_{s,t} \tag{3}$$

Where $P_{NT,t}$, $P_{H,t}$ and $P_{F,t}$ is the price for non-tradables, domestic and foreign goods respectively. $Y_{H,t}$ and $Y_{NT,t}$ are the domestic endowment of tradables and non-tradables goods, while $C_{H,t}$, $C_{F,t}$ and $C_{NT,t}$ are the consumption of non-tradable, domestic and foreign goods respectively. We also add a tax transfer from the government (T_t), the profit from the domestic banks (Π_t) and the initial startup capital given to the new banks ($T_{s,t}$). Households also save B_t from one period to another.

We assume a symmetric problem to the foreign families.

4.2. Domestic Banks

We model the banks in a similar way as in ([29]). A fraction $(1-\theta)$ of the banks are liquidated every period and their net worth is consumed. New banks also enter every period with some start-up capital from the households.

The bank's problem is to choose how much domestic and foreign bonds to buy, how much to invest in the bank abroad, and how much FX hedge it makes to maximize it's expected terminal wealth, where $(1-\theta)\theta^i$ is the probability that a banker exists in period $t+i$, conditional on having survived until then. $\beta^{i+1}\Lambda_{t,t+1+i}$ is the banker discount factor to a payment in period $t+i$, $N_{i,t+1}$ is the bank's net worth.

In each period, the bank faces the cost of having its net worth mechanically vulnerable to exchange rate variations. If a bank is too much exposed to exchange rate risk, it should either receive less deposits from the household or pay a higher return to them (or both). This kind of reputation damage is incorporated by this cost. Another way to interpret this cost is that the presence of a currency mismatch on the bank's balance sheet may trigger additional capital requirements, thereby reducing profitability or punishments by the regulatory agencies. Consequently, $\frac{\Psi_q}{2}$ is the parameter that controls the cost associated with the banks's FX mismatch, measured by $\frac{\partial N_{i,t+1}}{\partial S_t}$.

$$V_t = \max \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left(N_{i,t+1} - \frac{\Psi_q}{2} \left(\frac{\partial N_{i,t+1}}{\partial S_t} \right)^2 \right)$$

A Home banker i 's balance sheet in period t is described by Equation 4.

$$B_{i,t} + N_{i,t} + S_t H_{i,t} = D_{h,i,t} + S_t F_t + S_t D_{f,i,t} \tag{4}$$

The domestic bank takes $B_{i,t}$ deposits from households, has its own net worth $N_{i,t}$ and can borrow a quantity $S_t H_{i,t}$ abroad. It uses all these liabilities to invest in domestic bonds $D_{h,i,t}$, foreign bonds $D_{f,i,t}$ and in a branch abroad F_t.

In the next period, all assets and liabilities earn their respective returns and the bank settles the associated tax payments, as summarized in Equation 5. Domestic and foreign bond holdings yield the market-determined gross returns $R_{h,t+1}$ and $R_{f,t+1}$, respectively. Household deposits are remunerated at the benchmark domestic interest rate R_{t+1}. The bank pays the foreign borrowing rate $R_{c,t+1}$ on its external debt, while its investment in the foreign branch earns the foreign interest rate R^*_{t+1}.

$$\begin{aligned} N_{i,t+1} = {} & R_{h,t+1} D_{h,i,t} - \tau_h (R_{h,t+1} - 1) D_{h,i,t} + R_{f,t+1} S_t D_{f,i,t} \\ & - \tau_h (R_{f,t+1} - 1) S_t D_{f,i,t} - R_{t+1} B_{i,t} + \tau_h (R_{t+1} - 1) B_{i,t} \\ & - \left(\frac{S_{t+1}}{S_t} R_{c,t+1} \right) S_t H_{i,t} + \tau_h \left(\frac{S_{t+1}}{S_t} R_{c,t+1} - 1 \right) S_t H_{i,t} \\ & + S_{t+1} F_t R^*_{t+1} - \tau_f \left(\frac{S_{t+1}}{S_t} - 1 \right) S_t F_t - \tau_h \frac{S_{t+1}}{S_t} (R^*_{t+1} - 1) S_t F_t \end{aligned} \tag{5}$$

First, we see that the bank pays τ_h in every return with the exception of the exchange rate variation in the branch abroad, where it pays τ_f. This differentiation is exactly the tax distortion that generates the overhedge. We can substitute the deposits from Equation 4 to find the law of motion of the net worth of domestic banks, as in Equation 6.

