The size of foreign exchange reserves

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Abstract

This paper assesses the determinants of foreign exchange (FX) reserves in emerging market economies (EMEs). First, it reviews the drivers behind reserve accumulation and the metrics used to evaluate reserve adequacy. We argue that precautionary motives, at least until early 2000s, were the main drivers of reserves accumulation for most of the countries. However, more recently, goals related to monetary and exchange rate policies also play significant roles. Next, the paper evaluates the costs of holding reserves, both at the domestic and global levels. In particular, we highlight the low rate of return on reserves assets and valuation risks that EMEs face. We also discuss the possible role of higher reserves in reducing US long term interest rates. Finally, the paper discusses some supportive and alternative policies such as macroprudential policies and swap agreements, which could alleviate reliance on reserve accumulation.

Keywords: Foreign exchange reserves, reserve adequacy, precautionary demand, export competitiveness

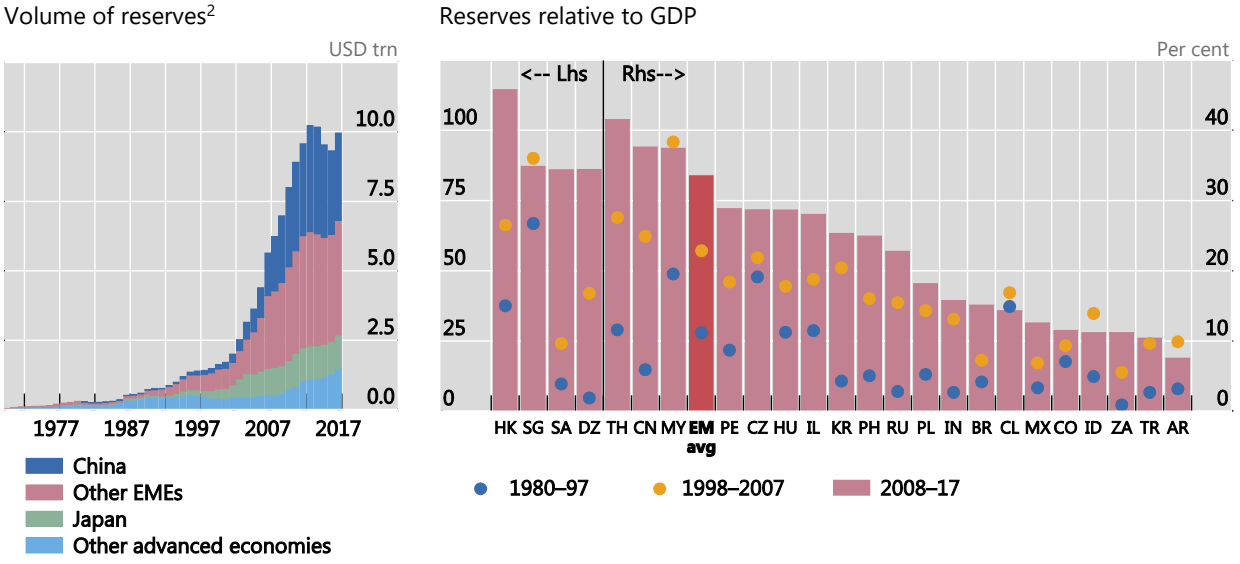
JEL classifications: F3, F31, F36, F41

1. Introduction

The foreign exchange (FX) reserves of emerging market economies (EMEs) have surged since the early 1990s. On average, the level reached almost 30% of GDP in 2018 from about 5% in 1990 (Graph 1). At the same time, cross-country differences are significant (Graph 1, right-hand panel). Even after the slowdown since 2010, Asian EMEs and oil exporters, notably Algeria and Saudi Arabia, hold the largest stocks relative to GDP.

This paper discusses the determinants of the size of EME FX reserves. It first reviews the reasons for reserve accumulation. It then analyses the trade-offs, by considering the main costs. Finally, it considers the extent to which other policies can reduce the need for reserves.

EMEs have accumulated large amounts of reserves[1] Graph 1



[1] AR = Argentina; BR = Brazil; CL = Chile; CN = China; CO = Colombia; CZ = Czech Republic; DZ = Algeria; HK = Hong Kong SAR; HU = Hungary; ID = Indonesia; IL = Israel; IN = India; KR = Korea; MX = Mexico; MY = Malaysia; PE = Peru; PH = Philippines; PL = Poland; RU = Russia; SA = Saudi Arabia; SG = Singapore; TH = Thailand; TR = Turkey; ZA = South Africa. [2] Only the EMEs listed in the right-hand panel.

Source: IMF.

2. Reserve accumulation: goals and benefits

Central banks accumulate reserves for a wide variety of reasons. A typical explanation highlights the precautionary role of holding reserves. Nevertheless, and depending on the country, reserves are accumulated also as a *by-product of* other factors, including the pursuit of price and financial stability, and even export competitiveness.[1] In this section, we briefly discuss these goals and some of the benefits of reserve holdings. Annex 1 provides an illustrative econometric analysis that attempts to disentangle and quantify the effects of various goals on reserve

[1] "Export competitiveness" is often referred to as the "mercantilist" motive.

accumulation. *FX intervention: goals, strategies and tactics* prepared for this meeting presents responses to a survey of central banks participating in the meeting regarding their own goals.

2.1 The precautionary motive

EMEs have experienced frequent crises since the 1980s: Latin America in the 1980s, Mexico in 1995, East Asia in 1997, Russia in 1998, Turkey in 1994 and 2001, Brazil in 1999, and Argentina in 2002 and 2018. One salient characteristic of these crises has been sudden stops in capital flows, which have disrupted the financial system and caused large and mostly permanent output losses.[2]

Having been burnt so many times, EMEs have naturally become more cautious. Given also the absence of a fully adequate global safety net, they have accumulated reserves in part as a form of self-insurance (Carstens (2018)). Over the last couple of decades, the rapid increase in gross financial flows, the resulting outsize external stocks in relation to GDP and the growth of domestic financial systems have all strengthened this precautionary motive. True, for most EMEs, current levels are above traditional reserve adequacy measures (Box 1).[3] That said, given the underlying uncertainty, judging reserve adequacy remains very challenging. This, in turn, further encourages prudence (contribution from Mexico).

The experience during and since the Great Financial Crisis (GFC) indicates that reserves help EMEs navigate stormy waters. For example, during the GFC the EMEs that held relatively more reserves experienced smaller currency depreciations (Graph 2, left-hand panel; see also the contribution from Saudi Arabia for a related discussion). This was also the case during the taper tantrum in 2013 and the recent turmoil in Argentina and Turkey (same graph; see also Davis et al (2018)).[4] Such benefits are naturally reflected in other variables: GFC-induced output losses (Llaudes et al (2010), Silva (2011));[5] the probability of facing a crisis (García and Soto (2004)); smoother credit growth during the GFC (Graph 2, third panel); lower borrowing costs (Graph 2, fourth panel; see also the contributions from Korea, Saudi Arabia and South Africa); and more stable credit ratings and access to external funding (contributions from Brazil and Indonesia). Moreover, large stocks of reserves could be deployed under stress in order to provide liquidity in foreign currency to domestic financial

[2] Traditional current account vulnerabilities are related to shortfalls in export earnings or outsize increases in import needs (Ghosh et al (2014)). Capital account vulnerabilities arise from sharp cutbacks in funding by non-residents or capital flight (Obstfeld et al (2010)). Borio and Disyatat (2015) argue that gross flows, and associated stocks, are much more relevant than current accounts for financial stability concerns. Nakamura et al (2013) find that crises, like the ones EMEs have experienced, lower consumption on average by 15% in the long run. For a discussion of the roles of globalisation and that of residents and non-residents, see eg Beck et al (2013), Pereira da Silva (2015) and Obstfeld et al (2010).

