Foreign exchange intervention and reserve accumulation in an emerging market economy: selected issues

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Abstract

The exchange rate plays a substantial role in the monetary and financial stability frameworks of emerging market economies. We look at the motivation behind foreign exchange intervention, including a thin foreign exchange market, high pass-through and foreign exchange as a determinant of inflation expectations. We examine how these features are reflected in the design of the new monetary regime in Argentina. Finally, we look at how reserve management policy can also incorporate the particular shocks faced by the economy.

JEL classification codes: E58, F31, G11

Keywords: monetary policy, foreign exchange, reserve management

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Note prepared for the meeting of Deputy Governors, the Bank for International Settlements, Basel, 14–15 February 2019. We wish to thank Sergio Barros, Gaspar Maciel, Pablo Orazi and Esteban Rodríguez for valuable inputs. Unless otherwise indicated, figure sources correspond to the Central Bank of Argentina (BCRA) data or own elaboration. All views expressed are the authors' own. References to monetary policy decisions are as of the BIS meeting's date.

1. Introduction

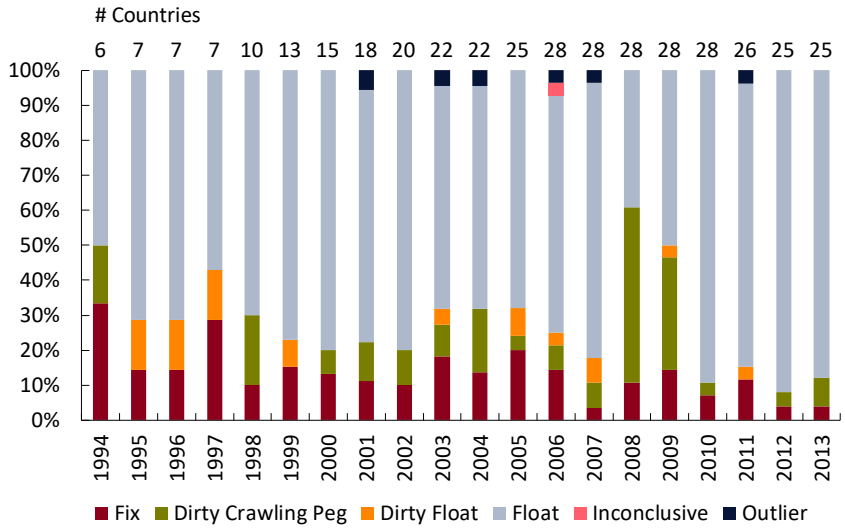
The role of the exchange rate in the monetary and financial stability framework is substantial in emerging market economies (EMEs), well beyond what is articulated in conventional schemes, including inflation targeting (IT) ones. In this note, we look at the motivation behind foreign exchange intervention in an economy like Argentina, including: thin foreign exchange market, high pass-through and foreign exchange as a determinant of inflation expectations. These factors can help rationalise Argentina's new monetary and FX regime, which is comprised of a monetary base growth target together with FX intervention and non-intervention zones. Just as monetary and FX policy design recognises the particular shocks the economy faces, reserve management policy should also incorporate them.

2. FX interventions and monetary policy

2.1 What countries do and how they perform

Measures like systematic FX intervention have long been part of the policy toolbox in developing countries, even in those that implement IT regimes. Actually, around 20% of IT countries do not have a purely floating exchange rate regime (Figure 1, with data as of 2013, the latest year available for the de facto exchange rate regime classification of Levy-Yeyati and Sturzenegger (2016)). This has changed over time, but what is just as revealing is that none of the 28 countries that have implemented IT since 1991 have always kept a purely floating exchange rate.

Inflation targeting countries and FX regime — Figure 1

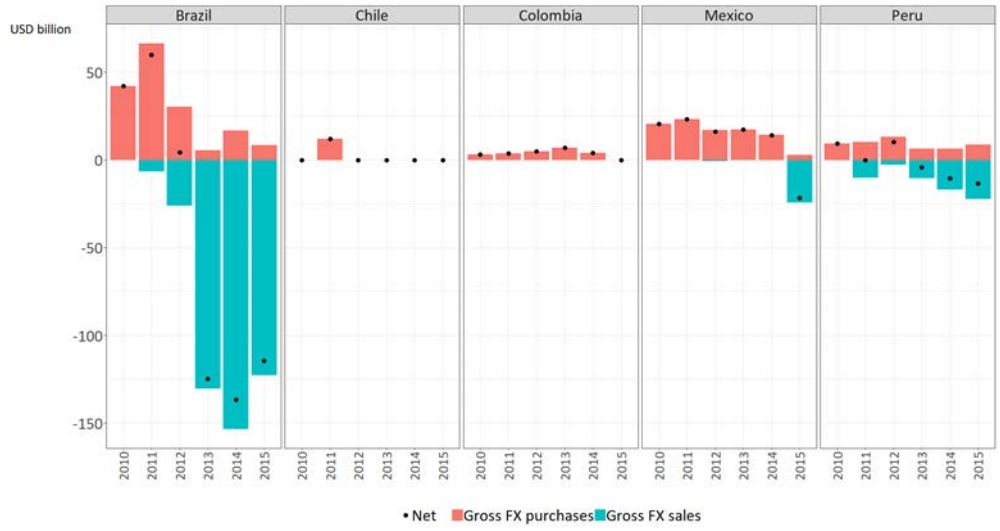


Sources: Own elaboration based on Levy Yeyati and Sturzenegger (2016). IT adoption dates taken from Mishkin and Schmidt Hebbel (2002), Hammond (2011) and central banks' information.