$$
\begin{aligned}
N_{i,t+1} = {} & (1-\tau_h)(R_{h,t+1}-R_{t+1})D_{h,i,t} + (1-\tau_h)\left(\frac{S_{t+1}}{S_t}R_{f,t+1}-R_{t+1}\right)S_t D_{f,i,t} \\
& -(1-\tau_h)\left(\frac{S_{t+1}}{S_t}R_{c,t+1}-R_{t+1}\right)S_t H_{i,t} \\
& +\left((1-\tau_h)\left(\frac{S_{t+1}}{S_t}R^*_{t+1}-R_{t+1}\right)+(\tau_h-\tau_f)\left(\frac{S_{t+1}}{S_t}-1\right)\right)S_t F_t \\
& +(R_{t+1}-\tau_h(R_{t+1}-1))N_{i,t}
\end{aligned}
\tag{6}
$$

With this expression in hand, we can calculate the exact expression for the cost the bank incurs if it has too much FX risk in Equation 7.

$$
\frac{\partial N_{t+1}}{\partial S_t} = (1-\tau_h)R_{t+1}(H_{i,t}-F_t-D_{f,i,t})-(\tau_h-\tau_f)F_t \tag{7}
$$

The expression $(\tau_h-\tau_f)\left(\frac{S_{t+1}}{S_t}-1\right)$ in the Equation 6 resumes the tax distortion that generates the overhedge. If the tax rate that is levied in the hedge is higher than the tax rate that is levied in the foreign branch, this term amplifies the impact that an exchange rate variation has in the bank's net worth in proportion to the size of the overseas branch.

This expression also generates the extra term in the equation 7. If there is no tax distortion, a hedge volume equal in size to the foreign branch and foreign bonds is enough to eliminate any FX risk. With the distortion, this is not true as the last term does not vanish.

The domestic bank is also subject to a participation constraint that ensures lenders are willing to supply funds to the bank, as given by Equation 8.

$$
\begin{aligned}
V_{k,t} \geq \vartheta_t \Bigg(& \left(\kappa_{h1}+\kappa_{h2}\tilde{D}_{h,t}\right)D_{h,k,t} + \left(\kappa_{f1}+\kappa_{f2}S_t\tilde{D}_{f,t}\right)S_t D_{f,k,t} \\
& + \left(\kappa_{e1}+\kappa_{e2}S_t\tilde{F}_{k,t}\right)S_t F_t \Bigg)
\end{aligned}
\tag{8}
$$

As in ([26]), we introduce a set of asset-specific constraint parameters to allow for differential pledgeability as collateral across assets. Specifically, we have κ_{h1}, κ_{f1}, κ_{e1} and as the constraint parameters for Home bonds, foreign bonds and the foreign branch. [7] Another way to interpret the participation constraint is as in ([29]), where the banker has enough "skin in the game" so that he chooses not to run away with the assets. Then, each parameter κ can be interpreted as the fraction that the banks can divert from each asset.

Finally, ϑ_t indexes global financial conditions. An increase in ϑ_t, interpreted as an adverse global financial shock, tightens the bank's participation constraint by raising the amount of pledgeable assets required for financing by the households.

We posit that holdings of the foreign branch are more constrained than government bonds, and in turn, Foreign bonds holdings are more constrained than Home bonds. The key idea is that domestic government bonds are more pledgeable than foreign equity or bonds because of their safety, liquidity and same country as the bank.

$$F_{i,t} - F_{i,t-1} = \gamma_t + \omega_1 \Delta(i_t - i_t^*) + \omega_2 \Delta\vartheta_t \tag{9}$$

$$\gamma_t = \rho\gamma_{t-1} + \varepsilon_t \tag{10}$$

Following our empirical exercise, we model the rate of change of the foreign branch as a function of the rate of change of the interest rate and the rate of change of the volatility of the exchange rate (Equation 9). We suppose also that the FX volatility is highly correlated with ϑ_t. Although we do not observe ϑ_t, it should become more restrictive in moments of high market stress that is also associated with higher FX volatility.