[3] Clearly, the more dollarised an economy, the larger the need for a precautionary buffer (contribution from Peru).

[4] Graph 2, like the other graphs in this note, shows simple correlations and does not seek to identify causality. A more systematic analysis is beyond the scope of this note.

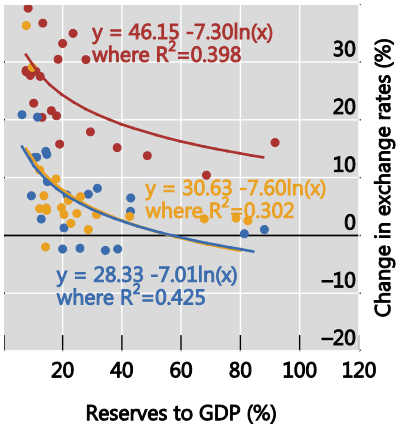
[5] However, benefits tend to diminish rapidly and become negligible at a high level of reserves.

institutions and non-financial companies, thereby preventing or mitigating a credit crunch (contributions from Chile, Peru, and Poland).[6]

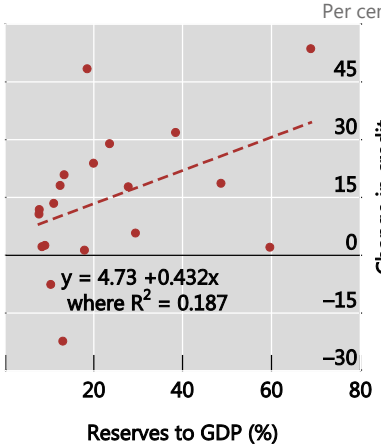
High-reserve countries suffer less from major shocks[1]

Graph 2

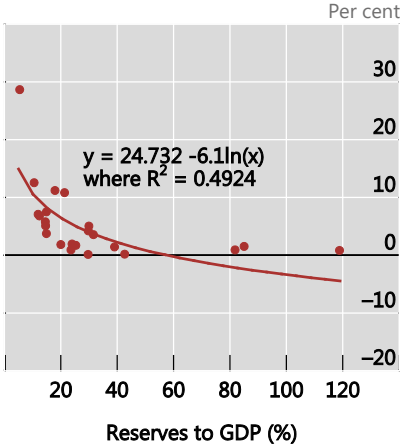
Nominal exchange rates: GFC, taper tantrum and turmoil in Argentina and Turkey[2]



Reserves in 2006 and changes in credit during the GFC[3]



Reserves and three-month borrowing costs[4]



- Great Financial Crisis
- Taper tantrum
- Turmoil in Argentina and Turkey

[1] For some panels, due to data availability, only a subset of the countries presented in Graph 1 is used. A solid (or dashed) regression line refers to significance (or insignificance) at the 5% level. [2] Peak-to-through depreciation in nominal exchange rates between 2006 and 2009, and reserves levels in 2006 are used for GFC. For the taper tantrum episode, exchange rate changes between the first and fourth quarters of 2013, and reserves levels in 2012 are used. For the turmoil in Argentina and Turkey, the exchange rate changes between the second and third quarters in 2018, and reserves levels in 2017 are used. [3] Changes in credit stocks relative to GDP from the first quarter of 2007 to the last quarter of 2009. [4] 2014–18 averages of three-month borrowing rates and reserves to GDP ratios are used.

Sources: IMF; Datastream; national data; BIS; BIS calculations; authors' calculations.

[6] Of course, for this purpose, reserves could be accumulated by borrowing ("borrowed reserves"). FX swap lines perform a similar function.

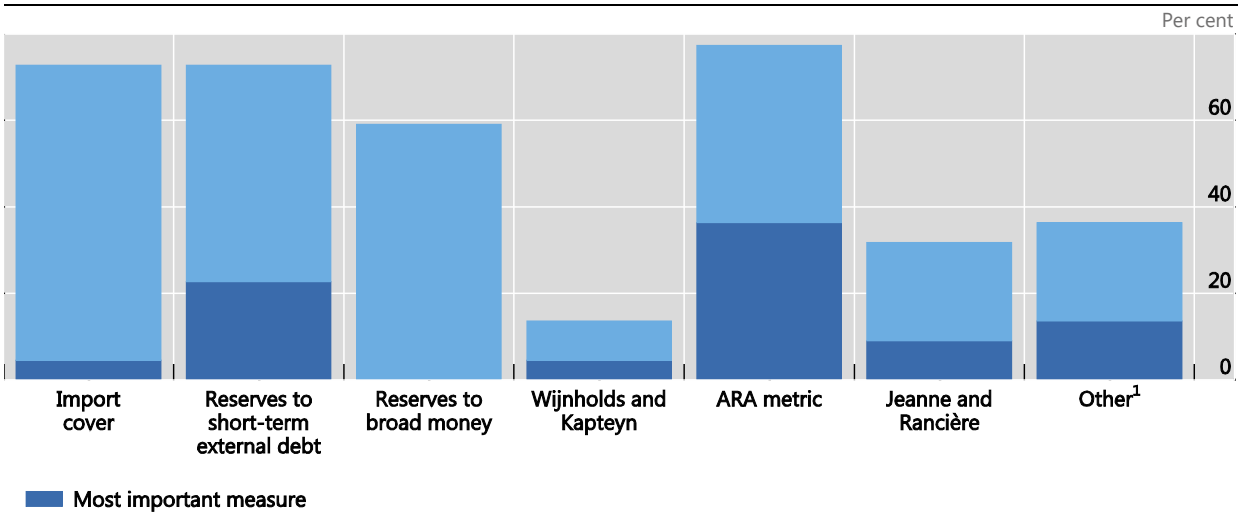
Box 1

Reserve adequacy measures

There is no unique framework with which to assess reserve adequacy for precautionary motives. Central banks follow an array of measures that compare a country's reserve position with proxies for a specific risk or vulnerability (Graph B1). These measures provide a practical starting point, but a complete assessment must consider country-specific factors such as the exchange rate regime and capital account openness as well as financial market depth and liquidity.

Central banks follow an array of reserve adequacy measures

Fraction of respondents that follow each measure — Graph B1



[1] In Colombia, reserves are required to cover at least the expected current account deficit plus external debt amortisations over the following year. Mexico applies the risk model of Ibarra et al (2011). South Africa adheres to the Southern African Development Community convergence criterion, which specifies cover comprising up to six months of imports. Poland has an internally developed indicator that takes into account the structure of short-term debt and the potential outflows of foreign portfolio investments. Argentina, Saudi Arabia and Thailand use scenario analysis based on episodes of extreme capital outflows. Peru applies an extended Jeanne and Rancière (2011) model that takes into account financial dollarisation. Hong Kong SAR and Saudi Arabia also consider a 100% mandatory currency backing.

Source: BIS survey, 2018.

