Leaning-against-the-wind intervention and the "carry-trade" view of the cost of reserves

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Abstract:

For a sample of emerging economies, we estimate the quasi-fiscal costs of sterilized foreign exchange interventions as the P&L of an inverse carry trade. We show that these costs can be substantial when intervention has a neo-mercantilist motive (preserving an undervalued currency) or a stabilization motive (appreciating the exchange rate as a nominal anchor) but are rather small when interventions follow a countercyclical, leaning-against-the-wind (LAW) pattern to contain exchange rate volatility. We document that under LAW, central banks outperform a constant size carry trade, as they additionally benefit from buying against cyclical deviations, and that the cost of reserves under the carry-trade view is generally lower than the one obtained from the credit-risk view (which equals the marginal cost to the country´s sovereign spread).

Keywords: Exchange rates, foreign exchange intervention, international reserves, self-insurance

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1. Introduction: three types of reserve accumulation

The accumulation of international reserves came to the foreground in the 2000s due to the buildup of *precautionary* reserve stocks, primarily in South East Asia, in countries that suffered capital account reversals in the late 90s that, in many cases, ended up in very costly currency-debt-banking crises. This *self-insurance* motive, aimed at buffering the economy against potential liquidity shortages driven by the global financial cycle, contrasts with the *neo-mercantilist* accumulation of reserve assets to contain the appreciation trend of the local currency and promote export-driven growth, most notably in Japan in the 80s and China in the 90s.

More recently, a *leaning-against-the-wind* (LAW) exchange rate intervention has been common in most emerging economies, particularly in financially open commodity exporters where reserves reflected the ups and downs of the twin commodity and financial cycles. While both the precautionary and the LAW interventions entailed a countercyclical pattern, as countries purchase reserves in times of bonanza and sell them in times of distress, they differ in a critical way: because the objective of the latter is to influence the market exchange rate, it needs to alter the relative supply of the local currency, regardless of the consequences in terms of the reserve stock, whereas the opposite is true for the former.

The recent literature on international reserves has centered primarily on the precautionary and LAW motives.[2] While right after the stream of currency crises of the 90s, it tended naturally to highlight the precautionary view –earlier work showed reserves to be positively correlated with past crises (Aizenman and Lee 2005) and with the degree of financial dollarization and currency imbalances (Levy Yeyati 2006), the data have increasingly flagged the presence of an exchange rate-smoothing objective as the main driver behind the gradual buildups and sharp declines in the stock of reserves, often in sync with local and global financial cycles.

Arguments *against* reserve accumulation often fall within one or more of these clusters: 1) reserves hoarding perpetuates global imbalances: they depress interest rates and stimulate asset bubbles, 2) reserves are not efficient as centralized precautionary safety nets can optimally substitute them, and 3) reserves are costly because reserve holders pay a carrying cost roughly proportional to their sovereign credit risk premium.

[2] A number of papers (Prasad et al. 2006; Rodrik 2008; Levy Yeyati et al. 2012, 2013) examine the mercantilist motive. Note that, while the distinction between motives is critical from the viewpoint of the associated fiscal and exchange rate consequences, both motives may coexist: on the one hand, LAW intervention could be used to accumulate precautionary reserve stocks; on the other, self-insurance and LAW are not necessarily at odds with each other in that an eventual reversal of fortunes (for example, a global financial downcycle or a negative local real shock that leads to a substantial real depreciation) may explain both the attempt to prevent a strong appreciation and the buildup of a reserve buffer in the good years.

The third of these criticisms, the costs of hoarding reserves, is the focus of this paper. As we will try to illustrate, the correct way of computing these costs depends critically on the nature of the intervention. Under the self-insurance motive, it is often assumed that reserve accumulation increases both foreign exchange assets and liabilities as if reserve assets were purchased with the proceeds of the primary issuance of foreign currency-denominated sovereign paper. If so, the marginal cost of carrying reserves would be proportional to the cost of the new debt net of the returns on reserves, which would typically equal the sovereign credit risk spread plus the term premium associated with the duration mismatch, if any, between sovereign debt and reserves assets. This "credit-risk" view of the cost of reserves contrasts with the situation under LAW: for reserves to counter exchange rate variations, the intervention should entail a change in the relative supply of local currency assets, which requires that reserves be funded by issuing local currency-denominated debt.[3] As a result, the central bank pays the local-to-foreign currency interest rate differential and receives valuation gains due to changes in the nominal exchange rate (in other words, it takes the other side of a "carry trade"). Both the carry and the valuation gains may be positive or negative.

As we document in this paper, the cost of reserves in these two cases differs substantially. We estimate the empirical costs of reserves under the two types of intervention and show that actual intervention cost depends on the timing (lower for countercyclical interventions) and the size of the interest rate differential (lower for nominally stable, low-interest rate economies). Moreover, the cost of intervention under the "carry-trade" view is generally lower than the one arising from the "credit-risk" view.

In what follows, section 2 discusses the pros and cons of hoarding international reserves according to their motives and argues that the costs depend critically on the nature of the intervention. Next, it documents that, in recent years, international reserves have been driven mainly by sterilized leaning-against the-wind interventions, consistent with a policy of smoothing out exchange rate volatility against the incidence of capital flows. Section 3 empirically estimates the cost of reserves under the "carry-trade" view, shows how these costs depend on the interest rate differential, and compares the results with the cost of a constant-sized carry trade –to illustrate the benefits of countercyclical intervention– and with the costs of holding reserves based on the credit-risk view. Section 4 summarizes and concludes.

2. What is behind reserve accumulation?

The currency crises of the late 1990s –as a result of a global financial downturn coupled with self-fulfilling dollar liquidity runs– tied with the sobering experiences of IMF-led

[3] Since intervention is geared to offset the demand for the local currency, the issuance of dollar debt would not do the trick in this case. By contrast, while the self-insurance motive does not require that reserves are purchased with foreign currency debt, the latter is a more natural choice if the goal is to avoid an undesired impact from the reserve transaction on the foreign exchange market.

adjustment packages led emerging economies to embrace self-insurance through the development of domestic financial markets and the buildup of war chests of liquid international reserves.[4]

This value of holding stocks of international liquidity was again apparent during the global financial crisis of 2008, as many central banks contained exchange rate overshooting and avoided domestic financial meltdowns thanks to the use of their stock of reserves –and the additional "liquidity assurance" provided international financial institutions and, most notably, the U.S. Federal Reserve through bilateral currency swap arrangements (Moessner and Allen 2010).

Panel A of Figure 1 illustrates the massive increase in emerging economies' share of international reserves in the late 90s and early 2000s, with a 30% peak in the aftermath of the 2008 global crisis. In turn, Panel B shows the substantial jump in reserve stocks after the failure of Lehman Brothers, especially in China (reaching a peak in 2014).[5] Ten years after that traumatic episode, emerging countries as a group almost have doubled (1.7 times) their international reserves, albeit less than the advanced countries (2.8 times). Interestingly for our purposes, while in the mid-90s the evolution of global international reserve stocks was explained mainly by a few countries with large trade surpluses (China, Japan, Taiwan, and oil exporters accounted for a ten-year-average of 50% of world reserves), recent reserve accumulation is more broadly distributed among countries with varied histories of financial distress.[6]

2.1. Precautionary reserve hoarding

In the literature, the *'optimal level'* of precautionary reserves is often discussed in terms of their insurance value against financial crisis relative to their holding cost. Because it is often assumed that foreign currency assets are funded by foreign currency liabilities (either new ones, the proceeds of which go to purchase reserve assets, or old ones, which could be potentially canceled by reserves), the cost of hoarding reserves is typically assumed to be the difference between the return on reserves and the service

[4] See, Fernandez-Arias and Levy-Yeyati (2010). As Martin Feldstein phrases it referring to the South East Asian crises: "*Liquidity is the key to self-protection. A country that has substantial international liquidity -- large foreign exchange reserves and a ready source of foreign currency loans -- is less likely to be the object of a currency attack*" (Feldstein 1999).

[5] While it exceeds the focus of this paper, it is worth noting that China, with its heavily managed exchange rate, represents both motives over time: a neo-mercantilist objective in the 90s and early 2000s, and a stabilizing (LAW) objective since the mid-2000s.

[6] Alternative precautionary reserve criteria have changed and become empirically less prevalent in the 2000s. Prior to financial globalization, the main driver of reserve hoarding was the current account side of the balance of payments, and central banks used to hold foreign exchange reserves equivalent to a given number of months of imports as an insurance against current account reversals (see Rodrik 2006; Panel A of Figure 2 illustrates how the reserve-to-imports ratio became unstable in the late 90s). The Guidotti-Greenspan liquidity rule (holding liquid reserves to meet the country´s foreign currency liabilities due within a year), popular in the 90s, ceased to be a binding concern in the 2000s (Panel B). Inspired by the dollar runs of the late 90s, the 2000s favored a bank-run view (reserves should cover broad monetary aggregates), as financial crises are largely driven by –and reserves are regarded as insurance against– capital outflows, mainly from local savers (Obstfeld et al. 2010).

cost of the funding liabilities, which in turn is proportional to the credit risk spread of the sovereign issuer (Jeanne and Ranciere 2011; Jeanne and Sandri 2016).