4.3. Foreign Banks

The foreign banks are modeled in the same fashion as the domestic banks. However, there are some key differences: first, the foreign banks do not pay taxes in the home country. Secondly, as the domestic bank invests in the foreign bank, it can take any amount of loans from the foreign bank. Consequently, although the variable $H_{j,t}$ is present in the foreign bank balance sheet, it is not a decision variable. Foreign banks are not subject to the financial friction we assumed for the domestic bank: they are not punished for

[7] We also introduce κ_{h2},κ_{f2} and κ_{e2} so the constraint depends on the aggregate bank holding of the assets. The idea is that the monitoring cost is increasing with the asset size. We set these parameter values very small (0.025) and the main purpose of these parameters is to introduce stationarity in the linearized model.

assuming FX risk. With those differences in mind, we can write the foreign banks' problem according to equation 11.

$$V_t = max \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda^*_{t,t+1+i} N^*_{j,t+1} \tag{11}$$

A foreign bank j 's balance sheet in period t is

$$B^*_{i,t} + N^*_{i,t} + F_t = D^*_{f,i,t} + \frac{D^*_{h,i,t}}{S_t} + H_{i,t} \tag{12}$$

The domestic bank takes $B_{j,t}$ deposits from households, has its own net worth $N^*_{j,t}$ and receives an investment $F_{j,t}$ from the domestic banks. It uses all these liabilities to invest in foreign bonds $D^*_{f,j,t}$, domestic bonds $D^*_{f,j,t}$ and to loan to the domestic bank.

In the next period, both assets and liabilities receive their remuneration, and the bank pay taxes:

$$N^*_{j,t+1} = \frac{R_{h,t+1} D^*_{h,j,t}}{S_{t+1}} + R_{f,t+1} D^*_{f,j,t} + R_{c,t+1} H_{i,t} - R^*_{t+1} F_t - R^*_{t+1} B^*_{j,t} \tag{13}$$

We can also substitute the deposit using the balance sheet in period t:

$$\begin{aligned} N^*_{j,t+1} = & \left(\frac{S_t}{S_{t+1}} R_{h,t+1} - R^*_{t+1} \right) \frac{D^*_{h,i,t}}{S_t} + (R_{f,t+1} - R^*_{t+1}) D^*_{f,j,t} \\ & + (R_{c,t+1} - R^*_{t+1}) H_{i,t} + R^*_{t+1} N^*_{i,t} \end{aligned} \tag{14}$$

The foreign bank is subject to the same kind of participation constraint as the domestic bank.

$$\begin{aligned} V^*_{j,t} \geq \vartheta_t \Bigg(\bigg(& \left(\kappa^*_{h1} + \kappa^*_{h2} \frac{\tilde{D}_{h,t}}{S_t} \right) \frac{D_{h,j,t}}{S_t} + \left(\kappa^*_{f1} + \kappa^*_{f2} \tilde{D}_{f,t} \right) D_{f,j,t} \\ & + \left(\kappa^*_{f1} + \kappa^*_{f2} \tilde{H}_t \right) H_{j,t} \Bigg) \end{aligned} \tag{15}$$

Here, κ^*_{f1}, κ^*_{h1} and κ^*_{c1} are the constraint parameters for the foreign holdings of foreign bonds, the foreign holdings of domestic bonds and the loans given to the domestic bank.

4.4. Balance of Payments

The balance of payment can be derived from the foreign budget constraint presented below.

$$P^*_{H,t}Y^*_{H,t} + B^*_t = R^*_t B^*_{t-1} + \frac{P_{H,t}}{S_t}C^*_{H,t} + P^*_{F,t}C^*_{F,t} + TR^*_t - T^*_{s,t}$$

To this end, we make some substitutions. Lets begin with the return of deposits to foreign households. This expression come from a simple interpretation of the equation 13.

$$R^*_t B^*_{i,t-1} = \frac{R_{h,t}}{S_t}D^*_{h,i,t-1} + R_{f,t}D^*_{f,i,t-1} + R_{c,t}H^*_{i,t-1} - R^*_t F_{i,t} - N^{e*}_{i,t} \quad (16)$$

We assume the following initial capital for new foreign banks. This ensures the steady-state stability.

$$T^*_{s,t} = \varphi\left(\frac{D^*_{h,t}}{S_t} + D^*_{f,t}\right)$$

The government taxes the households in such way that its debt level remains constant.

$$TR^*_t = \bar{D}_f - R_{f,t}\bar{D}_f$$

Finally, we recover the household deposits using equation 12.

$$B^*_{i,t} = D^*_{f,i,t} + \frac{D^*_{h,i,t}}{S_t} + H_{i,t} - N^*_{i,t} - F_{i,t} \quad (17)$$

Summing up all the equations above we got the balance of payment equation. It describes the goods and financial flow in the model and determines the exchange rate such that both inflows and outflows equilibrates.