Figure 1 also reveals that periods during which several IT countries were not pure floaters coincide with events of high market volatility, generally unrelated to those economies' fundamentals, such as the Asian financial crisis in 1996-97 and the global

financial crisis in 2008. Latin America has been no exception to this behaviour; Chang (2008) points out that IT in Latin America differs systematically from the "Taylor rule cum pure floating" formula. Far from being a deviation from best practice in monetary policy by the countries in the region, it obeys to the need to shield their economies from abrupt changes in international financial conditions. In 1991, Chile adopted IT with FX bands; when it moved to pure floating in 1999, it left the door open to occasional interventions – as did the central bank in 2008 when it announced its decision to virtually double the stock of international reserves, and in 2011. In the face of the taper tantrum episode, the Central Bank of Brazil has implemented FX interventions through daily swaps of up to USD 3 billion a week since August 2013. In 2015, following plummeting oil prices, Colombia defined a rule to intervene as daily FX volatility exceeded a certain threshold. In Mexico, the central bank has intervened on several occasions; in 2017, as uncertainty linked to the North American Free Trade Agreement (NAFTA) renegotiation loomed, the central bank implemented a programme of future auctions for up to USD 20 billion. In Peru, a highly financially dollarised economy, the central bank has intervened in the FX market since IT was adopted. These are all examples of IT Latin American central banks that have intervened as exchange rate volatility was detrimental to their aims (Carrière-Swallow et al (2016a)); Figure 2 details the amount of such operations in recent years.

Latin America: FX intervention, selected central banks — Figure 2



Source: Carrière-Swallow et al (2016a).

Central banks intervene in the FX market for a variety of reasons, including price stability, financial stability and international reserve accumulation. Exchange rate pass-through (ERPT) has declined in Latin America in recent decades as monetary policy has gained credibility (Carrière-Swallow et al (2016b)), but these and other emerging regions continue to show higher ERPT coefficients than advanced economies. In countries with high and volatile inflation history, or in those subject to external shocks, FX intervention can help dampen the impact on the local prices of exchange rate fluctuations.

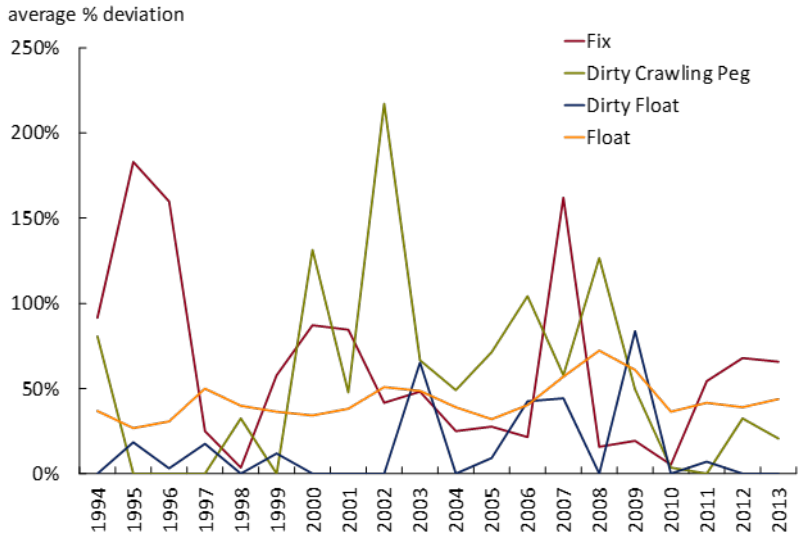
Dollarised assets and liabilities in the banking sector may also amplify exchange rate swings, jeopardising financial stability. There are multiple episodes in which a lack of FX liquidity was associated with large-scale financial crises with huge output

costs. In close relation to this, central banks intervene to accumulate international reserves: between 2010 and 2015, for example, Brazil, Colombia, Chile, Mexico and Peru accumulated reserves by amounts that range between 2 and 7 GDP points (Figure 2).

What is the inflation performance of countries that intervene in the FX market? Among IT countries, regimes that can be labeled as "dirty" floats tend to show over time lower deviations from target than purely floating ones (Figure 3). Indeed, during the 1994–2013 period, pure floats deviated from targets by 43% on average, while dirty floats did so by 30%.

IT countries: deviation from inflation targets and FX regime

Figure 3



Source: as in Figure 1. We computed percentage deviations from point targets, or from mid-point targets in the case of ranges, and averaged them across countries and years, for each de facto regime as classified by Levy-Yeyati and Sturzenegger (2016).