According to Moessner and Allen (2010), three types of arrangements satisfy the self-insurance criteria: multilateral reserve pools (for example, the Chiang Mai Initiative or CMI in East Asia, the Latin American Reserve Fund, the European Stability Mechanism, and, more broadly, the IMF),[7] bilateral arrangements (such as the Federal Reserve currency swap with selected central banks, or the many bilateral arrangements underlying the CMI), and unilateral action (reserve accumulation by individual countries).

If there is room for risk diversification, reserve pools should be more efficient than individual self-insurance.[8] However, the correlation risk (the empirical fact that, in the event of a systemic event, the correlation between liquidity shocks among member countries tends to increase sharply), considerably narrows the scope for diversification. Thus, to the extent that only the "issuers of last resort "(issuers of reserves currencies that face increased demand in crisis, such as the Fed, the Bank of Japan, and, to a lesser extent, the ECB) are in the position to offer liquidity assistance in a systemic crisis, central banks may find pooling their reserves with other non-reserve issuers less economically appealing than holding them on their own (Levy Yeyati 2020).

2.2. Are reserves costly?

Under self-insurance, to the extent that reserve accumulation is associated with the proceeds of hard-currency liabilities issued by the Treasury or the central bank, the opportunity cost of hoarding reserves could be proxied by the cost of serving this debt net of the returns of the corresponding reserves –the implicit assumption being that reserves could be alternatively used to buy back foreign currency debt. In this light, the cost of using reserves should depend on the sovereign credit risk premium, that is, the difference between the yield on the sovereign debt and the returns on reserves assets (Jeanne and Ranciere 2011; Rodrik 2006).[9] In practice, the cost of holding reserves differs from this simple formula in at least two ways.

[7] Fernandez Arias and Levy Yeyati (2010) explore the relationship between a reaction to the traditional IMF approach and the emerging in the 2000s of regional safety nets (CMI and LARF) as alternatives. For a more recent review of the attempts to build a global financial safety net, see Cheng (2016).

[8] Reserve pools and bilateral agreements may also elude the 'psychological' effect of seeing reserves collapsing during a run: whereas reserves reduce the propensity to a foreign exchange run, once the run is underway, their use (the sight of rapidly declining reserves) may confirm and even deepen the market fears that trigger the run in the first place, reducing their ex-post effectiveness. International loans do not tend to have the same optics.

[9] Rodrik (2006) contrasts the fiscal cost as traditionally computed (proportional to the sovereign credit risk spread, which corresponds to the case in which the government borrows foreign currency to build reserves) with a "social" cost (which corresponds to the case in which it is the private sector that brings the foreign exchange into the economy) given by the spread between the (generally higher) private external borrowing cost and the return on reserves. Here, we compare the fiscal cost in two situations: the credit risk view coincides with Rodrik´s, whereas the carry trade view (where the private sources of foreign exchange include external loans, a current account surplus, FDI) is given by the sum of the interest rate differential and the valuation change.

First, if the availability of liquid reserves improves the propensity to face an episode of financial distress –and, as a result, reduces the credit risk premium paid on the total (public and private) debt stock–, the credit-risk may overestimate the cost of carrying reserves (Levy Yeyati, 2011).

Second, there is plenty of evidence indicating that intervention is primarily geared to contain what policymakers may see as excessive volatility and unwarranted deviations of the exchange rate from its equilibrium level, which, as we will document in the next section, appears to account for reserve accumulation better than the precautionary motive.[10]

More to the point of this paper, if reserve accumulation follows this LAW pattern –in other words, if the intervention is aimed at affecting the market exchange rate– it should involve a change in the relative supply of the local currency. That is, reserves should be purchased with or sold in exchange for local currency assets. More specifically, the central bank would purchase part of the inflow of foreign exchange with new money and sterilize the latter with the issuance of central bank local currency liabilities (repos, short-term paper, or CDs) or, more often, with the sale of government assets in its balance sheet, and vice versa. In this case, the cost of managing a reserve stock would no longer be the credit risk spread but the sum of the interest rate differential between the reserve assets and the sterilizing local currency liabilities, plus valuation gains related with changes in the exchange rate.

It follows that a key question underlying the costs of hoarding reserves is how these reserves are funded. A few studies have circled around this, all of them with the emphasis suited on the central bank balance sheet: reserves must be purchased with local currency (unsterilized intervention) or with local papers denominated in local or foreign currency (sterilized interventions).[11]

While this approach is pertinent when analyzing the motives of the central bank, it may be misleading as a way to estimate the cost of intervention: by focusing on the cost of reserves to the central bank, it ignores the cases in which reserves are accumulated as the result of public sector borrowing abroad, for example, to cover the primary deficit. Should we limit attention to the central bank, or should we consider the situation as one in which reserves are funded by foreign currency liabilities?

In the first case, almost all cases of reserve purchases would result from sterilized interventions, as central banks rarely issue or sell foreign currency paper in the market. In the second case, the share of the change in reserves that can be explained by variations in the outstanding stock of sovereign liabilities (including those of the

[10] For surveys of intervention policies see Sarno and Taylor (2001) for advanced economies and Levy Yeyati and Sturzenegger (2010) for developing ones. For recent accounts on the motives of central bank intervention, see BIS (2005, 2013), Adler and Tovar (2011), and Daude et al. (2014).

[11] See, for example, Levy Yeyarti and Gomez (2019), and Sosa-Padilla and Sturzenegger (2021).

central bank) would correspond to the credit-risk view, whereas the rest could be regarded as purchased against an increase of local currency liabilities.

The previous question is relevant to identifying how often reserves could be regarded as purchased with local currency. The following section looks into this in more detail.

2.3. Where do reserves come from?

As we mentioned above, in recent years, reserve accumulation has been motivated not exclusively (and probably not primarily) by the self-insurance motive, but rather by a LAW exchange rate policy aimed at containing what central banks may perceive as excess market volatility in foreign exchange markets.[12] While it is beyond the scope of this paper to assess when and to what extent one motive dominates the other, the distinction between self-insurance and leaning against the wind is essential to the way reserve stocks are purchased, which in turn determines their opportunity cost. To see this, note that a critical difference between the two motives lies in the way their funding influences the exchange rate: self-insurance should be, a priori, neutral, as it aims at modifying the composition of net debt by extending its average tenor; LAW, in turn, should alter the equilibrium in the foreign exchange market, as it is intended to counter undesired exchange rate fluctuations.

Perhaps the simplest, although little researched way to examine how reserve buffers are built is through the government's investment position change based on the Balance of Payments (BoP) flows. In the BoP, a positive reserve variation should correspond to a positive combination of the current account balance, foreign direct investment, and financial flows. In turn, within the latter, we can distinguish changes in the net foreign debt position of the government and the central bank, and thus compute their contribution to the reserve change.

Figure 3 exemplifies for the case of Brazil. As can be seen, except in 2005, the central bank played a marginal role in BoP flows; by contrast, years with significant public debt issuance, particularly in the 2006-2012 period, are associated with increases in the stock of reserves. However, changes in reserves are primarily associated with the rest of the BoP flows, denoted by *Other*, and equal to the current account balance plus the private side of the financial account (or, alternatively, equal to the flows of the BoP not covered by dollar-debt-issuance).

Based on this data, how prevalent is the case where reserves are purchased with foreign exchange (in other words, where the change in reserves does not change the foreign currency position)? If we center on the central bank balance sheet, the contribution would be marginal. If we focus on the consolidated position of the public

[12] See Agenor et al. (2020) for a recent discussion.

sector (including both the central bank and the government), the answer is: nonnegligible but small.

We prefer the second option. From a fiscal perspective, inasmuch as LAW interventions are sometimes aimed to limit the appreciation pressure associated with external financing of the primary deficit, it is more natural to consider the three operations (sovereign debt issuance, foreign exchange sales by the public sector, sterilized reserve purchases) as one. Moreover, it is the stricter criteria against our case. Reassuringly, even in this case, data for our emerging market sample indicates that the carry trade view tends to prevail (see Figure 3b).

3. The cost of leaning-against-the-wind

Faced with appreciation pressures, a LAW central bank accumulates foreign-currency reserves against local-currency debt. In essence, this mirrors the position of a carry trader that shorts the foreign currency betting on further appreciation. In the absence of Tobin-type taxes on cross-border flows (or other similar restrictions on capital mobility), the loss of the central bank should equal the profit of the carry net of (typically minor) transaction costs –essentially, the profit of a reverse carry trade position.