$$\begin{aligned} P^*_{H,t}Y^*_{H,t} + \frac{D^*_{h,i,t}}{S_t} + D^*_{f,i,t} = {} & \frac{R_{h,t}}{S_t}D^*_{h,i,t-1} + R_{f,t}D^*_{f,i,t-1} + R_{c,t}H^*_{i,t-1} \\ & - R^*_t F_{i,t} + \frac{P_{H,t}}{S_t}C^*_{H,t} + P^*_{F,t}C^*_{F,t} + \bar{D}_f - R_{f,t}\bar{D}_f \end{aligned} \quad (18)$$

4.5. Central Bank

As we have an endowment model with non-tradables goods, the interest rates are fully determined by the path of the endowment of each economy.

Nevertheless, we allow the central bank to engage in foreign exchange market interventions in some scenarios.

4.6. Calibration

The model is calibrated to values that are consistent with standard practices in the literature and reflect broad empirical patterns, such that we have a stylized but credible economy.

Since the focus is on understanding qualitative mechanisms, such as the role of bank frictions or FX risk in amplifying shocks, rather than replicating precise data moments, calibration serves to ensure that the model generates dynamics and policy insights under plausible economic conditions.

Table 7: Calibration

Parameter	**Description**	**Value**
β	Domestic intertemporal discount factor	0.99
β^*	Foreign intertemporal discount factor	0.99
θ	Bank Survival Probability	0.95
φ	Bank Starting Networth	0.001
Ψ_q	Cost of FX Risk	100
$\overline{D_h}$	Domestic Total Government Debt	7.5
$\overline{D_f}$	Foreign Total Government Debt	12.4
τ_f^{ss}	Tax on Foreign Investments	0 & 0.5
τ_h^{ss}	Tax on Domestic Investments	0.5
$\kappa_{h,1}$	Home bank constraint value on home bonds	0.03
$\kappa_{f,1}$	Home bank constraint value on foreign bond	1.14
$\kappa_{e,1}$	home bank constraint value on foreign branch	0.5
$\kappa_{h,1}^*$	Foreign bank constraint value on domestic bond	1.2
$\kappa_{f,1}^*$	Foreign bank constraint value on foreign bond	0.1
$\kappa_{c,1}^*$	Foreign bank constraint value on foreign loan	0.19
Y_T	Domestic Endowment of Tradable Goods	3
Y_{NT}	Domestic Endowment of Non-tradable Goods	7
Y_T^*	Foreign Endowment of Tradable Goods	2.4
Y_{NT}^*	Domestic Endowment of Non-tradable Goods	7.6

5. Stilized Facts

5.1. The bank's overhedge makes the economy more volatile

The first stylized fact is that the overhedge makes the economy more volatile. To show this, we make a stochastic simulation of different shocks. The main idea is to compare the volatility of some macroeconomic variables before and after bank's overhedge correction.

Table 8: Comparison of Standart Deviations with and without Distortion

Metric	**With overhedge**	**Without overhedge**
Exchange Rate	0.110487	0.086254
Consumption	0.183312	0.170792
Domestic Bonds Rate	0.036921	0.035615
Loan Rate	0.028938	0.026008
Hedge Volume	3.093291	2.262142

The most obvious variable that shows more volatility is the exchange rate. Suppose that the bank faces some shock that obligates it to reevaluate the foreign investment position. If it has to make more hedge to actually protect itself from exchange rate risk, then we should expect more trades and pressure in the exchange rate market meaning directly more volatility. This result is corroborated by ([30]), that concluded that the correction of the overhedge significantly reduced the implicit volatility of the Brazilian exchange rate extracted directly from the premium of currency options with remaining maturity of 1 month.

Due to the higher exchange rate volatility, as we have a endowment model, this converts directly to a more volatile consumption and consequently a lower level of welfare.

5.2. The overhedge makes the economy more vulnerable to financial constraint shocks

The second stylized fact we aim to illustrate is that a financial constraint shock—such as those observed during the COVID-19 recession—has more severe consequences in an economy with overhedge. To demonstrate this, we increase ϑ_t and ϑ_t^* following the approach in ([26]), which effectively worsens the quality of all assets used as collateral. The impulse response functions