2.2. Analytical and empirical motivation for intervention

To gain a better understanding of the link between exchange rate regime and inflation, econometric studies control for different macroeconomic variables and possible endogeneity. Using a panel of 22 countries that adopted IT between 1990 and 2006, Aguirre and Burdisso (2008) find that developing countries with intermediate exchange rate schemes show some 2% to 3% lower annual inflation than pure floaters. In contrast, intermediate regimes appear to be associated with higher inflation than purely floating ones in advanced economies. Pourroy (2012) extends the analysis to IT countries during the global financial crisis, and finds that exchange rate intervention contributed to limiting the extent to which both inflation and excess inflation over the desired target increased, also dampening the loss of credibility in the face of an external shock. He concludes that the most credible central banks were not those that did what they said they would (ie follow "strict" IT with a Taylor rule and floating exchange rate), but those that enlarged their toolkit with other goals and tools (ie following "hybrid" IT). Berganza and Broto (2012) also find that while IT entails higher exchange rate flexibility, exchange rate intervention in IT countries has been more effective in reducing exchange rate volatility than in non-IT countries.

Thus, rather than relating exchange rate intervention to a higher or lower degree of monetary autonomy, it should be understood as one more tool that the central bank may use to smooth the volatility of the business cycle. For instance, Escudé (2009) builds a dynamic stochastic general equilibrium (DSGE) model to show that FX intervention together with interest rate policy are optimal for a large set of alternative policymakers' preferences, that give different weights to the volatility of different variables. For a broad set of preferences regarding growth, inflation and the current account, the model always yields that FX intervention, together with interest rate policy, deliver lower volatility than just using the latter tool with a floating exchange rate, or putting in place a peg (Table 1). Comparable results are obtained in smaller models that can b estimated more easily (Elosegui et al (2007)). Aguirre and Grosman (2010) use a structural model to assess empirically whether a managed floating regime is associated with lower volatility of key macroeconomic variables than under a pure floating or fixed exchange rate regime; their findings suggest lower volatility under managed floating in the case of Argentina.

Exchange rate regime and macroeconomic volatility in a DSGE model of Argentina Table 1

		Highest weight in policymaker's preferences given to:			
		Inflation	Growth	Trade balance	Equal weights
Monetary policy instruments	Interest rate and exchange rate	1	1	1	1
	Interest rate only (floating exchange rate)	2	2	2	2
	Exchange rate only (peg)	3	3	3	3

[1] 1=Minimum value for loss function

Source: Escudé (2009).

These models are part of general research literature aimed at reflecting analytically the way in which central banks use tools beyond the interest rate and assessing the advantages of managed floating in EMEs. Benes et al (2013) build an open economy new Keynesian model with a Taylor rule and sterilised interventions that operate through balance sheet effects in the financial system. They find that such policy combination allows the economy to be better cushioned to sudden changes in international financial conditions. In turn, Airaudo et al (2016) build an open economy model with two sectors and imperfect substitution between local and foreign assets. They find that pure floating involves a higher risk of multiple equilibria, which can induce volatility driven by self-fulfilled expectations and unrelated to fundamentals; and that small shocks may give way to much higher inflation. Both problems are solved by complementing interest rate policy with FX intervention.

These findings on FX regimes are in line with recent policy discussions in international financial institutions. Under certain conditions, EMEs may profit from employing intervention so as to contain excessive exchange rate volatility, unrelated to macroeconomic fundamentals (Ostry et al (2012)). In addition, both interest rate and intervention should be employed; Stone et al (2009) find that just including an

FX term in the interest rate rule may help reduce volatility of the exchange rate, the interest rate and the trade balance, but with higher volatility of inflation and output; see Annex I for a compilation of recent evidence on the effectiveness of intervention. The actual performance depends on the specific circumstances of each economy, but there are reasons to believe that FX intervention actually enhances the possibility of achieving policy objectives.

2.3 An integrated monetary policy framework: price stability and financial stability

While ERPT is endogenous and dependent on the monetary policy stance (see Palleja (2018) for an analysis of selected Latin American countries)), in an economy with a high inflation history and recurrent crises like Argentina, it continues to be a source of concern for inflation. ERPT coefficients for Argentina have declined in recent decades, but they continue to be four to eight times higher than other Latin American countries. The role of the exchange rate for expectations formation also stands out in estimated Phillips curves for Argentina in different periods (D'Amato and Garegnani (2009) and Krysa and Lanteri (2018)), where the coefficient for the exchange rate is several times higher than that for the output gap. As noted before, calibrated/estimated DSGE models of the Argentine economy also reveal a crucial role of the exchange rate in inflation dynamics.

In economies where the degree of financial dollarisation is significant, FX also has a financial stability dimension. Measures like intervention can also be understood as part of the macroprudential package (Agenor and Pereira da Silva (2018)). One way in which financial stability considerations may be incorporated into monetary policy making is by adding a credit growth gap to the conventional interest rule, thus making interest rate decisions dependent not only on inflation and output conditions, but also on excessive credit growth that can jeopardise financial stability. But in underdeveloped financial markets, the credit gap may not be a sufficient statistic of future financial distress. Financial intermediation is fundamentally about maturity transformation; but in shallow financial markets, maturity decisions may be compressed to, say, less than a year, with scarce long-term credit to speak of. Thus, the decision of lenders and borrowers may not be so much about how to smooth intertemporal consumption over a long period of time (through maturity transformation), but about how to allocate wealth in local or foreign currency (ie currency substitution). In the latter case, exchange rate swings may weigh on financial stability much more than could be expected, and may be a better indicator of financial distress.