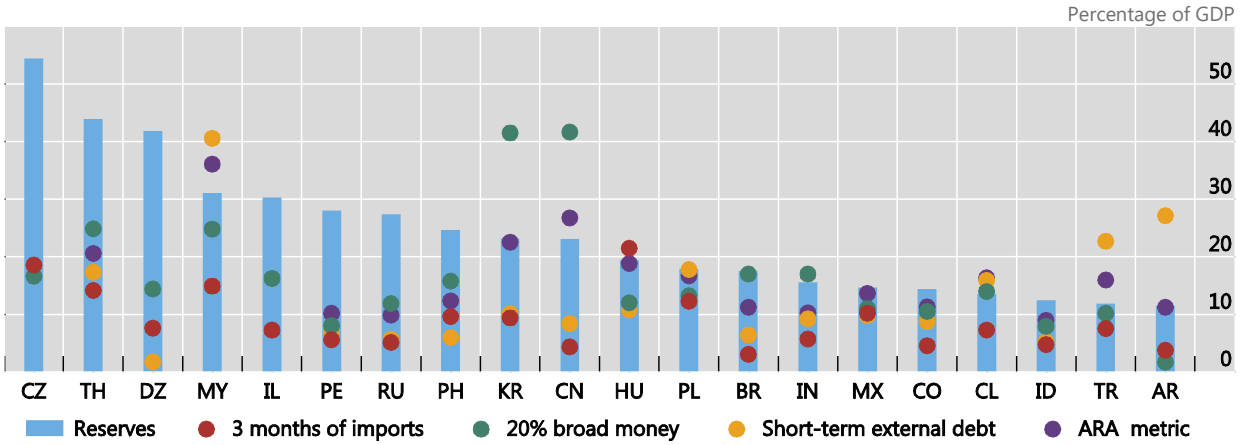
The traditional measures are:

- **Import cover:** measures the number of months that reserves can sustain imports. This indicator is considered relevant for countries with a closed capital account. The benchmark is three months of coverage.
- **Ratio of reserves to short-term external debt:** measures the potential demand for repayments related to a country's short-term external foreign currency borrowing.① The Guidotti-Greenspan rule proposes a 100% cover. This rule can be extended to consider the full potential 12-month financing need, measured by short-term external debt minus the current account balance.②
- **Ratio of reserves to broad money (M2):** measures the potential demand for foreign assets from domestic sources. This indicator is considered relevant for countries with financially developed markets and an open capital account. The benchmark is typically set at 20%.
- **Wijnholds and Kapteyn (2001):** measures both the potential drain on reserves that results from the non-rollover of short-term external debt and that from residents' capital flight. It is the sum of short-term external debt plus an adjusted M2. The adjustment to the second component depends on the exchange rate regime and country risk. The authors propose a 100% reserve cover.③

- **Assessing reserve adequacy (ARA) metric:** measures a broad set of risks reflecting potential drains on the balance of payments. The IMF's metric has four weighted components: short-term external debt; M2; export income; and other liabilities. The last two components reflect potential terms-of-trade shocks and other portfolio outflows, respectively. The measure is adjusted if the country is dollarised, if it has capital controls or if it is a commodity exporter/importer. The benchmark is between 100% and 150% reserve cover.④
- **Jeanne and Rancière (2011):** measure the optimal level of reserves by calibrating a cost-benefit model. The model balances the opportunity cost of holding reserves with the gains from smoothing domestic absorption during sudden stops. The level of optimal reserves varies considerably depending on the assumptions on output loss, probability of a sudden stop, and risk aversion.

In most countries, the stock of reserves in 2017 was higher than the suggested benchmarks of the measures followed by the majority of central banks (Graph B2). However, caution should be exercised when examining the measures individually. A comprehensive assessment of reserve adequacy should consider the consolidated position of the domestic banking sector and the availability of additional external buffers. In addition, as argued in the country contributions for this meeting, reserve adequacy should be used as a reference and not as an explicit goal.

Reserves are in most cases higher than traditional benchmarks[1] Graph B2



[1] Data from 2017.

Source: IMF.

① Short-term external debt on a remaining maturity basis is measured by adding the value of outstanding short-term external debt (original maturity) to the value of outstanding long-term external debt (original maturity) due to be paid in one year or less. ② Foreign liabilities of domestic banks due to operations in foreign markets are not included in this measure. These operations may increase maturity, interest rate and currency mismatches and put additional pressure on potential draws of reserves. During both the Mexican (1982) and Korean (1997) crises, the positions of domestic banks in foreign markets exacerbated the crisis (Álvarez (2015), Blustein (2001)). ③ The weights are between 0.1 and 0.2 for countries with a managed float or fixed exchange rate regime, and between 0.05 and 0.1 for countries with a floating exchange rate regime. Country risk is measured using *The Economist*'s country risk index. ④ The relative risk weights for each component are based on the 10th percentile of observed outflows from EMEs during exchange market pressure episodes.

Sources: IMF (2015); Jeanne and Rancière (2011); Wijnholds and Kapteyn (2001).

2.2 Goals related to monetary and exchange rate policies

FX reserves may also not necessarily be accumulated with a specific adequacy *reference* level in mind, but as a *by-product* of the pursuit of other goals. While, given overlaps, drawing a dividing line between such goals is not straightforward, they

include price stability as well as smoothing output and financial fluctuations.[7] Preserving export competitiveness may also play a role.

Price stability

Accumulating reserves as a by-product of aiming to maintain price stability is not uncommon. This occurs whenever the central bank considers that simply adjusting interest rates and letting the exchange rate float is not sufficient or not the preferred strategy (see Ho and McCauley (2003) for an in-depth discussion). For example, if inflation is below target, and if the currency comes under appreciation pressure and interest rates are already very low then the central bank may prefer to resist the appreciation by intervening rather than cutting interest rates further. This may be especially beneficial if inflation expectations were threatening to dis-anchor or the central bank was concerned about the rapid pace of domestic credit growth and the build-up of financial vulnerabilities (see *FX intervention: goals, strategies and tactics* and the discussion below). Clearly, the more highly managed the exchange rate is, the higher the average level of reserves (Graph 3, left-hand panel). Finally, larger reserves holdings may also help monetary policy to control inflation by lowering exchange rate volatility, hence its pass-through to inflation.

Countries lie along a spectrum. At one end, reserve accumulation is passive in pegged exchange rate regimes, where a country ties its currency to a larger economy from which, in effect, it "imports" the inflation rate (Hong Kong SAR and Saudi Arabia). The Czech Republic set a ceiling to its exchange rate vis-à-vis the euro from November 2013 to April to bring low inflation levels back to target. They implemented this additional monetary policy instrument during a period of zero lower bound on interest rates. Singapore influences inflation through an (undisclosed) path for the appreciation of its currency. At the other end, other countries pursue their inflation objectives with very limited FX intervention (Colombia and Chile).

Smoothing financial and business fluctuations

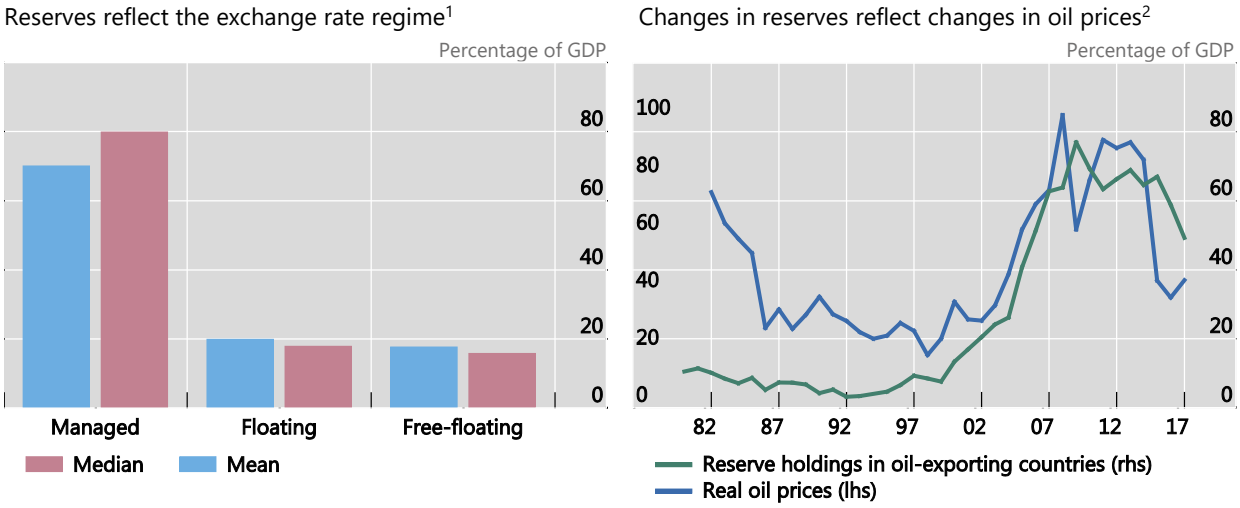
The path of reserve accumulation may also result from a "leaning against the wind" policy. Here, the central bank purchases reserves to contain appreciation, and sells them in the event of a sudden stop (Kiguel and Levy Yeyati (2009)). This would tend to smooth the financial and macroeconomic fluctuations. If the original level of reserves fell short of adequacy benchmarks, the accumulation phase would push it towards the prudential reference. But, depending on the strength and persistence of the exchange rate pressure, reserves could end up well beyond that reference.