The main concern about sterilized interventions has been the cost of carry, namely, the frequently large local-to-foreign currency interest rate differential that the central bank has to pay on its local currency-funded reserve position. This situation might lead central banks to deal with quasi-fiscal losses associated with steep interest rate differentials. These differentials may reflect either a decline in international rates (for example, due to the spillovers of the U.S. monetary policy that led to financial capital flows to emerging economies, as highlighted in the financial cycle literature)[13] or a tightening of domestic monetary policy that triggers speculative capital inflows (which the exchange rate intervention tries to offset).

However, the conventional wisdom that relates intervention costs with interest rate differentials ignores a critical aspect of hoarding reserves: the countercyclical nature of LAW intervention, and the cyclical valuation effect that might work in its favor. If official intervention in the foreign exchange market is intended to smooth out cyclical fluctuations, the central bank will sell reserves when the exchange rate depreciates and buy them when it appreciates, so that, when the exchange rate moves back to its equilibrium level, the central bank benefits from a valuation gain that may even offset the high carry and deliver positive profits over the cycle.

This contrasts with the case in which intervention attempts to delay an inevitable appreciation as in the neo-mercantilist motive, or to postpone depreciation as in the

[13] See Rey (2015) and Bruno and Shin (2015).

case of an exchange rate-based nominal anchor: in both cases, the central bank would buy at highs and sell at lows, at a considerable cost.

The above discussion has a trivial but often overlooked implication: the cost of LAW reserve accumulation must be measured over the long run to include the full exchange rate cycle. More specifically, in floating exchange rate regimes, participation of central banks in the foreign exchange markets is expected to have, at times, positive and negative valuation effects. It follows that LAW reserve accumulation would sustain significant valuation losses only to the extent that the appreciation pressures are permanent.

How does this carry trade view differ from the credit-risk view? If the Uncovered Interest Rate Parity (UIP) condition holds, the interest rate differential should equal the expected exchange rate variation (if the differential favors the local currency, the latter should depreciate, and vice versa) so that the cost of sterilized purchases should ultimately be, on average, similar to purchases directly funded by dollar debt (the only difference being that, in the first case, it is the central bank that bears the currency risk). However, as UIP seldom holds in the short run, the central bank could arbitrate cyclical deviations from UIP. Ultimately, both the amplitude of these deviations and the intensity of interventions are critical in assessing the fiscal costs of LAW[14].

This previous one is not the only difference between the carry trade and credit-risk versions of the cost of reserves. In a real-life version of the latter, reserves assets are shorter than the foreign currency liabilities used to fund them, in which case a term premium should be added to the credit risk premium in the computation; by contrast, the local currency instruments used to sterilize reserve purchases (central bank facilities and paper, and even local Treasuries) are typically shorter, so a term premium should be subtracted from the carrying cost. More precisely, if reserves are funded with foreign-currency debt, then the interest rate differential can be expressed as:

$$
\begin{aligned}
IRD^{dollar} &= y_l - r_s^* \\
&= (y_l - r_l^*) + (r_l^* - r_s^*)
\end{aligned}
$$

where y_l is the yield on the long-term sovereign bond, r_l^* is the long-term risk-free rate, and r_s^* is the short-term risk-free rate (the return on reserves), so the first parenthesis is the sovereign spread, and the second is the term premium.

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[14] Can the central bank intervene in a way that maximizes valuation gains? While that purpose is not often written in official documents, Sarno and Taylor (2002) suggest that the information available to, and used by market agents is often less accurate than the authorities provide. Along the same lines, Blinder et al. (2008) argue that 'central banks may have, or may be believed to have, superior information on the economic outlook [because they] usually devote many more resources than private sector forecasters to forecasting and even to estimating the underlying unobservable state of the economy'. By this token, the central bank with its powerful research department may use its more accurate data to intervene in a profitable way, by hoarding reserves while its price is perceived to be low, and selling when it is perceived to be high. A similar argument has been proposed and tested to explain why an unanticipated interest rate hike by the central bank typically shifts the yield curve upwards despite the fact whereas it is expected to reduce inflation over the long run (see, for instance, Romer and Romer (2000)).

If, on the other hand, reserves are funded with peso debt, then the interest rate differential can be expressed simply as $y_s - r_s^*$ where y_s is now the interest rate on a short-term peso debt, and valuation effects are the changes in the exchange rate, with depreciations being 'good' for the country (in that they reduce the cost).

Moreover, while central banks in nominally volatile and uncertain environments sometimes should pay high local currency rates that increase the carry, in most cases, the credit risk (and the associated premium) on local currency debt is below that on foreign currency obligations, attenuating the interest rate differential and further reducing the cost of reserves.

It follows that the actual cost of holding reserves from sterilized interventions, measured as the flow cost of the local-to-foreign currency interest rate differential plus valuation changes due to exchange rate changes, may differ significantly from the one computed based on the standard credit-risk view. Valuation changes here denote the variation in the local currency value of the initial stock of reserves during the duration of the trade. For example, a central bank holding U.S. dollar reserves will benefit from a depreciation and lose as a result of an appreciation of the local currency. The Appendix contains a brief description of data sources and procedures.

How did emerging economies fare in this regard? We conduct a simple exercise to estimate the realized costs of central bank intervention in the spot exchange rate market. We start the exercise from the beginning of 2005, far enough from the ripple effects of the currency crises of the late 90s that undervalued emerging currencies and at the early stages of the appreciation trend that characterized most of the 2000s. We calculate monthly reverse carry trades' cumulative Profits and Losses (P&L). Specifically, we assume that, starting in January 2005, at the beginning of each month, the central bank purchases international reserves, funded by the issuance of local currency debt, for an amount equal to the change in the reserve stock during the month —where the latter is corrected for interest income assuming a continuous income flow associated with an annualized return equal to the yield on 2-year Treasury notes, as well as for variations in the U.S. dollar value of the reserve currency basket (see the Appendix).[15]

We computed the P&L as the sum of the local-to-foreign currency interest rate differential (henceforth, the Cost of Carry, which is typically positive, hence a cost from the perspective of the holder of international reserves) and valuation changes (for the central bank standpoint, a loss whenever the local currency appreciates and a profit when it depreciates; henceforth, the Valuation Gain).

Figure 4 shows our empirical estimates of the cumulative Cost of Carry and the Valuation Gain for a sample of emerging economies. On the one hand, because of the

[15] This is, naturally, an approximation to actual spot intervention in January 2005, but, as Adler and Tovar (2011) indicate, differences with actual spot interventions tend to be relatively minor over monthly frequencies.

generally positive interest rate differential, the Cost of Carry (blue area) is positive and accumulates steadily over time (NB: in the figure, it is shown with a negative sign since it is a cost from the perspective of the central bank). On the other hand, the Valuation Gain accumulates losses (green area) during the appreciation phase and declines during an exchange rate correction (see, for instance, Brazil before and after 2012s and Peru before and after 2015s), and a LAW central bank tends to buy cheap reserves that it sells later on at a higher price in times of currency stress, a 'market maker' gain that partially offsets the cost of carry. As a result of different combinations of carry and exchange rate trends, the total return from intervention (solid black line) differs widely.

The numbers show that the fiscal cost tended to be substantial in countries with strong currencies (Israel, Korea, Thailand, where intervention exhibited a systematic "fear of appreciation" pattern), large in economies with relatively stable currencies and moderate interest rate differentials (India, most South East Asia), and modest or even negative in countries with marked cyclical exchange rate movements, even within carry currencies characterized by wide interest rate differentials (Brazil, Russia, Turkey).

The final toll for the central bank over the 15 years under consideration also differs significantly (first three columns of Table 1): in countries in Latin America and the Caribbean (LAC) and in the EMEA (Europe, Middle East and Africa) region, the large valuation gains (an average of 9.4% and 5.6% of GDP, respectively) more than offset the generally large interest rate carry to yield an average intervention "gain" of 2.2% and 0.9% of GDP, respectively. By contrast, in South East Asia (SEA), modest but still positive interest rate differentials outweigh near-zero valuation gains due to stable-to-stronger currencies for a total average cost of 1.7% of GDP. As can be seen, once properly normalized by GDP, the fiscal cost of intervention for carry currencies is fairly minor, or even reverts to a profit.

How economically important are these costs from a fiscal perspective? In Figure 5, we perform the same analysis, this time computing quasi-fiscal intervention profit and losses relative to GDP over each fiscal year.

How does all this compare with the credit-risk view? The last column of Table 1 reports our estimations based on the sovereign credit risk and shows that they tend to exceed the numbers based on the carry-trade view.[16] This is also shown in Figure 6, as the return on the carry trade (solid line) tends to outperform (particularly since 2014) the return on the credit-risk view (solid line with dots) every year, reflecting a global strengthening of the U.S. dollar (about 10% from mid-2014 to mid-2015, according to the DXY index) that stabilized at a higher level thereafter: whereas the credit-view

[16] For simplicity, we abstract from the benign marginal effect of reserves on spreads estimated in Levy Yeyati (2011). While the effect may affect the spread differently according to the funding currency –in particular, liquidity may be more relevant when the corresponding liability is denominated in a foreign currency, here we assume that, if anything, it is sufficiently small to be ignored.

captures the smooth decline in credit spreads up until the beginning of the pandemic, results under the carry trade view are heavily influenced by the exchange rate cycle.