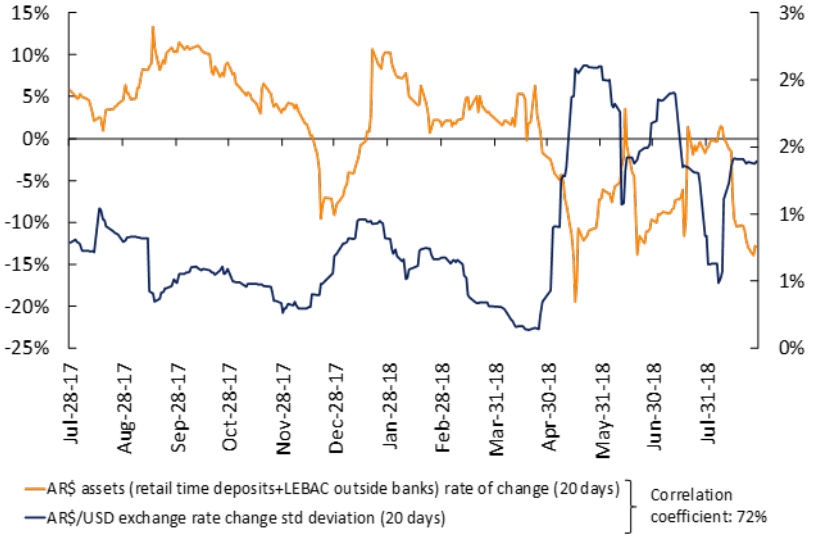
To take one example from Argentina: over time, exchange rate volatility is negatively associated with savings decisions in local currency. In recent years, for instance, the sum of time deposits and private non-financial sector holdings of central bank bills shows a negative correlation of 72% with nominal exchange rate volatility (Figure 4). Thus, in EMEs with an underdeveloped financial system and high dollarisation, augmenting the policy rule with the exchange rate may be just as relevant in terms of financial stability than by adding a credit gap.

In a relatively small FX market like that of Argentina, very small movements can become easily amplified. This reinforces the motivation for central bank intervention when such movements are unrelated to economic fundamentals. To give an idea of relative size: the daily turnover in the Argentine FX market represents 2% of the

volume traded in Mexico, 3% of that in Brazil, 15% in Chile, 24% in Colombia and 50% in Peru[2]. In such a small market, the difference that FX intervention makes is substantial (Figure 5). Between June and November 2018, the average daily gross turnover in the Argentine interbank FX market amounted to almost USD 600 million, but the net supply was USD 100 million on average, with net demand being almost twice that amount. This implies that even modest trades can be potentially disruptive (eg market turbulence that broke off in late May 2018 was triggered by sales of central bank bills from foreign investors in the order of USD 5 billion). FX intervention can make the difference between disruption and stability. Indeed, it is the absence of intervention that can be destabilising in such markets (Agenor and Pereira da Silva (2018)).

Argentine peso asset holdings by the public and exchange rate volatility

Figure 4



Finally, as nominal exchange rate variability translates into the real exchange rate, this may distort relative price signals to domestic producers. Much research has been devoted to examining EME central banks in the 2000s that intervened systematically to resist the real appreciation of their currencies in the face of capital inflows or positive terms of trade shocks. Levy Yeyati et al (2013) find evidence suggesting a robust, persistent and economically important effect of intervention on economic growth; a 10% intervention is associated with roughly a 0.11% increase in growth the following year, and to 0.22% increases in long-run growth over four years.

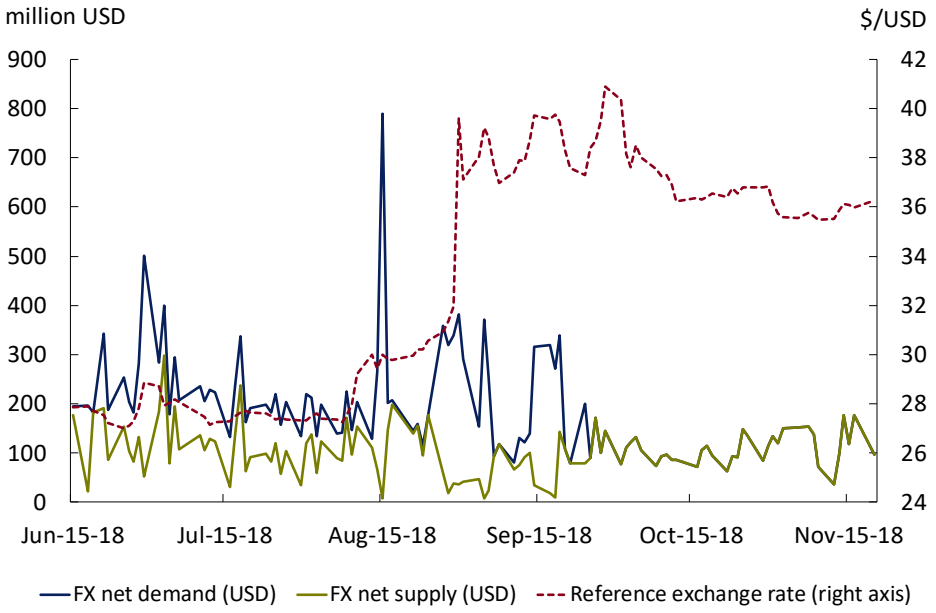
All things considered, monetary policy regimes that allow for some degree of FX intervention are based on the presence of one or more of the following conditions: (i) the high impact of nominal exchange rate movements on inflation or inflation expectations; (ii) the real exchange variability that distorts consumption and investment decisions; (iii) the impact of portfolio shifts between local- and foreign currency-denominated assets on financial stability; and (iv) underdeveloped FX markets. These conditions are summarised in Figure 6. As all four of them are met, a monetary policy regime that adds intervention as a tool is favoured. Whereas in countries where (i) ERPT is low, (ii) financial markets are developed and all risks on