Specifically, leaning against the appreciation wind during expansions can be cast as a countercyclical prudential response to procyclical capital flows and real exchange rate fluctuations (Carstens and Shin (2019); see also contribution from China). For one, just as with, say, the countercyclical capital buffer, building up reserves in good times allows the central bank to run them down in bad times, strengthening the economy's resilience. In addition, it may also dampen the easing impact on financial conditions linked to currency appreciation and capital flows. In the presence of currency mismatches and large FX debt in either firm, government or household balance sheets, exchange rate appreciation improves the creditworthiness of borrowers, either because it raises the value of collateral or because it reduces the burden of foreign

[7] *FX intervention: goals, strategies and tactics* (this issue) provides a detailed summary of the central bank goals underpinning FX interventions.

currency debt. Limiting appreciation may thus restrain the expansion in the demand and, above all, supply of credit – the exchange rate or risk-taking channel (Bruno and Shin (2015)). Moreover, it is also possible that the sterilisation leg of the intervention may restrain credit expansion to the extent that it "crowds out" lending in bank balance sheets (Chang (2018), Hofmann et al (2019)).[8]

There are large differences in reserves holdings across FX regimes — Graph 3



[1] For the classification of countries, IMF definitions are used. "Managed" countries: CN, DZ, HK, MY, SA and SG. "Floating" countries: AR, BR, CO, HU, ID, IL, IN, KR, PH, TH, TR and ZA. "Free-floating" countries: CL, MX, PL and RU. See footnote 1 of Graph 1 for a key to the abbreviations. [2] Algeria, Russia and Saudi Arabia are the major oil producers in the sample. Extending the sample with other exporters keeps the shape of the curve intact.

Sources: Federal Reserve Bank of St Louis; IMF; authors' calculations.

Data and recent research provide supportive evidence that reserve accumulation may indeed smooth financial cycles (Graph 4; see also Hofmann et al (2019)). At least since the 2000s, EME central banks have tended to increase their reserves when capital inflows surged. For instance, European Union fund inflows have been the major driver of reserves for European EMEs. Countries that accumulated more reserves experienced slower credit growth (Graph 4, centre panel). More formal analysis confirms these conclusions (BIS (2018); see also Graph 4, right-hand panel).

Partly related to the income- and output-smoothing goal, but over longer horizons, reserve accumulation may be designed to deal with persistent commodity price shifts (or improved terms of trade in broader terms).[9] Fiscal policies of commodity exporting countries have made this goal prominent. For instance, as oil prices surged beginning in 2000, oil exporters' reserves reached around 80% of GDP in 2007 (Graph 3, right-hand panel). Thereafter, as oil prices declined, countries ran down their reserves. For example, in Saudi Arabia, peg aside, the reliance of fiscal policy on oil revenues has influenced the dynamics of the country's reserves, which are more akin to a sovereign wealth fund. Other examples include the structured

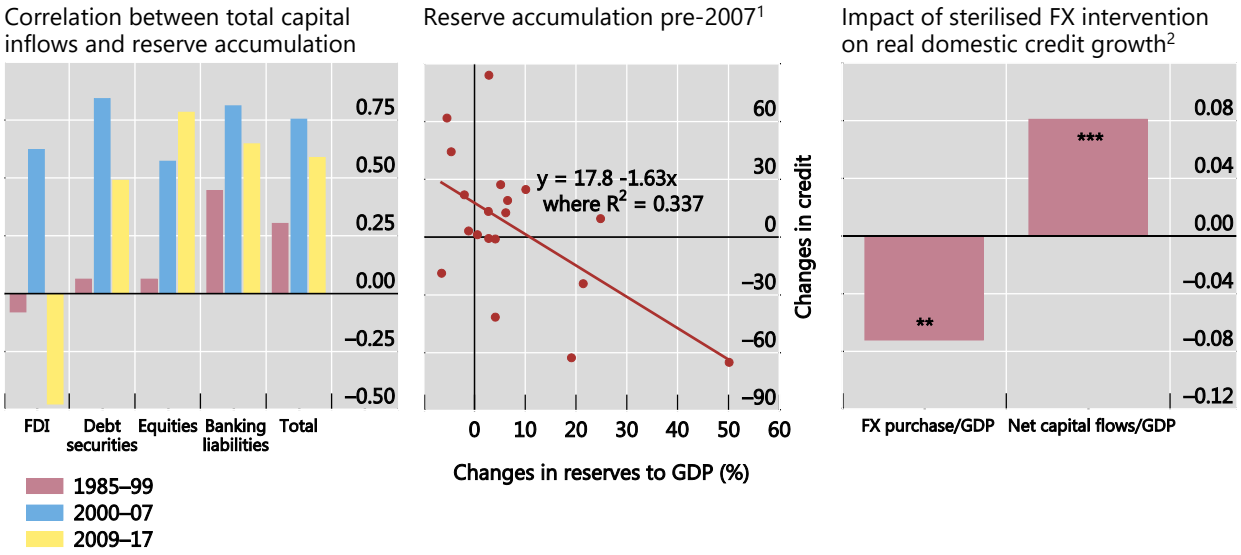
[8] Crowding-out of domestic lending if some of the bank funds are used to finance reserves (Cook and Yetman (2012)) can generate similar dynamics. Hofmann et al (2019) argue that the role of exchange rates is stronger than that of the bank balance sheet channel.

[9] See survey responses reported in *FX intervention: goals, strategies and tactics* (this issue) regarding the role of commodity cycles on reserve accumulation.

balance rule in Chile and the fiscal rule in Russia. In the case of Mexico, the central bank law requires Pemex, and similar non-financial entities that operate with foreign currency, to trade with the central bank. As a result, Pemex has been the biggest contributor to reserve accumulation.

Reserve accumulation goes hand in hand with smoother credit growth

Graph 4



[1] A solid (or dashed) regression line refers to significance (or insignificance) at the 5% level. [2] Panel shows the coefficient of the variables on the horizontal axis from a panel regression analysis for 45 EMEs from 2005 to 2013 reported in specification (7) in Table 9.2 of Ghosh et al (2017). **/*** indicates statistical significance at the 5/1% level.

Sources: IMF; BIS.

Export competitiveness

Preserving or promoting export competitiveness is a more controversial objective. It potentially spans a broad range of options, from intervening only when the currency is seen as blatantly overvalued so as to avoid long-term damage to export and growth potential,[10] to seeking to maintain or gain competitiveness regardless of any overvaluation.[11]

Perhaps the most stringent critique of large EME reserve holdings is that they are accumulated as a by-product of FX interventions to maintain or gain competitiveness. Such an objective may seem more likely in countries where reserves are much higher than conventional "rule of thumb" thresholds (eg Krugman (2008)).