A final comparison sheds light on the nature and motives of intervention. As noted, the total return of central bank sterilized intervention under a LAW policy could be regarded as a reverse carry trade that changes the notional size one-by-one with the change of the reserve stock held by the central bank. A priori, if the central bank intervenes countercyclically, it would tend to buy low and sell high, overperforming a constant size carry trade that keeps the notional constant over the whole period. Conversely, the overperformance of the central bank over a constant size trade (say, 100 U.S. dollars position opened in January 2005 and closed by December 2020) would be a good gauge of the degree of countercyclicality of interventions, as LAW, by definition, should exhibit a buy low-sell high strategy over the length of the exchange rate cycle that should beat a passive carry trade strategy. This exercise is presented in Table 2: with a few notable exceptions (Argentina, Turkey, Russia, and South Africa), the central bank consistently outperforms the constant size trader, sometimes significantly, in line with the benefits expected from countercyclical interventions.[17]

In sum, while realized intervention costs depend crucially on the timing and nature of the intervention and tend to vary considerably over the cycle (particularly under LAW policies), the conventional view that exchange rate intervention and international reserve accumulation are costly due to wide sovereign spreads and heavy quasi-fiscal losses associated appears to have been overstated.

4. Conclusions

In a world where the behavior of the exchange rate was common knowledge, the marginal cost of funding reserves with foreign or local currency debt should be ex-ante identical. If so, decisions to go one way or the other should be driven by cost arbitrage.

However, to the extent that the funding currency has distinct implications for the exchange rate (while pure self-insurance should be neutral, LAW should not), the funding currency would be chosen according to whether the central bank's objective is to build a reserve war chest or to contain perceived exchange misalignments. In the latter case, the central bank and the market expectations may differ, but even if they shared the same view, a central bank may still have a different, typically longer horizon in mind and, therefore, a different distribution based on which to evaluate the cost and risk balance. Even if they share views *and* horizons, the central bank may care about the velocity and depth of the exchange rate cycle, for example, because, unlike market players, it internalizes its potential effect on the real economy. At any rate, the

[17] While they deserve a closer and more specific analysis than the one in this paper, these four exceptions are possibly because they spent an important share of their reserves trying to defend their currencies from an ultimately inevitable depreciation (an extreme version of a nominal anchor). The carry-trade cost of holding reserves is artificially low in periods under foreign exchange controls, which are therefore excluded from the calculation.

motivation of this paper is not to rationalize the nature of this intervention from a normative perspective but rather to evaluate it from a positive viewpoint.

Studies of the costs of exchange rate intervention often overlook the fact that reserve accumulation increasingly reflects sterilized, LAW central bank interventions. The way in which intervention is conducted –either funded by a similar variation in central bank foreign currency liabilities with no change in the sovereign's overall currency position, or through changes in local currency liabilities that reflect in a variation in the relative supply of local currency assets– should a priori be irrelevant under perfect markets, inasmuch as the cross-currency interest rate differential equals on average the realized exchange rate change.

However, this situation is more the exception than the rule: uncovered interest rate parity holds, if anything, only over very long periods. Central bank intervention tends to act countercyclical, buying foreign exchange at its lows and selling it at its highs (which reduces intervention costs), and, in some cases, pays high real interest rates, even at very short tenors, to make up for policy deviations and nominal uncertainty, thus raising the intervention bill. This implies that the actual cost of holding reserves differs in many ways from the standard credit-risk view: in the case of sterilized interventions, the costs should be proxied by the sum of the local-to-foreign interest rate differential plus valuation effects due to exchange rate corrections: the other side of a carry trade.

The estimates reported in the paper indicate that actual intervention costs depend on the timing and the size of the interest rate differential: they are lower for countercyclical interventions (as illustrated by the comparison with the constant-size carry trade simulation) and for nominally stable, low-interest rate economies (as shown by Table 1), Conversely, they are larger for sand-in-the-wheel policies in a context of persistent real exchange rate changes (for example, in Israel and Korea, where the local currency appreciation was not cyclical but, rather, structurally driven, and efforts to delay appreciation were ultimately costly). Interestingly, the cost of sterilized LAW interventions is generally lower than the one estimated based on the sovereign credit risk spread.

Needless to say, our estimates do not quantify the exact cost of the intervention effort, as both the start and end points are arbitrary, and the final account depends on the evolution of the underlying variables. Instead, they are an example based on the realized result for a specific period to illustrate that, for a sufficiently long period, the cost of LAW intervention may be relatively inexpensive or even profitable and different from what is usually estimated using the more standard credit-view approach.

While the quasi-fiscal costs of reserves reported in the paper depend trivially on the period over which it is measured and could be further refined to take into account the currency and maturity composition of the local currency debt, or the incidence of the complementary intervention in forward markets, our approach proposed here and the resulting estimations strongly suggest that the cost of reserves held by central banks with reasonable policy interest rates that aim at reducing cyclical currency fluctuations are considerably smaller than it is often suggested in the literature, strengthening the case for its use as a macroprudential tool.

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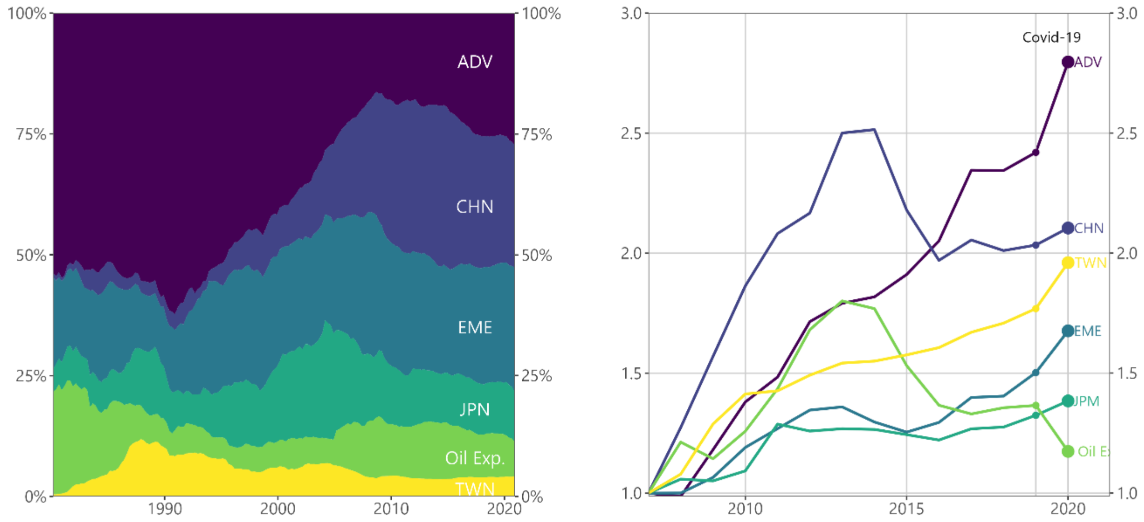
Figure 1: Composition and evolution of international reserves

Panel A **Panel B**

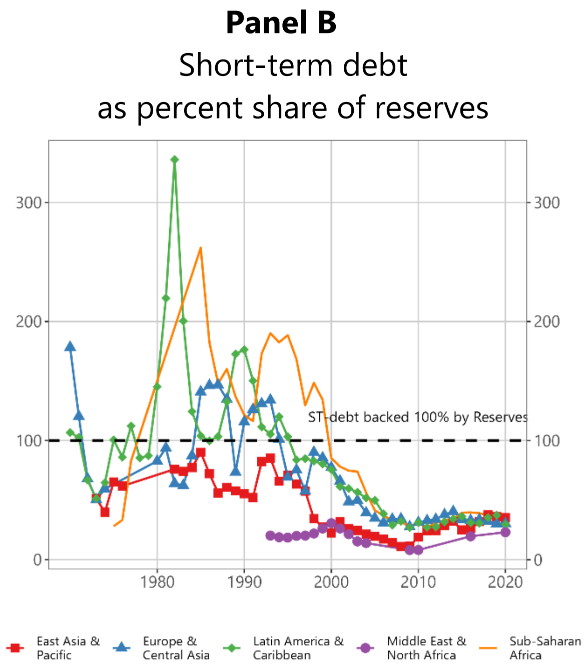
Composition of international reserves and its evolution after the 2008 global crisis

Index (1 = 01, January 2007)



Note: ADV stands for Advanced Economies (IMF, code XR29) excluding Japan, EME stands for Emerging and Developing Economies (IMF code XR43) excluding China, Taiwan, and Oil Exporters (Algeria, Iran, Iraq, Kuwait, Libya, Nigeria, Oman, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela).
Source: Authors' estimates based on IMF´s International Financial Statistics.