[2] Data as of April 2016: see Table A1 in BIS (2017).

balance sheets (especially foreign currency ones) are moderate, and (iii) the real exchange rates act as a shock absorber rather than an amplifier, conditions tend to favour a purely floating exchange rate regime. In the following section, we link these concepts to the changes in monetary regime in Argentina that took place during 2018.

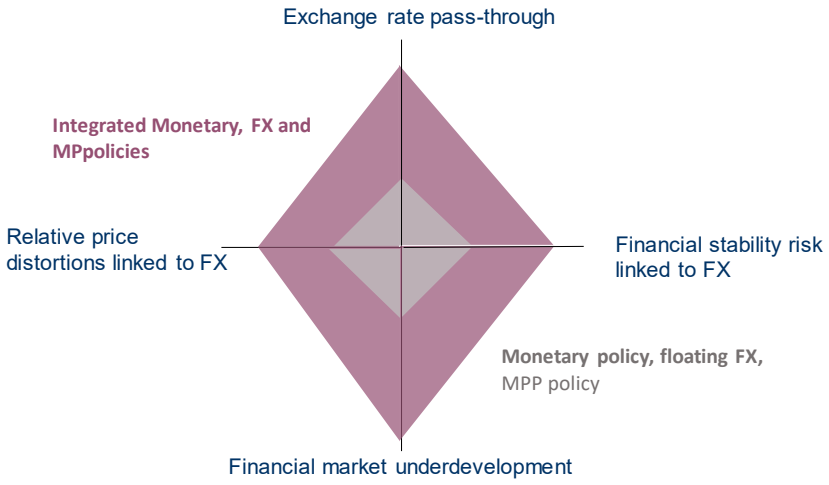
Argentina: interbank FX market net supply and demand

Figure 5



Conditions for the implementation of integrated and standard monetary and FX regimes

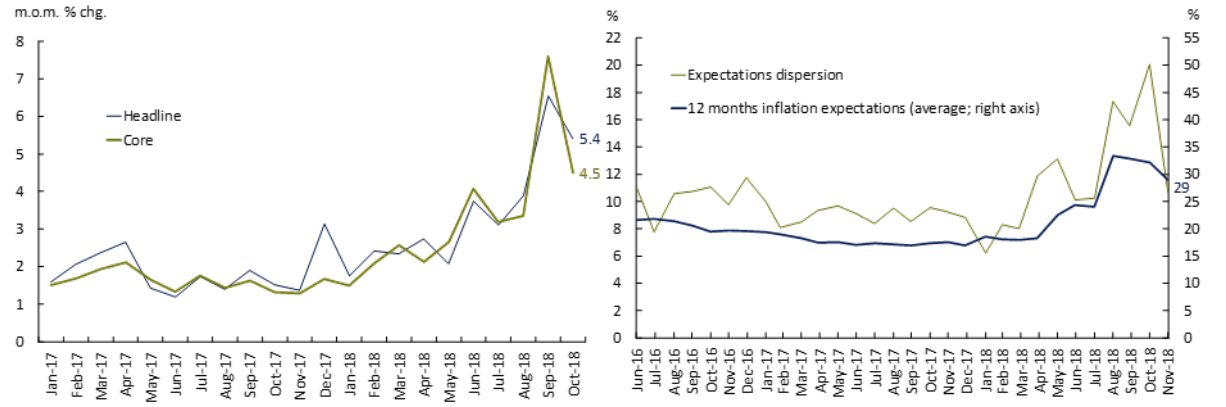
Figure 6



3. The new monetary policy scheme in Argentina

Argentina was among the countries that suffered the most from the tightening of financial conditions for EMEs that began in late April 2018. The local currency depreciated, with the US dollar gaining over 100% against the Argentine peso from April to September. This impacted both inflation and inflation expectations. Monthly inflation reached very high rates in September and October (6.5% and 5.4% month on month, respectively), while inflation expectations rose sharply, together with a higher dispersion of inflation expectations. All this pointed to a significant risk of de-anchoring of inflation expectations (Figure 7).