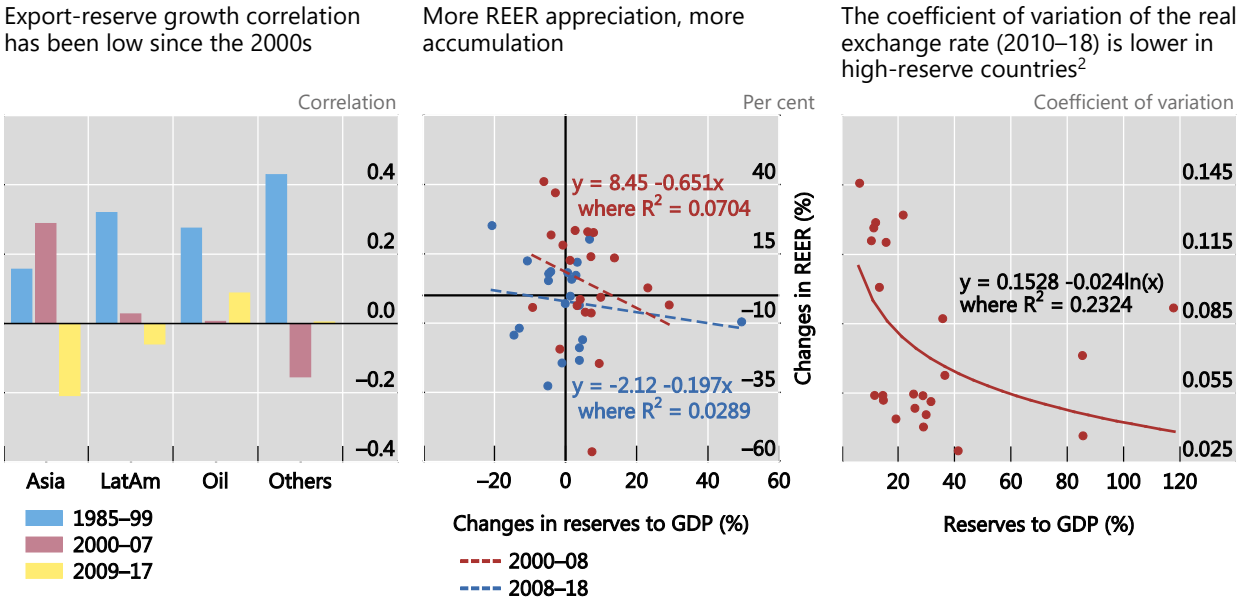
The evidence for this claim is not that strong, however. For most of the countries, the correlation between reserve accumulation and export growth has been low (Graph 5, left-hand panel). And while a weakening real exchange rate tends to go hand in hand with less reserve accumulation, the correlation is weak (Graph 5, centre

[10] See Magud and Sosa (2010) for a literature review.

[11] The export competitiveness motive has been relevant also for several advanced economies, eg Denmark and Switzerland after the GFC.

panel).[12] More formally, Ghosh et al (2014) estimate that, after the 2000s, the cumulative impact of this motive on the countries' stock of reserves increased to 3.5% of GDP (or about 10% of FX reserves) in Asian EMEs – not a very large figure.[13]

Reserve accumulation provides some support for trade[1] Graph 5



[1] Includes all countries presented in Graph 1 except Algeria. A solid (or dashed) regression line refers to significance (or insignificance) at the 5% level. [2] Monthly real exchange rate data after 2010. Average level of reserves between 2009 and 2018. Limiting the sample to the countries with reserves lower than 60% strengthens the negative correlation.

Sources: Datastream; BIS; authors' calculations.

3. Reserve accumulation: costs

Despite numerous and potentially large benefits, holding large reserve chests does not come free. The costs can be at both the domestic and the global level.

Domestic

Countries pay a premium to use reserves as an insurance mechanism (Graph 6, left-hand panel). A simple accounting exercise that uses spreads between the yield on reserve assets and the cost of foreign borrowing suggests that the income loss for

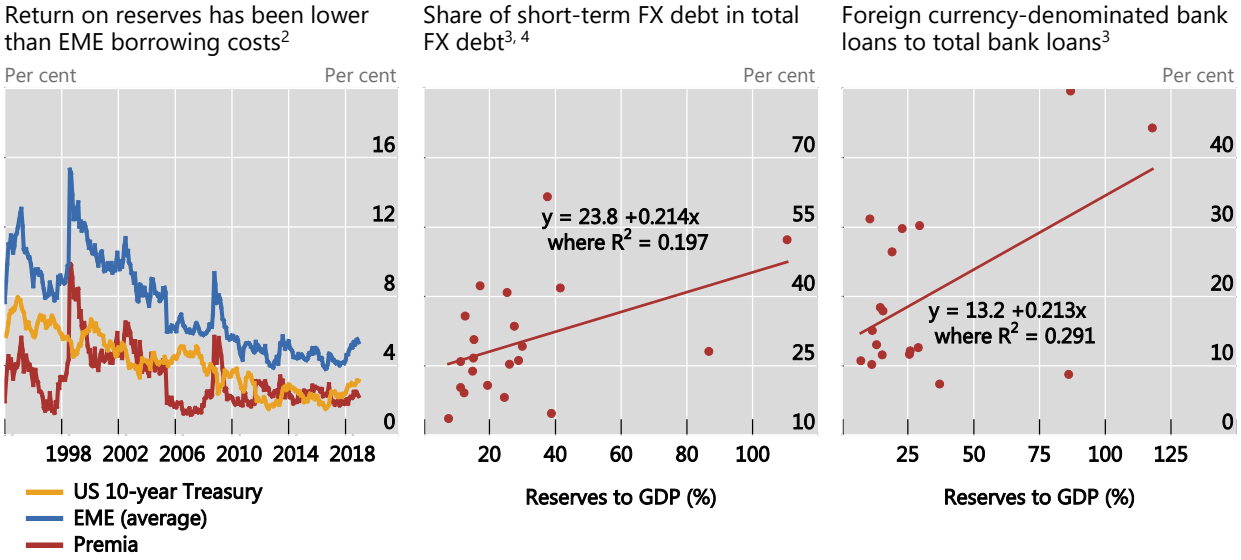
[12] High reserve levels may also help the tradable sector indirectly by limiting real exchange rate volatility, possibly because they lower the risk of crises (Graph 5, right-hand panel).

[13] Ghosh et al (2012) propose proxies for export competitiveness motives following three approaches. The macro balance approach states that the exchange rate is undervalued if a real appreciation is required to close the gap between the actual current account and its norm. The equilibrium real exchange rate approach compares the real exchange rate with its equilibrium value as implied by fundamentals. The external stability approach compares the prevailing exchange with the one that would generate a current account balance that stabilises the net foreign asset position.

these countries may be close to 1% of GDP (Rodrik (2006)). However, this simple calculation does not take into account that, absent reserves, borrowing rates would be higher. As a result, both the spread differentials and the costs are overstated by as much as 50% according to some estimates (Levy-Yeyati (2008)).[14]

High reserve levels often accompany FX risk-taking[1]

Graph 6



[1] Depending on data availability, only a subset of the countries presented in Graph 1 is used. A solid (or dashed) regression line refers to significance (or insignificance) at the 5% level. [2] Return on reserves is proxied by US 10-year Treasury rate. EME borrowing costs are approximated by the average of the EMBI across EMEs with available data. [3] Most recent available data. [4] Sum of government and non-financial corporate FX-denominated debt.

Sources: IMF; Datastream; JPMorgan Chase; national data; BIS calculations; authors' calculations.

Reserves also expose countries to valuation risks. From a macroeconomic perspective, these risks may be second-order, as reserves act precisely as a hedge. Losses will be realised when domestic currencies appreciate, which will be most likely when domestic economies are strong, and gains when currencies depreciate, which is bound to occur, especially when the economy faces stress. That said, losses can give rise to political economy challenges, which could even undermine central bank autonomy (See *Reserve management in emerging market economies: trends and challenges* prepared for this meeting).