Figure 2: Early precautionary reserve criteria

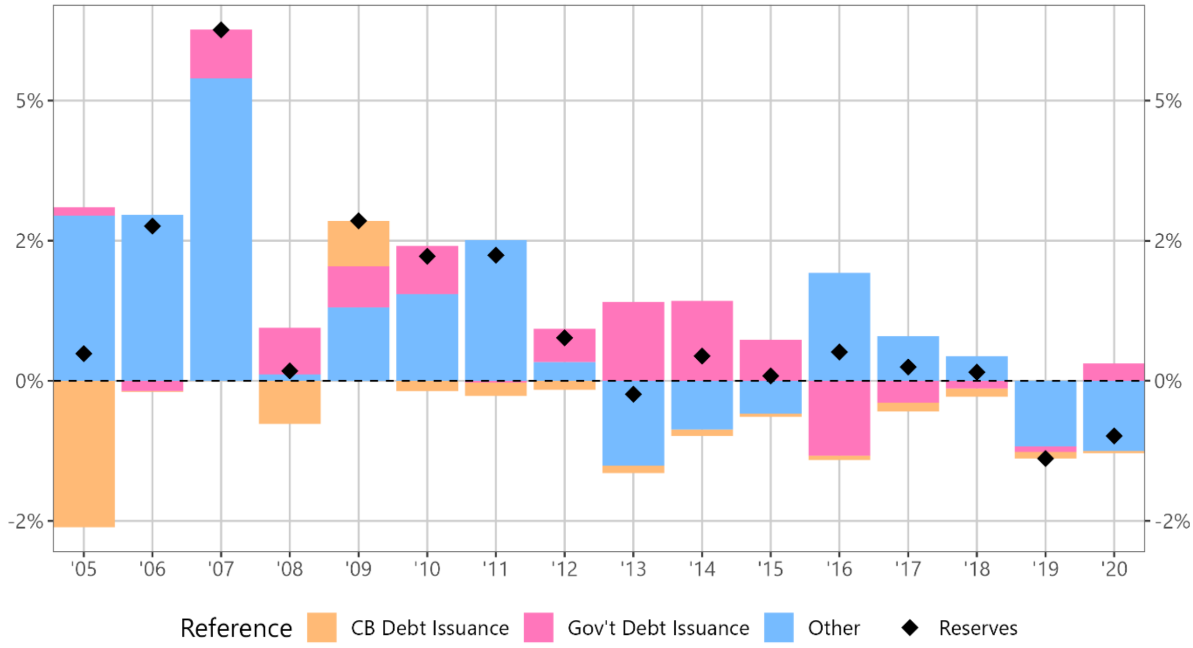


Note: Short-term debt includes all debt having an original maturity of one year or less and interest in arrears on long-term debt. Total reserves include gold.
Source: The World Bank Group.

Figure 3a: How are reserves built up?

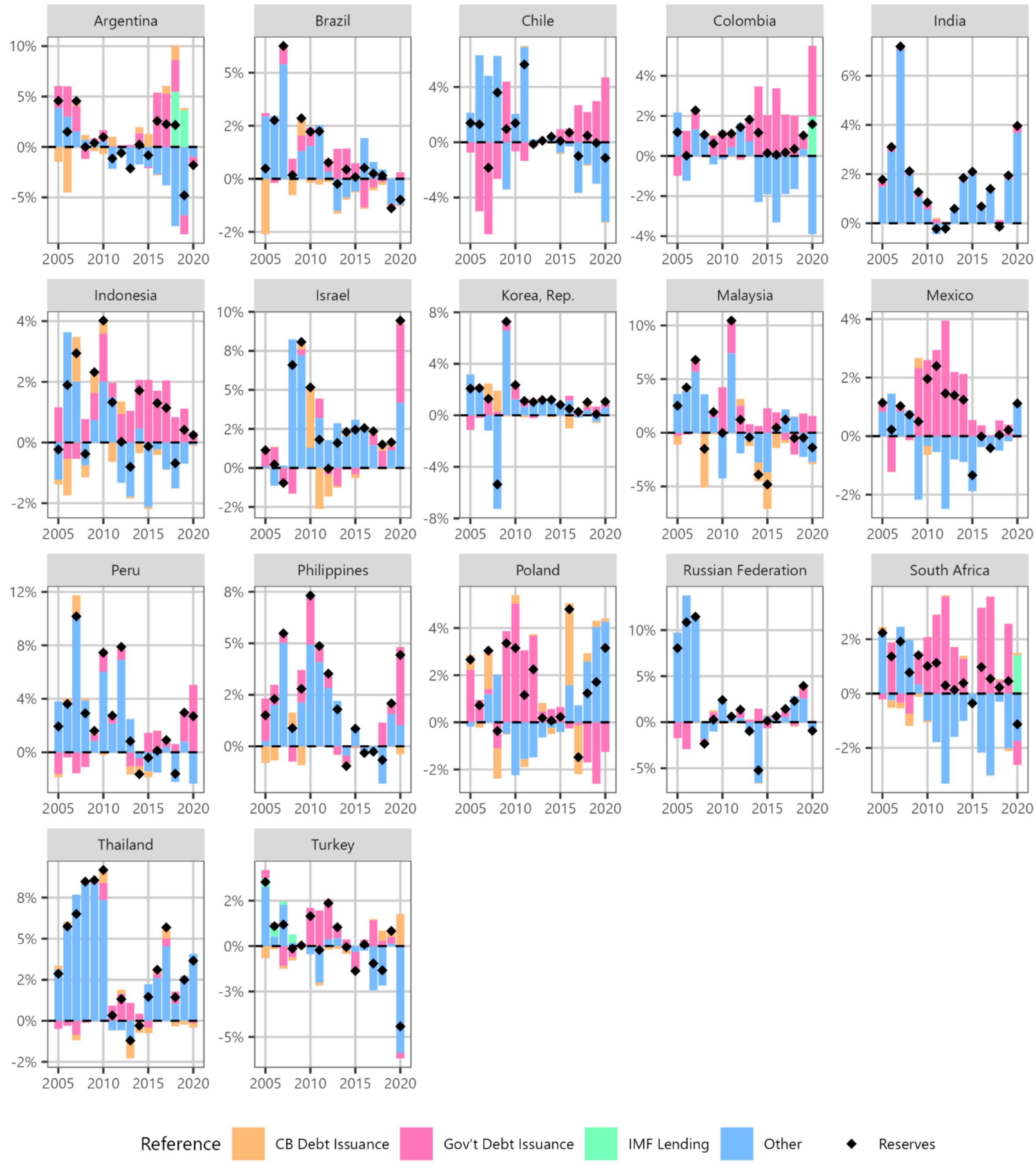
A reading from the Balance of Payments

Brazil (% of GDP)