Argentina: inflation and inflation expectations — Figure 7

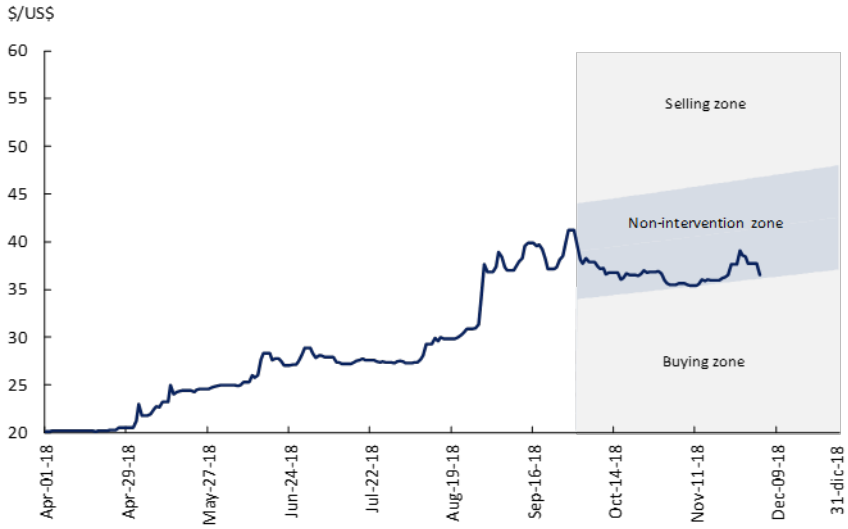


Deep changes in the monetary policy regime were initiated by the Central Bank of Argentina in response. The IT scheme was suspended, as it no longer ensured price stability. Since October 2018, the BCRA has been committed to a 0% growth target of the average monthly monetary base ; the growth target will be seasonally adjusted in December and June when money demand increases. As base money is under direct control of BCRA, the commitment to a monetary target is strengthened. Controlling liquidity limits both inflation acceleration and excessive FX depreciation. It is a very strict yet easy-to-follow target aimed at producing an expectation shock.

The 0% monetary growth target is complemented by FX intervention and non-intervention zones. The non-intervention zone is initially defined between ARS 34 and ARS 44 per 1 USD (as from 1 October 2018 and adjusted daily by a 3% monthly rate until end-2018; from January until March 2019 the monthly rate will be 2%). Within that band, the currency floats freely (Figure 8).

In the case of excessive depreciation of the peso, the central bank may sell FX reserves through daily auctions for up to USD 150 million. This makes sense in the face of decreased demand for peso assets; and entails a tighter policy stance as forex market intervention mops up excess peso liquidity. Should the peso appreciate strongly, the central bank may buy international reserves: monetary growth may become positive only in the face of increased confidence and higher demand for pesos. This scheme combines the benefits of floating with those of preventing excessive exchange rate volatility.

Argentina: exchange rate intervention and non-intervention zones Figure 8



The results since the implementation of the monetary growth target have been positive:

In October and November 2018, the target was overachieved, as the average monetary base was 1.5% and 1.2% below the target, respectively. The exchange rate has also appreciated within the non-intervention zone since implementation. This plan is sustainable for several reasons: (i) the real exchange rate is competitive; (ii) there is no fiscal dominance; and (iii) the central bank's balance sheet is stronger.

- The design of the non-intervention zone is consistent with external competitiveness. The real exchange rate at the upper bound is comparable to 2003, when the local currency was at record levels of depreciation. In turn, the lower bound involves a real exchange rate comparable with that of 2010–11, consistent with a balanced current account.
- Fiscal dominance has been eliminated, ie central bank financing of the Treasury decreased from 4.6% of GDP in 2015 to 0.2% in 2018 and 0% henceforth. The fiscal balance in 2019 and surplus in 2020 guarantee zero transfers to the Treasury; the Treasury financing needs are already covered by the standby agreement with the IMF.
- The new monetary policy has been implemented with a stronger BCRA balance sheet. Interest-bearing liabilities have dropped by more than one half in terms of GDP. The coverage ratio between interest-bearing liabilities and international reserves has more than doubled.

The central bank has adopted this plan in order to signal the strongest possible commitment to price stability, taking into account the importance of the exchange rate in inflation expectations and financial stability. Over time, IT may be re-implemented as inflation goes down and conditions for its adoption are met. But at this point, the priority is to recover a nominal anchor.

Just as the monetary policy regime recognises the type and magnitude of shocks that hit the economy, so does the reserve management strategy. The next section deals with this issue.

4. International reserve management and external shocks

Central banks hold reserves for a variety of reasons, but mainly as a liquidity insurance to mitigate country exposure and vulnerability to external shocks. For EMEs, the exposure to capital flows is high, as they are more dependent on external savings. As soon as a sudden stop occurs, the country's current consumption capacity is significantly reduced and the marginal value of an extra unit of reserves increases.

Although insurance arrangements (eg contingent credit lines and bilateral swap agreements) could help address these precautionary needs, the decision to hold a large amount of international reserves has been an attractive self-insurance mechanism, as it is under the full discretion of the country that holds them. This decision has challenged central banks and reserve managers' jobs.