While, ceteris paribus, reserve accumulation increases resilience, it may also create perverse incentives. For one, domestic private agents, and sometimes even governments, may take advantage of the improved general sense of safety to assume more risk (Fatum and Yetman (2018); see also the contribution from Thailand). And to the extent that intervention removes the perception of two-way risk, it may encourage further capital inflows in the short run and larger currency mismatches in the longer run. If so, accumulating reserves would be in part self-defeating.

There is some suggestive evidence that such a mechanism may be at work (eg Barajas and Morales (2003) and Berrospide (2008)). Simple cross-country correlations support this conclusion to some extent (Graph 6). In countries with higher

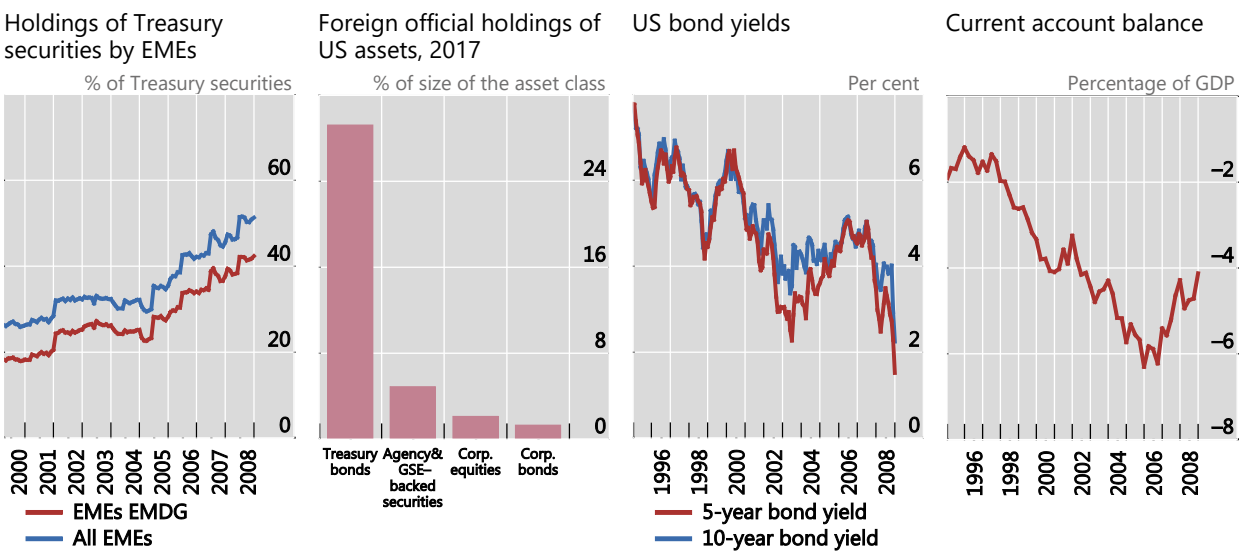
[14] In addition, aggregate EME reserves also affect US Treasury rates, as discussed in the policy section of this note.

reserves, firms and governments tend to finance themselves more with short-term foreign currency debt (Graph 6, right-hand panel). And the share of foreign currency bank loans in the total is also higher (Graph 6, centre panel; see also Ize and Levy-Yeyati (2003)).[15] That said, the direction of causality is ambiguous. Moreover, unfortunately, good statistics on currency mismatches are generally not available, making it harder to test the hypothesis.

Global

While reserves may provide insurance for each accumulating country, globally they may add to vulnerabilities.[16] For instance, several studies find that EME reserve accumulation has reduced US long-term interest rates significantly (Graph 7 and Table A3). According to one view, the resulting low-yield environment fuelled the credit and property price boom that eventually triggered the GFC (Bini Smaghi (2010)). Large current account deficits prior to the GFC were supported by official EME reserve accumulation (Bernanke (2005), Summers (2006)).[17] According to another view, however, the crisis was essentially a transatlantic affair, unrelated to current account surpluses or EME reserves accumulation (Borio and Disyatat (2011), Shin (2012), McCauley (2018)).

EME reserve accumulation and the pre-GFC boom in the United States — Graph 7



Sources: FED Z1 Flow of Funds; US Department of the Treasury; BIS; BIS calculations.

[15] Despite its intuitive appeal, some of the results in Graph 6 are driven by several countries that hold a very high level of reserves. For the centre panel, if the two largest reserve holders are removed, the positive correlation survives; for the right-hand panel, the line becomes flat. We chose to plot the graphs with all the available countries, as the mechanisms referred to in the text are likely to work across all of them.

[16] See *Reserve management in emerging market economies: trends and challenges* prepared for the meeting for a discussion of spillover risks to advanced economies in the event of a joint liquidation of reserves.

[17] Bernanke (2005) coined the term "saving glut" to denote this phenomenon.

4. Supporting and alternative policies

Given the potential costs and the trade-offs, are there policies that could alleviate reliance on reserve accumulation?

Policymakers have a broad set of tools that, to varying degrees, can perform this function. In general, other policies – be they fiscal, microprudential or macroprudential – that strengthen an economy and its financial system would reduce the need for FX reserves as a precautionary buffer. Some of these policies, such as those relying on macroprudential or even capital flow management measures, operate more at the cyclical frequency; others, such as those designed to ensure fiscal space or strengthen microprudential safeguards, have a more structural character. Similarly, reducing the dollarisation of both assets and liabilities may help (contribution from Peru).

At the margin, some innovative FX intervention methods introduced in recent years may also help reduce the costs – and, possibly, lower the required amount – of reserves. For instance, the Central Bank of Turkey's Reserve Option Mechanism (ROM) gives private banks the option to hold some parts of their required reserves in FX. Banks make extensive use of this option, as their cost of borrowing in FX is lower than that in the domestic currency. When it becomes difficult to obtain FX funding, banks may then tap these reserves to alleviate liquidity pressures. This mechanism has two benefits. First, it is market-friendly: depending on market conditions, banks decide how much FX to hold at the central bank. Second, it lowers the cost of holding reserves for the central bank.

Specific use of derivatives to intervene in the FX markets may also to some extent lower the required amount of reserves (see *FX intervention: goals, strategies and tactics* (this issue) for a more detailed discussion).[18] For instance, the Central Bank of Brazil's FX swap policies have aimed at providing FX hedges to corporates by operating in instruments that settle in domestic currency (Kohlscheen and Andrade (2014)). That said, for this policy to be effective, a strong backing from high reserve holdings is still necessary.

More importantly, a way to reduce the need for self-insurance is to provide international insurance. Several arrangements seek to do precisely that, such as swap lines between central banks (Graph 8; see also Allen and Moessner (2011)), regional schemes, such as the Chang Mai Initiative Multilateralization, and the IMF's Flexible Credit Lines.[19] For instance, Mexico has a USD 74 billion flexible credit line agreement with the IMF at a financial cost below that of holding reserves (contribution from Mexico).

These schemes provide a useful complementary form of insurance. They are especially helpful when market participants question the central bank's credibility (contribution from the Philippines) or see reserve buffers as inadequate. For instance, when Korea came under pressure during the GFC, it was the Fed's swap line that finally stabilised the situation (Baba and Shim (2010)).

[18] For instance, the combined net long forward position of seven East Asian countries increased from a mere USD 22 billion in April 2009 to USD 235 billion in mid-2011 (Domanski et al (2016)).