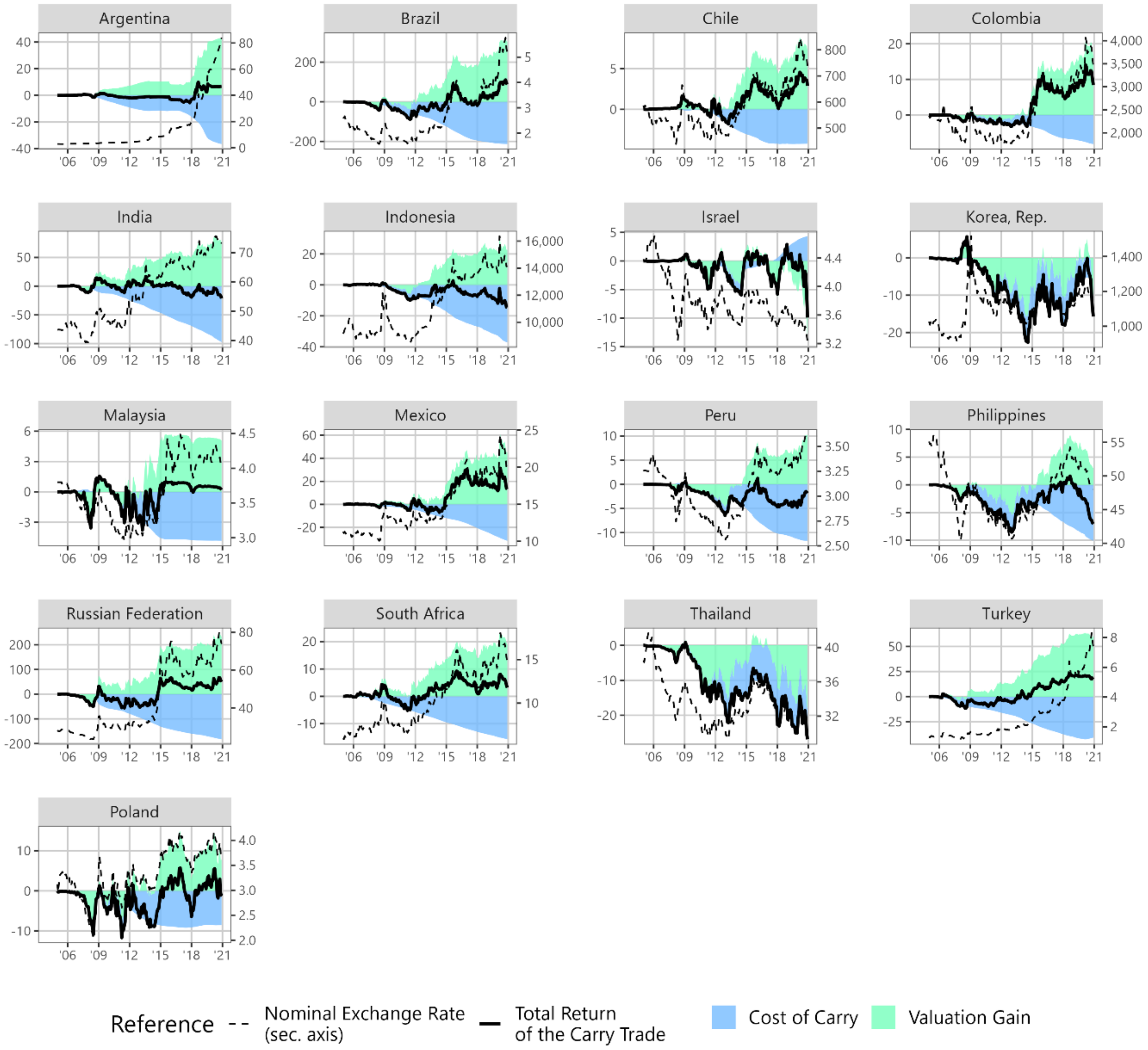
Note: "Reserves" are the annual change in the stock of official foreign exchange reserves, "CB Debt Issuance" and "Gov't Debt Issuance" are changes in the net foreign debt position of the Central Bank and the Central Government, respectively. "Other" are the remaining flows, different than dollar-debt-issuance, that cause reserve accumulation.
Source: Authors' estimates based on data from the IMF's Balance of Payments Statistics and The World Bank Group.

Figure 3b: How are reserves built up?
A reading from the Balance of Payments
(Selected countries, % of GDP)



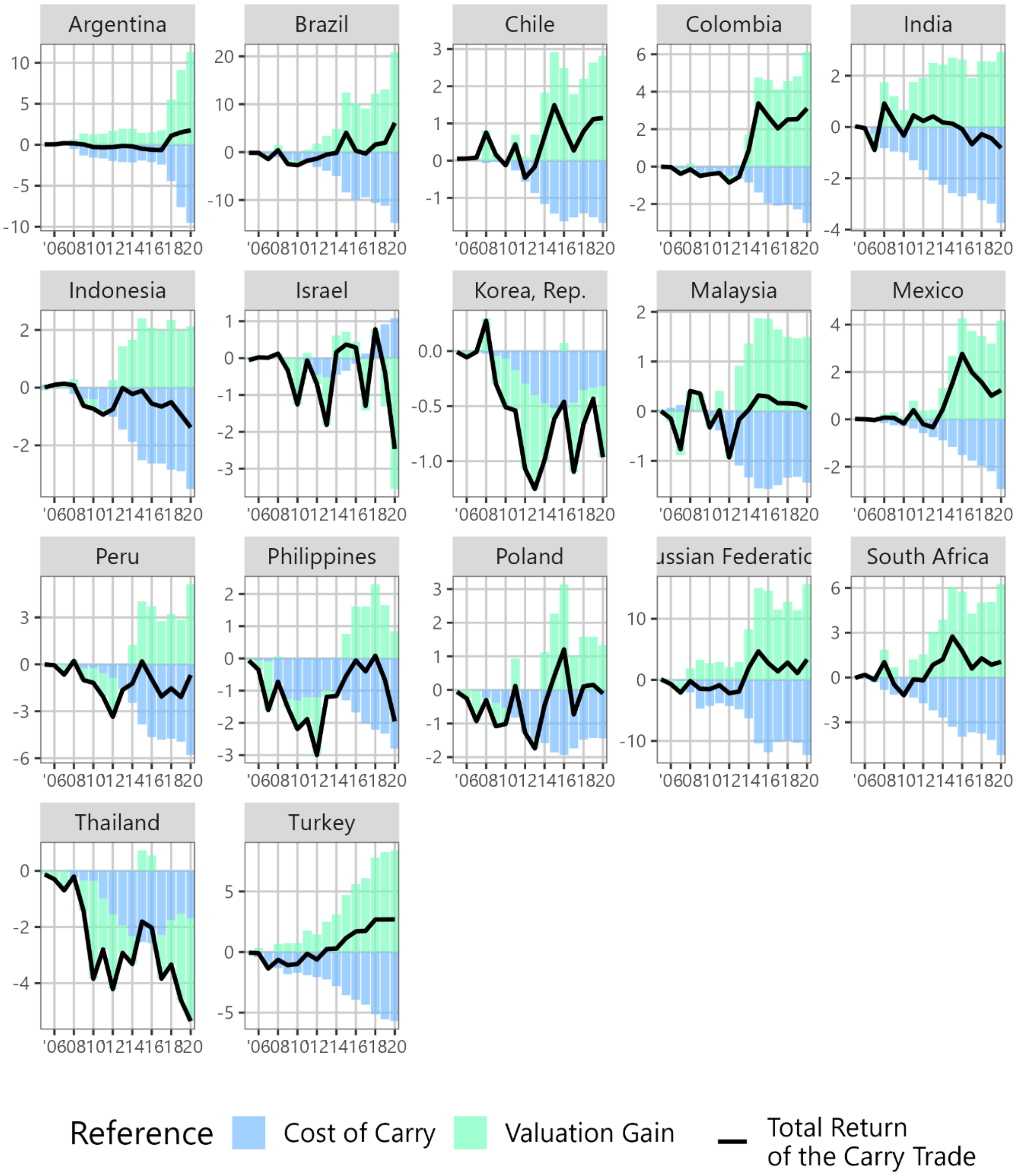
Note: "Reserves" are the annual change in the stock of official foreign exchange reserves, "CB Debt Issuance" and "Gov't Debt Issuance" are changes in the net debt foreign position (assets minus liabilities) of the Central Bank and the Central Government, respectively. "IMF Lending" are loan disbursements. "Other" are the remaining flows, different than dollar-debt-issuance, that cause reserve accumulation. GDP is the current Gross Domestic Product collected by the World Bank Group. Ostensibly, India reports less disaggregate data of their Balance of Payments to the IMF, and their "Other" category shown in this figure must not be considered as telling the whole story.
Source: Authors' estimates based on data from the IMF's Balance of Payments Statistics and The World Bank Group.

Figure 4: Cumulative monthly returns as measured by the carry-trade view
(Left Axis: USD billions // Right Axis: Local Currency Unit per unit of USD)



Source: Reserves and Nominal Exchange Rates are from IMF's International Financial Statistics, and carrying rates are three-month implied yields derived from the covered interest rate parity condition built by Bloomberg, L.P. Carry rate of Argentina was built as the difference between three-month central bank papers ('Lebacs') and U.S. Treasury rates of the same maturity up to 2018, then as the difference between the rate on the one-month central bank paper ('Leliq') and U.S. Treasury rates of the same maturity. Data on Argentina is from Argentina's Central Bank, and data on U.S. Treasuries are from the Federal Reserve Bank of St. Louis.