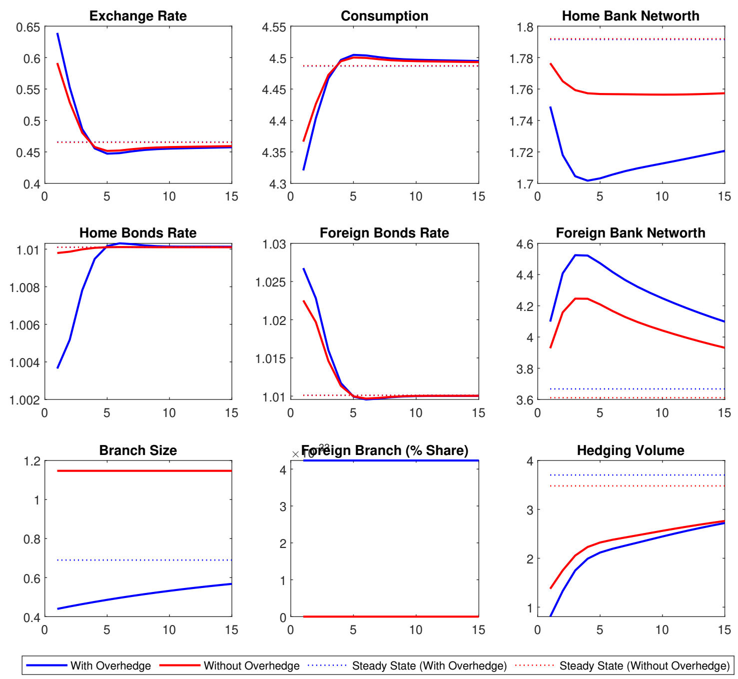

Figure 3: Impulse response functions following an adverse financial shock that tightens collateral constraints. Blue lines represent an economy with tax-induced overhedging, red lines an economy without overhedging, and dotted lines steady-state values. Overhedging amplifies exchange rate depreciation, reduces consumption, and magnifies adjustments in banks' balance sheets and hedge positions.

(IRFs), comparing the economy with and without overhedge, are shown in Figure 3.

In both cases, we initially observe an exchange rate depreciation. This results from a flight to safety and unbalanced retrenchment—each economy demands more of its own country's bonds, yet foreign bonds remain marginally better collateral.

However, with the overhedge, as supported by our empirical findings, there is a contraction in the size of the foreign branch, accompanied by an almost twofold reduction in the hedge position. Consequently, banks are forced to purchase more foreign currency to unwind their short U.S. dollar positions, which further depreciates the exchange rate.

As the financial condition shock gradually ease, banks are able to purchase less pledgeable assets in their balance sheets. This means the domestic bank expands their foreign branches and the foreign bank invests more in domestic

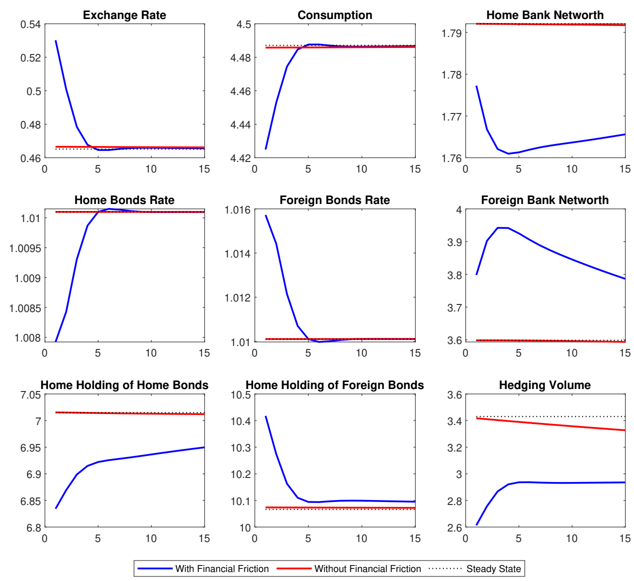

Figure 4: Impulse response functions following the elimination of the tax asymmetry between FX hedging instruments and foreign investments (in blue). The correction triggers a sharp exchange rate depreciation, a contraction in consumption, and a pronounced decline in hedge volumes, reflecting the forced unwinding of excess dollar short positions. In red, it is highlighted the role of the financial friction imposed in the domestic bank's problem. Without it, the UIP holds and the exchange rate does not move.

bonds. The model predicts a currency appreciation at this stage in opposition to the initial depreciation.

5.3. The overhedge correction depreciates the exchange rate.

The impulse response functions shown in this section illustrate the macroeconomic consequences of correcting the tax-induced overhedge. This correction essentially eliminates the incentive that banks previously had to hold excessive hedge positions, effectively forcing them to unwind those positions.