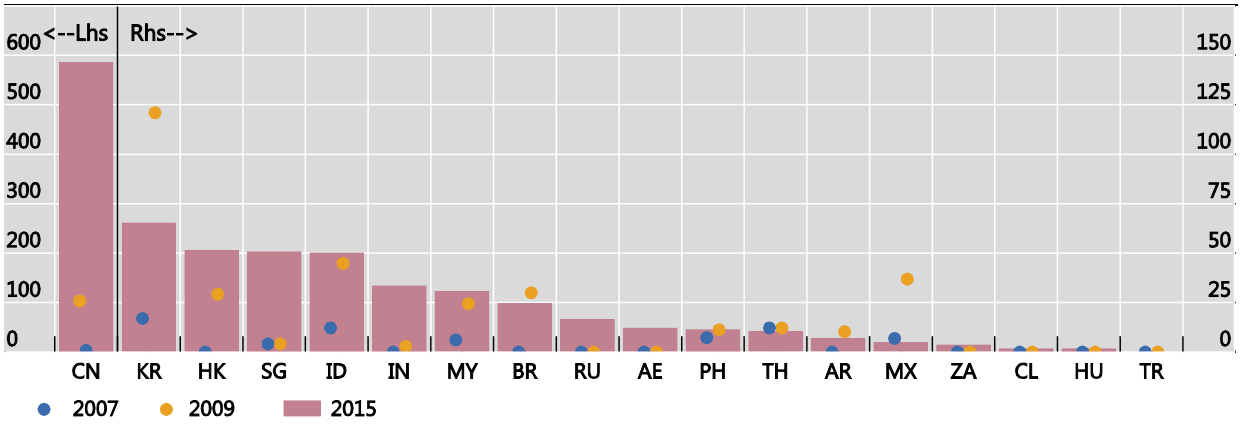
[19] Of course, additional access to IMF resources can be provided under a programme.

That said, these backstops have a number of limitations. Central bank FX swap lines tend to be granted selectively, and their activation is not certain and could be held hostage to political developments (contribution from Saudi Arabia). They are not fully under the control of the country that needs them (contribution from Argentina). All this constrains their size and reach. Similarly, IMF resources fall short of potential needs, given the rapid growth of financial interlinkages reflected in the long-run surge in the external stocks of assets and liabilities (Carstens (2018)). And many countries still see them as bearing a stigma. All these limitations stress that the global safety net is not flexible and large enough to reduce the required level of reserves significantly.

Swap lines have been growing

In billions of US dollars

Graph 8



The size of a country's swap line (from a borrower's perspective) is determined by the sum of all active swap line agreements active in a given year.

Source: Denbee et al (2016).

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Annex 1

Determinants of reserve accumulation: some econometrics

How important are the different factors discussed in the main text as drivers of overall reserve accumulation in EMEs? Following the recent studies (Obtsfeld et al (2010), Ghosh at al (2012, 2014), Aizenman and Lee (2007), Aizenman et al (2014), Delatte and Fouquau (2012)), we perform a regression analysis to estimate how precautionary and exchange rate policy-related motives influence reserves. Since there are no direct measures of the specific motives, we use widely accepted proxies developed in the literature.[20] That said, the proxies are not perfect. As a consequence, the econometric results can be at most as good as the proxies allow.

The econometric methodology is standard. The panel equation we estimate is the following:

$$\ln\left(\frac{Res_{it}}{GDP_{it}}\right) = \alpha + \beta_P Precautionary_{it} + \beta_{ERP} ExRate\ Policy + \beta_O Other_{it} + \varepsilon_{it}$$

where:

$$Precautionary_{it} = \{Curr\ Ac\ Vulnerab_{it},\ Size\ of\ Fin\ System_{it},\ Cap\ Ac\ Openness_{it}\},$$

$$ExRate\ Policy_{it} = \{Overval_{it},\ ExRate\ Stab_{it}\}, \qquad Other_{it} = \{\ln(Pop_{it}), \ln(\mathrm{GDPpc}_{it})\}$$

Proxies related to precautionary motives are the most important (Graph A1). These results are in line with the findings of the literature, country contributions and survey responses reported in *FX intervention: goals, strategies and tactics* prepared for this meeting. Among precautionary motives, current account vulnerabilities matter most, followed by capital account openness. In addition, we find that the share of growth in reserves explained by the overvaluation of the exchange rate has remained stable, while the role of exchange rate stability has diminished over the past 10 years.[21]

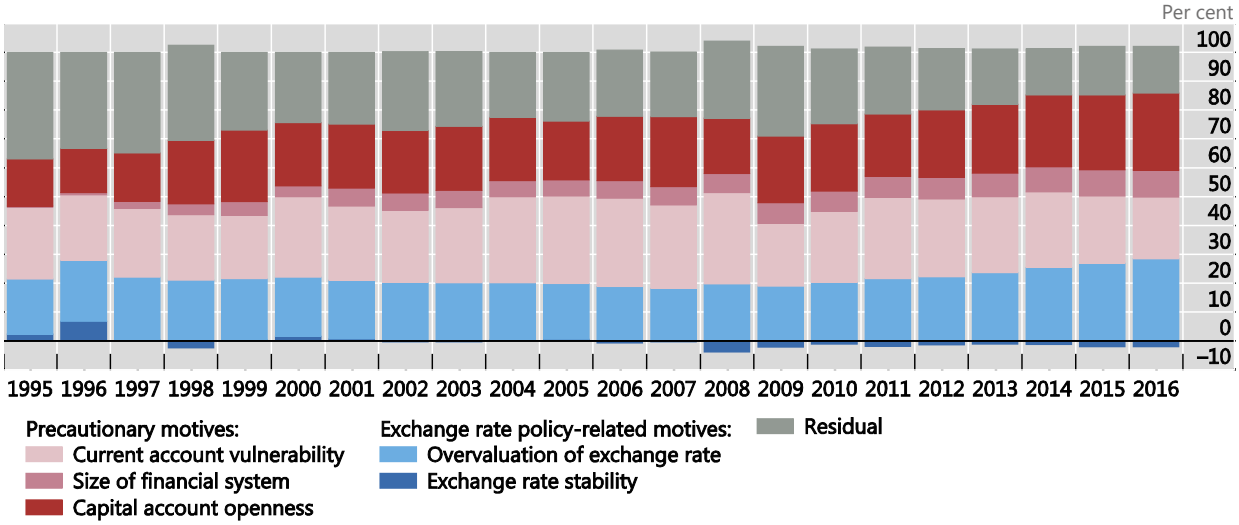
To examine how the drivers of reserve accumulation change over time, we divide the sample into subperiods. The cutoffs are chosen to coincide with the Asian crisis and the onset of the GFC. The importance of each of the factors that influence the demand for reserves has evolved in accordance with developments in EMEs and the global economy (Graph A2, left-hand panel, and Table A1). Within the precautionary motives, current account vulnerabilities have gained importance with respect to capital account vulnerabilities. In particular, financial openness has become increasingly relevant. Consistent with the survey results reported in *FX intervention: goals, strategies and tactics*, the role of overvaluation of the exchange rate has declined. It ceased to be significant in the post-GFC period. Finally, the role of exchange rate stability has remained stable.

[20] The factors included in precautionary motives are current account vulnerability (proxied by trade (IMF (2015)), size of financial system (proxied by broad money (Wijnholds and Kapteyn (2001)) and capital account openness (proxied by the sum of assets and liabilities (Lane and Milesi-Ferretti (2007)). The factors included in exchange rate-related motives are overvaluation of the exchange rate (Aizenman and Lee (2007)) and exchange rate stability (Aizenman et al (2013)).

[21] We measure the overvaluation of the exchange rate as the deviation of the price level from the trend implied by per capita income (Aizenman and Lee (2007)). The measure does not take into account other sources of currency misalignments or banking system liabilities.