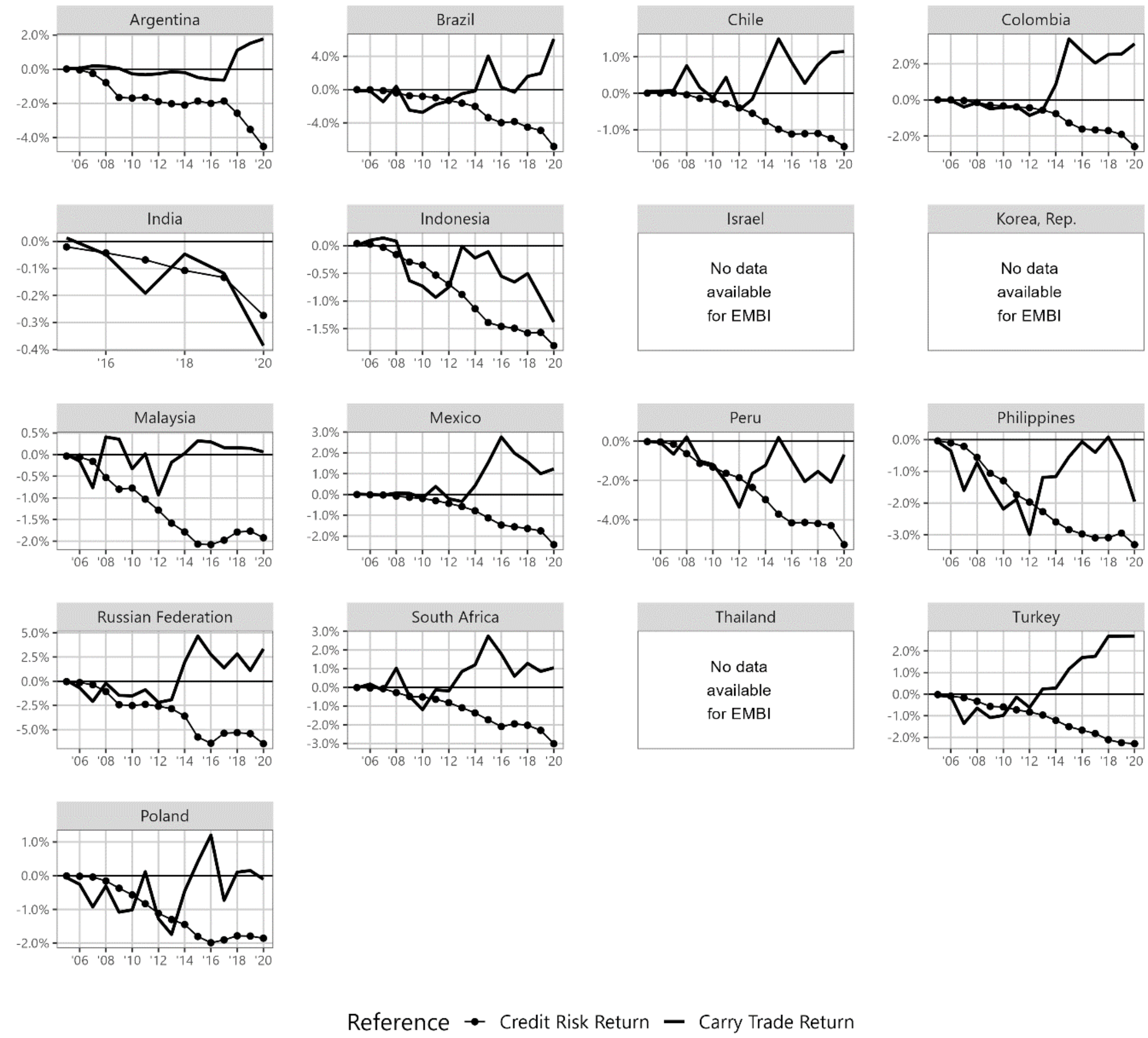
Figure 5: Cumulative annual returns as measured by the carry trade view
(% of GDP)



Source: Same as Figure 4, plus GDP from the World Bank Group.

Figure 6: Cumulative annual returns from reserve purchases as measured by the carry-trade and the credit-risk views

In Percent of GDP



Note: India starts in 2015, as EMBI data is available from there onwards. Credit Risk Return is proxied by EMBI + UST Term Premium (2y-5y). Carry-trade Return is the sum of Valuation Effect and the Cost of Carry.

Source: Same as Table 1.

Table 1: Carry-trade and the credit-risk views on the cost of reserves
Cumulative 2005-2020 returns as a percent of 2020 GDP (positive = gain)

	Carry Trade Return			
	Valuation Gain	Cost of Carry	Total	Credit Risk Return (*)
LAC				
Argentina (**)	15.1%	−12.5%	2.6%	−3.7%
Argentina (***)	11.3%	−9.5%	1.8%	−4.5%
Brazil	20.9%	−14.8%	6.1%	−6.9%
Chile	2.8%	−1.7%	1.1%	−1.5%
Colombia	6.1%	−3.0%	3.1%	−2.6%
Mexico	4.2%	−2.9%	1.2%	−2.4%
Peru	5.1%	−5.8%	−0.7%	−5.3%
Median	**6.1%**	**−5.8%**	**1.8%**	**−3.7%**
Average	**9.4%**	**−7.2%**	**2.2%**	**−3.8%**
Asia				
India (****)	0.3%	−0.6%	−0.4%	−0.3%
Indonesia	2.1%	−3.5%	−1.4%	−1.8%
Korea, Rep.	−0.6%	−0.3%	−1.0%	NA
Malaysia	1.5%	−1.4%	0.1%	−1.9%
Philippines	0.8%	−2.8%	−2.0%	−3.3%
Thailand	−3.7%	−1.7%	−5.4%	NA
Median	**0.5%**	**−1.6%**	**−1.2%**	**−1.9%**
Average	**0.1%**	**−1.7%**	**−1.7%**	**−1.8%**
EMEA				
Israel	−3.5%	1.1%	−2.5%	NA
Poland	1.3%	−1.4%	−0.1%	−1.9%
Russian Federation	15.6%	−12.3%	3.3%	−6.5%
South Africa	6.2%	−5.2%	1.0%	−3.0%
Turkey	8.4%	−5.7%	2.7%	−2.3%
Median	**6.2%**	**−5.2%**	**1.0%**	**−2.7%**
Average	**5.6%**	**−4.7%**	**0.9%**	**−3.4%**

Note: (*) Proxied by EMBI + U.S. Term Premium (2y-5y). These results are robust to other proxies of the U.S. term premium (such as the one between the Fed Funds rate and the 5-year Treasury, the 2y10y, the 3m-10y, and the FF10y). Results are available on request. (**) Excludes periods with foreign exchange restrictions in 2011-2015 and 2019-2020. (***) Full sample. LAC stands for Latin America and the Caribbean, and EMEA for Eastern European, the Middle East, and Africa.
Source: Same as Figure 4 plus EMBI from the World Bank Group and Bloomberg and the U.S. Term Premium from The Federal Reserve Bank of St. Louis.

Table 2: 2005-2020 Compound Average Growth Rate (CAGR) of returns of two trades: one following a carry-trade that mimics a LAW central bank and the other with a constant notional of 100 U.S. dollars over the whole period

(positive = gain)

	Carry Trade with variable size (LAW)	Carry Trade with Constant Size	Does the Central Bank outperform the constant size trader?
LAC			
Argentina (*)	0.28%	11.98%	No
Argentina (**)	0.11%	7.64%	No
Brazil	0.37%	−1.46%	Yes
Chile	0.07%	−0.98%	Yes
Colombia	0.19%	−1.24%	Yes
Mexico	0.08%	−0.16%	Yes
Peru	−0.04%	−1.34%	Yes
Median	**0.11%**	**−0.98%**	—
Average	**0.15%**	**2.06%**	—
Asia			
India	−0.05%	−0.45%	Yes
Indonesia	−0.09%	−1.93%	Yes
Korea, Rep.	−0.06%	−0.69%	Yes
Malaysia	0.00%	−1.03%	Yes
Philippines	−0.12%	−3.76%	Yes
Thailand	−0.34%	−2.88%	Yes
Median	**−0.07%**	**−1.48%**	—
Average	**−0.11%**	**−1.79%**	—
EMEA			
Israel	−0.16%	−2.23%	Yes
Poland	−0.01%	−0.98%	Yes
Russian Federation	0.21%	1.04%	No
South Africa	0.07%	0.62%	No
Turkey	0.17%	3.55%	No
Median	**0.07%**	**0.62%**	—
Average	**0.06%**	**0.40%**	—

Note: (*) and (**) Excludes and includes periods with foreign exchange restrictions in 2011-2015 and 2019-2020. respectively.
Source: Same as Figure 4.

Table 3: Variables and Sources

Name	Description	Source
Reserves	International Reserves and Liquidity, Liquidity, Total Reserves excluding Gold, Foreign Exchange, U.S. Dollar	IMF IFS Code: RAXGFX_USD
Exchange Rates	Exchange Rates, Domestic Currency per U.S. Dollar, End of Period, Rate	IMF IFS Code: ENDE_XDC_USD_RATE
Currency Composition of Reserves	Shares of Allocated Reserves, Percent	IMF COFER
2-Year and 5-Year U.S. Treasury yields	Market yield on U.S. Treasury Securities Constant Maturity, Quoted on an Investment Basis	St. Louis FRED Codes: DGS2, DGS5
U.S. Term Premiums	Market yield on Long-Term U.S. Treasury Securities Constant Maturity minus Market yield on Short-Term U.S. Treasury Securities Constant Maturity	St. Louis FRED Codes: T5YFF, T10Y2Y, T10Y3M, T10YFF
Local Currency Yields (except Argentina)	Implied yields are annualized interest rates for a given currency and tenor derived from the covered interest rate parity theorem. They are derived from the prevailing spot and forward rates for the currency versus the U.S. dollar for the corresponding time period, along with the U.S. interest rate for the same period.	Bloomberg, L.P.
Lebac, Leliq	Central Bank Rate of Argentina	BCRA
GDP	Gross Domestic Product (Current U.S. Dollars)	WBG Code: NY.GDP.MKTP.CD
EMBI	JO Morgan EMBI global index blended spread, in bps	The World Bank and Bloomberg, L.P.