As expected, the most immediate and pronounced response is a sharp depreciation of the exchange rate. This occurs because, when overhedged banks unwind their excess FX hedge positions, they need to repurchase foreign currency (typically U.S. dollars), creating significant upward pressure on the exchange rate. This movement aligns with the theoretical mechanism discussed in the model: the elimination of the tax distortion reverses the incentive for excess-dollar short positions, triggering a large-scale demand for USD in both spot and derivatives markets.

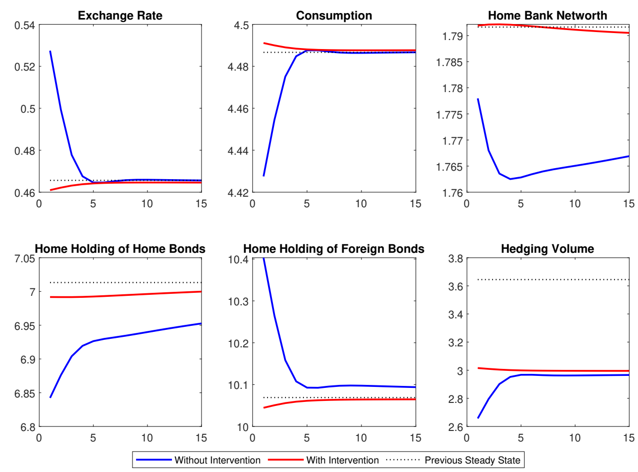

Figure 5: Impulse response functions comparing economies with and without central bank FX intervention during the unwinding of overhedged positions. FX intervention stabilizes the exchange rate, preventing consumption losses, and preserves bank net worth, highlighting its role as a macroprudential tool during periods of market stress.

The depreciation translates into a drop in real consumption. Given the endowment structure of the model, where consumption depends on the real purchasing power of the representative household, a weaker domestic currency reduces the endowment value, underscoring the welfare cost of the overhedge correction.

Finally, there is a notable drop in total hedge volume, consistent with the policy change that removes the tax asymmetry.

5.4. An FX intervention avoids the exchange rate depreciation.

The impulse response analysis show in Figure 5 confirms that a timely and well-calibrated foreign exchange (FX) intervention by the Central Bank can effectively cushion the adverse effects of an overhedge unwinding. In contrast to the dynamics observed in Section 5.3, the exchange rate remains significantly more stable when intervention is present, mitigating the sharp depreciation that would otherwise occur.

This stabilization has important spillover benefits. Consumption falls by a smaller margin, reflecting smoother adjustment in relative prices and preserved purchasing power. Additionally, the home bank's net worth suffers less, highlighting how FX interventions can preserve financial sector resilience.

In sum, this simulation illustrates that FX interventions can play a critical role in managing transition dynamics when correcting regulatory distortions. Although they may not be a permanent solution, they serve as an essential buffer that allows for smoother market adjustment, lower welfare losses, and reduced systemic risk.

6. Conclusion

This paper examined the critical interplay between tax policy, financial regulation, and macroeconomic stability, focusing on the "overhedge" practices of Brazilian banks. Through a combination of empirical analysis and a two-country DSGE model, we have demonstrated that a specific tax asymmetry created powerful incentives for banks to build excessive hedge positions, transforming a regulatory loophole into a source of systemic risk. While seemingly a rational strategy for individual banks, this overhedging behavior amplified exchange rate volatility and heightened financial fragility, especially during periods of market stress.

Our empirical findings revealed that Brazilian banks strategically increased their foreign investments and corresponding hedge volumes to capitalize on interest rate differentials, leveraging the asymmetric tax framework for near-risk-free returns. The theoretical model further illuminated these dynamics, showing that overhedging not only exacerbated financial instability but also magnified the economy's vulnerability to external shocks.

The gradual correction of this tax distortion, coupled with the Central Bank of Brazil's active FX interventions, provided a crucial case study. It highlights the necessity of timely and targeted macroprudential measures to counteract unintended consequences of regulation. Our findings underscore that regulatory frameworks must be holistic, accounting for incentive structures that can inadvertently foster destabilizing financial behaviors.

Ultimately, this article contributes to the literature on macroprudential policy and exchange rate dynamics by identifying a novel channel—tax-induced overhedging—through which fiscal policy can profoundly influence financial sector behavior and macroeconomic outcomes. For policymakers, our insights reinforce the critical importance of aligning tax and regulatory incentives to safeguard financial stability in an increasingly interconnected global economy.

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