Precautionary motives are the main drivers behind reserve accumulation

Contribution of each factor to the cumulative growth in reserves — Graph A1

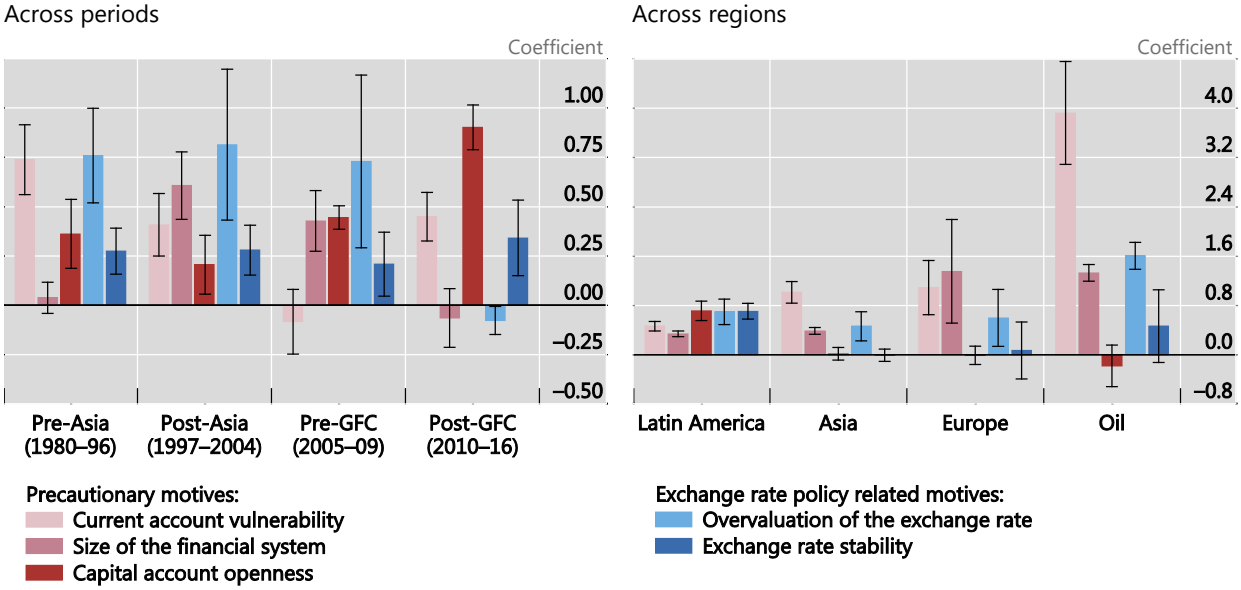


Decomposition of the cumulative change in reserves obtained from the fitted regression of reserves on proxies of precautionary and exchange rate policy-related motives. The contribution of each factor is calculated as the product of the coefficients from the full-sample regression and the time-varying proxy.

Sources: Aizenman et al (2014); Ghosh at al (2014); Obtsfeld et al (2010); BIS calculations using data from IMF, *International Financial Statistics*, and World Bank, World Data Indicators.

The determinants of demand for reserves shift across periods and regions

Graph A2



Coefficients of the regression of reserves on proxies of precautionary and exchange rate policy related motives. The lines correspond to the standard errors.

Sources: Aizenman et al (2014); Ghosh at al (2014); Obtsfeld et al (2010); BIS calculations using data from IMF, *International Financial Statistics*, and World Bank, World Development Indicators.

Finally, we divide the sample by region (Latin America, emerging Europe, Asia) and also parcel out oil exporters (Graph A2, right-hand panel, and Table A1). The results suggest that while precautionary motives, on average, are significant in all regions, the importance of their subcomponents vary across regions. For instance, capital account openness has been more important in Latin America, a region arguably more prone to external funding shocks. In Europe, a region with fewer currency mismatches, the size of the financial system (ie domestic vulnerabilities) appears to matter more.

Determinants of demand for reserves across periods

Table A1

	(1) Full sample	(2) Pre-Asia (1980–96)	(3) Post-Asia (1997–2004)	(4) Pre-GFC (2010–16)	(5) Post-GFC (2010–16)	(6) Latin America	(7) Asia	(8) Europe	(9) Oil exporters
Precautionary motives									
Current account vulnerability	0.735***	0.739***	0.408**	–0.083	0.450***	0.462***	1.014***	1.089**	3.925***
	(0.183)	(0.177)	(0.159)	(0.164)	(0.123)	(0.077)	(0.174)	(0.442)	(0.837)
Size of financial system	0.266**	0.038	0.607***	0.428***	–0.064	0.337***	0.386***	1.353	1.328***
	(0.134)	(0.079)	(0.171)	(0.154)	(0.148)	(0.045)	(0.054)	(0.841)	(0.137)
Financial openness	0.423**	0.362**	0.206	0.445***	0.902***	0.711***	0.014	–0.012	–0.180
	(0.210)	(0.175)	(0.149)	(0.060)	(0.113)	(0.157)	(0.100)	(0.148)	(0.337)
Exchange rate policy-related motives									
Overvaluation of exchange rate	0.635***	0.759***	0.814**	0.729*	–0.077	0.696***	0.461*	0.596	1.606***
	(0.231)	(0.240)	(0.382)	(0.437)	(0.072)	(0.208)	(0.236)	(0.463)	(0.219)
Exchange rate stability	0.357***	0.275**	0.280**	0.209	0.342*	0.706***	–0.009	0.068	0.464
	(0.112)	(0.117)	(0.126)	(0.162)	(0.191)	(0.128)	(0.100)	(0.462)	(0.591)
Scale variables									
Population	0.394***	0.118	0.098	0.147	0.233**	0.096*	0.353***	0.019	1.079***
	(0.151)	(0.104)	(0.116)	(0.096)	(0.105)	(0.049)	(0.076)	(0.216)	(0.178)
Real GDP per capita	0.145	0.293	0.224	0.354*	–0.323*	–0.852***	0.431***	–1.213	–0.398
	(0.156)	(0.184)	(0.296)	(0.194)	(0.184)	(0.156)	(0.073)	(1.031)	(0.279)
Constant	–5.644***	–5.007**	–4.675	–3.747	1.097	5.071***	–8.870***	4.549	–18.210***
	(1.714)	(2.044)	(3.158)	(2.365)	(1.908)	(1.484)	(1.287)	(9.153)	(6.287)
R^2	0.61	0.60	0.67	0.52	0.45	0.97	0.95	1.00	0.89
Observation	814	334	192	120	168	226	381	108	98
Number of countries	24	24	24	24	24	6	11	4	3

Robust standard errors in parentheses. ***/**/* indicates significance at the 1/5/10% level.

Source: BIS calculations using data from IMF, *International Financial Statistics*, and World Bank, World Development Indicators.

The effect of reserve accumulation on US Treasury yields: literature summary

Table A2

Bernanke et al (2004)	Interventions undertaken by the Japanese Ministry of Finance between 2000 and 2004 could have lowered 10-year US Treasury yields by 66 basis points for every purchase of USD 100 billion.
Jiang and McCauley (2004)	Significant negative relationship between weekly changes in 10-year US Treasury yields and foreign official holdings, with the latter proxied by custodial holdings at the Federal Reserve Bank of New York, but only over two short periods in 2000 and 2003.
Warnock and Warnock (2005)	Had foreign governments not accumulated US government bonds over the 12 months ending May 2005, the 10-year Treasury yield would have been 90 basis points higher.
Beltran et al (2013)	USD 100 billion in foreign official inflows lowered the five-year yield by 40–60 basis points in the short and medium run, and by 17–20 basis points in the long run, over the 1994–2007 period.
Sierra (2014)	Excess returns are negatively associated with foreign official purchases during 1994–2007. The impact of foreign official flows gradually weakens for longer maturities (over six years).
Wolcott (2016)	Foreign official purchases have shifted the entire yield curve down, with the largest and statistically significant impacts at the short end of the curve and more persistent effects at the long end of the curve. An inflow equal to 1% of the amount of Treasuries outstanding lowers the 10-year yield by 6 basis points and the three-month yield by about 80 basis points.