Central banks usually focus on three pillars to manage their reserves: safety, liquidity and return. The investment of international reserves that covers precautionary purposes generally privileges safety and liquidity, whereas the investment of "excess balances" places a greater weight on returns.

Caballero and Panageas (2004) analyse the (non-contingent) reserves' management strategy typically followed by central banks, and conclude that the strategy of immobilising large amounts of cash to insure against jumps in volatility and risk-aversion is clearly inferior to one in which portfolios may include assets that are negatively correlated with external shocks, such as terms of trade and capital flows' volatility.

In oil-producing countries, for example, a sharp drop in the price of oil can significantly affect not only the growth of the economy but also the fiscal balance. Therefore, the correlation between changes in the oil price variations and in the price of financial assets should also be considered to construct a portfolio of financial assets whose main purpose is to provide a liquidity insurance against shocks. Sometimes countries have natural hedges that reduce the need for a sophisticated investment strategy. For example, Argentina produces soybean, which tends to increase in price when the crop falls. This type of adjustment may explain why some countries, particularly commodity economies, find little incentive to buy insurance or assets that provide hedging against these kind of shocks. But in many cases, this is patently suboptimal.

In 2017, the BCRA started to develop a new model to set up its strategic asset allocation decision. Under the new model, the optimisation is run in a different risk/return framework, one where risk is not limited to the volatility of financial assets but expanded to consider the volatility in the reserves' portfolio caused by external shocks.

This type of model considers the role of FX reserves within the balance sheet of the economy as a whole, where contingent liabilities may arise due to both the role of the central bank acting as a financial agent of the national government, as well as the interaction that the central bank has with the private sector, for monetary and exchange regulation purposes (see the Annex for more details of the model).

The introduction of external shocks in the process of optimising the asset allocation of international reserves generates very important changes in the composition of the efficient frontier. These changes depend, to a large extent, on the relative importance of each shock within the balance sheet of the economy (see Annex II for details).

For example, financial shocks (captured as changes in Argentina's country risk index) account for two thirds of the variability produced by external shocks, and real shocks (changes in terms of trade) explain the third remaining part. Therefore, the hedge of financial shocks is one of the main factors that started to influence the strategic allocation decision for BCRA reserves.

Once hedge properties are considered, the asset allocation decision might drastically change. For example, under a traditional optimisation, where the objective is to minimise the volatility of financial assets, a highly risk-averse fixed income investor should tend to choose short-term bonds, as they tend to provide lower volatility for the financial asset's portfolio. However, once the definition of risk is expanded to include the volatility from external shocks, the optimisation will tend to give more preference to hedge assets like long-term bonds and, paradoxically, the greater the weight of these assets within the portfolio, the lower the volatility of the portfolio (due to the hedge provided).

Under stress scenarios, when reserves are more needed, US Treasuries tend to rally, especially in the long end, and the US dollar tends to appreciate. In contrast, other currencies tend to depreciate, being less attractive for those EMEs looking to reduce their vulnerability in terms of trade shocks. This kind of relationship is usually ignored in traditional optimisations. Moreover, gold, a traditional safe haven asset for most central banks, has usually been underestimated in traditional efficient frontiers, as their hedge properties are ignored.

Although this general idea is very straightforward, empirical or practical implementations are rare, probably due to reputational risks. An efficient strategy in terms of immunisation may be suboptimal in terms of the efficiency observed in the central bank's balance sheet, since it will be exposed to greater volatility.

The implementation of these strategies in practice is not simple. However, central banks should try to improve their risk management strategies when investing FX reserves in assets that yield the highest returns at the time when most needed or, at least, that do not correlate positively with negative shocks.

5. Concluding remarks

The importance of the exchange rate in EMEs' monetary policy formulation cannot be overemphasised. A country should be closer to adopting an integrated framework of interest rate policy, FX intervention and macroprudential policy depending on the importance of (i) exchange rate pass-through; (ii) financial stability risks due to foreign exchange volatility; (iii) financial market underdevelopment; and (iv) relative price distortions linked to FX volatility.

Argentina is a case in point, with a thin FX market, high ERPT and foreign exchange as an important determinant of inflation expectations. These features are reflected in the design of Argentina's new monetary and FX regime, which is comprised of a monetary base growth target that is complemented by FX intervention

and non-intervention zones. While the central bank remains committed to bringing down inflation, it recognises the important role the exchange rate plays in price and financial stability.

Finally, just as in the case of monetary policy design, reserve management strategies should also incorporate the particular shocks the economy is subject to and the tools to deal with them. This includes developing investment strategies that consider assets that yield the highest returns at the time when they are most needed, or that do not correlate positively with negative shocks.