Appendix

Following Dominguez, Hashimoto & Ito (2012), the definition of International Reserves used in this paper is foreign currency reserves, consisting of currency, securities, and deposits, excluding gold, SDR, the reserve position at the International Monetary Fund (IMF), and other reserve assets.

Let R_t be the stock of foreign exchange (FX) reserves reported in U.S. Dollars in month t. The variation of R_t can be attributed to (i) an actively managed component of FX reserves by the monetary authority plus (ii) a passive component outside of its control.

The passive component is usually associated with (a) the interest earned by the deposits and securities plus (b) any valuation effect arising from changes in the relative values of the reserve currencies. Due to the limited availability of long series of the currency profile of international reserves for individual countries, we assumed that reserves are allocated in the same currencies and by the same shares as the IMF reports in the COFER database for the aggregate of all 149 reporters.

For the interest income, we assume that all R_t is allocated in 2-year U.S. Treasuries. For the reserve´s currencies valuation effect, we compute the sum of foreign exchange monthly changes, weighted by its share of total reserves:

$$y_t = \sum_{k=1}^{K} \left(\frac{S_t^k}{S_{t-1}^k} - 1 \right) \cdot q_t^k \qquad (1)$$

Where $y_t$is the yield on the basket of reserves currencies, S_t^k and S_{t-1}^k are the spot exchange rates for the currency *k* in period *t* and *t-1*, respectively, and q_t^k is the percentage share that currency *k* represents in total reserves reported in the COFER database.

Thus, the level of FX Reserves net of the passive components, NR_t, can be defined as:

$$NR_t = \frac{R_t}{\left(1 + \frac{UST_t^{2y}}{12}\right) \cdot (1 + y_t)} \qquad (2)$$

Therefore, the reserves' monthly variation, ΔI, is our proxy of active intervention:

$$\Delta I_t = NR_t - R_{t-1} \qquad (3)$$

Let S_t and ΔS_t be the level and the monthly change of the exchange rate in month t, respectively:

$$\Delta S_t = S_t - S_{t-1} \qquad (4)$$

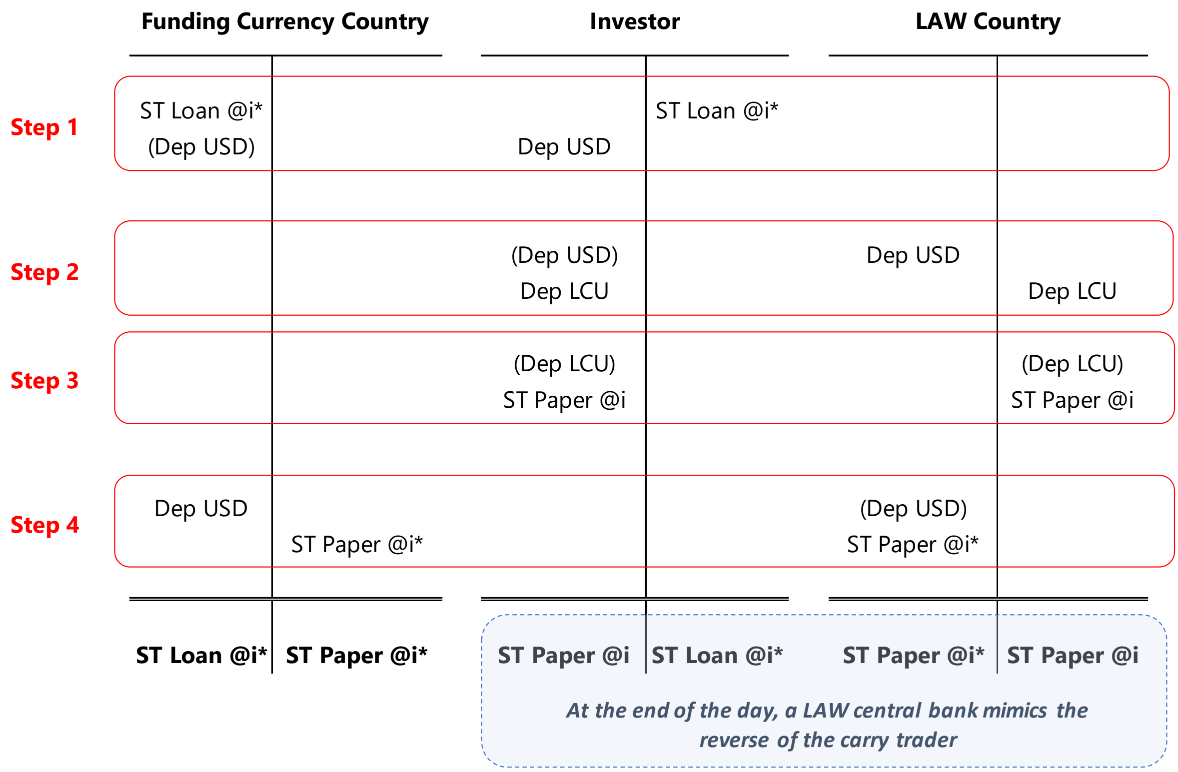
Our sample starts in January 2005: we compute cumulative sums of (3) as a proxy of stocks of reserves as if intervention started at the beginning of the sample period (as noted, the choice is arbitrary, and the criterion is to cover a sufficiently long time range to include complete exchange rate cycles):

$$NR_t^* = \sum_{Jan\ 2005}^{t} \Delta I_t \qquad (5)$$

Carry Trade Return Calculation

The cost of hoarding reserves for a central bank motivated by a LAW policy mimics the reverse of the carry trade. The following diagram illustrates the flow of funds: in step 1, an investor opens the carry by raising funds in a low-interest rate currency market (a so-called *"funding currency"* market). In step 2, the funds are brought to a high-interest rate currency market (a so-called *"carry currency"* market), then converted into local currency units and bought by the central bank. In steps 3 and 4, the investor and the LAW central bank open positions in short-term local currency paper and in short-term hard currency paper, respectively.

Figure A-1: Stylized balance sheets during the process of hoarding reserves by a LAW central bank



Note: LCU means Local Currency Unit. Dep USD and Dep LCU mean a deposit in USD and LCU, respectively. "i" and "i" mean the interest rate in LCU and USD, respectively. ST means Short-Term.*

At the end of the day, LAW mimics the reverse of the carry trader. In reality, as the central bank can go longer than the funding tenor of the trader, the monetary authority benefits from the term premium, which should be subtracted from the carrying cost.

However, this trade exploits rate differentials without an exchange rate hedge: if at the end of the trade, the valuation of the U.S. Dollar in terms of the local currency rose more than the interest rate differential, the whole trade reports a loss. Therefore, as the carry trade should be evaluated after the end of the trade to capture the valuation effect, the same applies to the LAW central bank: besides it pays the interest rate differential, it might report profits when this valuation effect comes into consideration "after the trade," which in this context means after the full exchange rate cycle.

Cost of Carry

Define x_t as the annual interest rate differential between the carry currency rate and the funding currency rate in month *t* as:

$$x_t = \frac{(1 + i_t)}{(1 + i_t^*)} - 1 \tag{6}$$

where i_t is the 3-month local currency local yield[18], and i_t^* is the 2-year market yield on U.S. Treasury Securities[19].

Then the central bank's P&L in month *t* is:

$$PNL\_Carry\_Monthly_t = -NR_t^* \cdot \left[(1 + x_t)^{\frac{1}{12}} - 1\right] \tag{7}$$

Nota bene: since the nominal interest rates are usually positive, the central bank's P&L from the carry is expected to be negative.

The cumulative P&L in month *t* is:

$$PNL\_Carry_t = \sum_{Jan\ 2005}^{t} PNL\_Carry\_Monthly_t \tag{8}$$

Valuation Effect

FX purchases valuation effect in LCU:

$$PNL\_Valuation\_Monthly\_LCU_t = NR_t^* \cdot \Delta S_t \tag{9}$$

FX purchases valuation effect in USD:

[18] Due to the limited availability of 2-year local currency yields for all countries, we use 3-months implied local rates derived by Bloomberg L.P. from the covered interest rate parity theorem (see Table 3 for the proper definition).

[19] By using the 2-year market yield on U.S. Treasury Securities we are capturing the short-term interest rate plus a term premium, as stated in Figure A-1 and the subsequent paragraph.

$$PNL\_Valuation\_Monthly\_USD_t = \frac{NR_t^* \cdot \Delta S_t}{S_{t-1}} \tag{10}$$

The cumulative valuation effect in month *t* is:

$$PNL\_Valuation_t = \sum_{Jan\ 2005}^{t} \frac{NR_t^* \cdot \Delta S_t}{S_{t-1}} \tag{11}$$

Total return of the Carry Trade

Finally, the total return of the carry trade is:

$$PNL\_Total_t = PNL\_Valuation_t + PNL\_Carry_t \tag{12}$$