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Annex I: Selected papers on the effectiveness of FX intervention

Paper	Period	Region/country	Results
Berganza and Broto (2012)	1995–2010	37 countries (emerging market and developing economies)	Using a panel data model, they find that although IT leads to higher exchange rate instability than alternative regimes, forex interventions in some IT countries have been more effective in lowering volatility than in non-IT countries.
Blanchard et al (2015)	1990–2013	35 countries (emerging market and advanced economies)	Using VAR estimations, they find that larger FX interventions lead to less exchange rate appreciation in response to gross capital inflows.
Fratzscher et al (2018)	1995–2011	33 countries (advanced, emerging market and developing economies)	They find that FX market intervention has been very effective in smoothing the path of exchange rates, and in stabilising the exchange rate in countries with narrow band regimes.
Daude, Levy Yeyati and Nagengast (2016)	2003–2011	18 countries (emerging market economies)	Using an error-correction model approach, they find that on average, intervention is effective in moving the real exchange rate in the desired direction, controlling for deviations from the equilibrium and short-term changes in fundamentals and global financial variables. Also, they find some evidence of more effective interventions for large deviations from the equilibrium.
Chamon, Garcia and Souza (2017)	2013–2015	16 countries (emerging market and advanced economies)	In the aftermath of the taper tantrum, the Central Bank of Brazil announced a major programme of sterilised FX intervention. They use a synthetic control approach to estimate its impact on the level and volatility of the exchange rate. The counterfactual results, based on the experience of other emerging market economies, indicate the programme led to an appreciation of the Brazilian real in excess of 10%.
Oliveira (2018)	2006–2016	Brazil	They find that both spot interventions FX swaps are capable of affecting the conditional mean of the process of the nominal exchange rate in all the sample period. They estimate continuous time models using a GMM analysis.
Nedeljkovic and Saborowski (2017)	2008–2013	Brazil	Using instrumental variable regressions, they find that the Central Bank of Brazil appears to use spot intervention more than derivatives-based intervention in reaction to daily movements in the exchange rate and to capital flow pressures. Conversely, it is more likely to use futures-based intervention to smooth trend movements in the exchange rate and when price pressures dominate.
Claro and Soto (2014)	Two event study: 2008 and 2011	Chile	They analyse two central bank interventions that occurred in 2008 and 2011. Although successful in terms of mitigating exchange rate volatility, these interventions entailed some costs. Before these intervention episodes, the balance sheet position of the central bank was already weak. With the amount of reserves accumulated following intervention (of the order of 5.5% of GDP), the balance sheet mismatch has increased, and the cost of carrying reserves has amplified the negative profits of the central bank.
Kuersteiner et al (2018)	2001–2012	Colombia	They apply regression discontinuity methods to identify the surprise component of rules-based interventions and use this variation to measure how they affect exchange rates and capital flows. The results indicate that interventions had significant effects on the exchange rate, albeit short lived (2–3 weeks).
Tobal and Yslas (2016)	2000–2013	Mexico and Brazil	By applying the VAR methodology, they conclude that FX interventions only have had a short-lived effect on the exchange rate in both economies.
Rossini, Quispe and Serrano (2014)	2007–2013	Peru	The sterilised intervention in the FX market and the use of reserve requirements on local banks' foreign currency liabilities have contributed significantly to reducing excessive exchange rate volatility in Peru.
Durán-Vanegas (2016)	2003–2015	Peru	They examine the interventions in the spot FX market with two methodologies: event study and a threshold econometric model. The results indicate that interventions reduce exchange rate volatility and change the trend of the exchange rate in periods of extreme volatility.

Annex II: The BCRA's new model for reserves' allocation decision

In Argentina, the two most common sources of external volatility are real terms of trade shocks and financial shocks. These shocks are quantified into a time series of cumulative wealth shocks by constructing a synthetic asset proportional to the size of the BCRA's FX reserves, which is then detrended to avoid biases and expected returns different than zero in order to focus only in the correlation of this synthetic asset with the financial assets' portfolio (Figure 9).

This synthetic asset is then incorporated into an optimisation framework similar to the one proposed by Gintschel and Scherer (2008), which seeks to minimise the variance of a portfolio of reserves $Var(r)$ allocating an omega ω proportion to a synthetic asset and the remaining $1-\omega$ to a portfolio of financial assets whose weights are described by the vector w:

$$min\ Var(r) = \omega^2\sigma^2_{Act.Sint.} + (1-\omega)^2 w^T \Sigma w + 2\omega(1-\omega)\sigma^2_{Act.Sint.} w^T \beta$$

The variance to be minimised is composed of a first term that reflects the volatility of the synthetic asset, a second term that reflects the volatility of the portfolio of financial assets $w^T \Sigma w$ and a third term $2\omega(1-\omega)\sigma^2_{Act.Sint.} w^T \beta$ that reflects the correlation between synthetic assets and the portfolio of financial assets. The beta β contains the sensitivities of each financial asset in relation to the synthetic asset.

The problem is solved subject to the following restrictions:

$$1^T w = 1$$

$$E(r_i)^T w = \mu$$

$$w_i \geq 0\ \forall w_i$$

$$CVaR_{95\%}(r^T w) < CVaR_{limit\ 95\%}$$

That is, the optimisation must comply that the sum of the weights assigned to each asset total 100%, that the assets have a non-negative weight, that the financial assets have the expected yield (μ) that has been projected based on their risk factors, and that changes in the market value of the portfolio of financial assets do not exceed a given threshold set in terms of its Conditional Value-at-Risk ($CVaR$).

Synthetic asset (cumulative shocks) Figure 9