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# Foreign Exchange Intervention: A Dataset of Public Data and Proxies

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**Foreign Exchange Intervention: A Dataset of Public Data and Proxies**  
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**ABSTRACT:** A better understanding of foreign exchange intervention (FXI) is often hindered by the lack of data. This paper provides a new dataset of FXI covering a large number of countries since 2000 at monthly and quarterly frequencies. It includes published official data for about 40 countries as well as carefully constructed estimates for 122 countries. Estimates account for a wide range of central bank operations, including both spot and derivative transactions. These estimates improve upon traditional proxies based on changes in reserves, by adjusting for valuation changes, income flows, and changes in other foreign-currency balance sheet positions (both vis-à-vis residents and non-residents)—the first estimates to do the latter to our knowledge—thus providing a more accurate measure of operations that change the central bank’s foreign currency position. The dataset also provides a classification of FXI operations into sterilized or not sterilized, a key dimension for economic analysis. Finally, the paper discusses the merits of the new estimates relative to traditional proxies, and presents stylized facts.

The dataset is updated periodically and can be found [here](#) or [here](#).

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## I. INTRODUCTION

Exchange rate policy and the use of foreign exchange intervention (FXI) are central aspects of policy making in open economies and highly debated topics. A key debate pertains to whether interventions are effective in moving the exchange rate and several theoretical channels have been proposed to understand how FXI could be effective. A main channel is linked to the portfolio balance theory, first proposed by Kouri (1976), Henderson and Rogoff (1982), which has seen a revival of late with several influential papers by Gabaix and Maggiori (2015), Cavallino (2019), Fanelli and Straub (2021), and Itskhoki and Mukhin (2021), (see also the review in Maggiori, 2022). Under the portfolio balance theory, FXI can affect the exchange rate when domestic and external assets are imperfect substitutes. Sterilized purchases (sales) of foreign currency increase (decrease) the relative supply of domestic currency assets, driving currency risk premia up (down) and, thus, exerting depreciation (appreciation) pressures on the exchange rate. Other channels include *signaling*<sup>1</sup> whereby FXI changes market participants' expectations about future monetary policy. The microstructure literature,<sup>2</sup> which documents that large orders on one side of the market (including by the central bank) can move equilibrium prices, provides a particular mechanism through which the portfolio balance and the signaling channel affect exchange rates.<sup>3</sup>

Empirical studies to test these theoretical concepts have often been severely limited by data availability, consistency, or accuracy. One branch of the literature has focused on published official FXI data, typically at high frequency. While appealing at a first glance, including because high frequency data allows to overcome endogeneity issues, using only official data has a number of drawbacks. First, this approach inevitably entails studying only a limited group of countries, mostly advanced economies, because only some countries actually publish this information reliably – see Sarno and Taylor (2001), Neely (2005), and Menkhoff (2013) for surveys and references therein.<sup>4</sup> This precludes drawing general lessons on the use of FXI for other countries, particularly for emerging markets and developing economies, despite the fact that FXI is especially relevant for them. A recent exception is Fratzscher et al (2019), who study the implications of sterilized FXI using official data for 33 countries for a period of about 15 years. However, most of the data used in their study were provided to the authors on a confidential basis, precluding further analysis by other researchers. Beyond the fact that the decision to publish FXI data is not random (see further discussion on this below), there is another, less obvious, drawback of using published official data: FXI is not defined consistently across countries. For example, some countries exclude, intentionally or unintentionally, certain operations that researchers would likely consider FXI.<sup>5</sup> In fact, as discussed

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<sup>1</sup> See reviews in Sarno and Taylor (2001) and Neely (2005). Taylor (1995) emphasizes a coordination channel which is subsumed in the signaling channel.

<sup>2</sup> Evans and Lyons (2002).

<sup>3</sup> The mechanism through which order flow moves exchange rates relies on both imperfect substitution of assets and on imperfect information across market participants, in particular on an informational advantage of the central bank.

<sup>4</sup> Recent examples of country-specific studies in emerging markets are Kuersteiner et al (2018) and Hofman et al (2019) for Colombia and Chamon et al (2017) and Gonzalez et al (2021) for Brazil. A good discussion for Latin America where published FXI data is typically available is Chamon et al (2019).

<sup>5</sup> There may be differences in the effectiveness of FXI if operations are regarded as official interventions rather than routine commercial transactions. See, for example, Fischer and Zurlinden (1999).

below, it is surprisingly difficult to find clear definitions of what central banks publicly report as FXI, which should be a source of concern to any researcher that uses such data.

A different branch of the literature has tried to overcome the lack of official data by relying on estimates of FXI, essentially trading-off greater country coverage and consistency of the definition of FXI with possibly less accurate and lower-frequency measures. Studies in this area have typically proxied FXI by using the change in the stock of central bank's reserves or reserve flows from balance-of-payment statistics, sometimes adjusting for valuation, income effects, or both. Examples of studies using these measures include the work on exchange rate regimes (see, for example, Ilzetzki et al, 2019), currency manipulation (Bayoumi et al, 2015; Gagnon 2012 and 2013) and exchange rate management more broadly (Adler et al, 2019; Blanchard et al, 2015; Daude et al, 2016; Dominguez et al, 2012, Dominguez, 2012 and 2020; among others).

This paper contributes to the literature by filling a sizable gap in data availability. It provides a new and comprehensive dataset that compiles published official data and estimates of FXI, for both operations in spot and derivative markets, covering the period 2000-22 and for an ample set of countries. Moreover, by focusing on a clear definition of FXI, the data allows for comparable analyses across countries and time and can thus be used by researchers and policy makers to draw general lessons on the use of FXI.

The dataset includes:

- 1) Published official FXI data (i.e., publicly available but often scattered across reports) covering 39 countries at monthly- and 43 countries at quarterly-frequency.<sup>6</sup>
- 2) Comparable FXI estimates for 122 countries at monthly and quarterly frequency (that capture any transaction that alters the central bank's foreign currency position).

To our knowledge, this is the most comprehensive dataset of FXI for macroeconomic analysis. First, it is the only publicly available dataset encompassing published official data for a significant number of countries. Second, the dataset provides comprehensive (both in the country and time dimension) estimates of FXI that improve on earlier measures by Dominguez (2012), Dominguez et al (2012) and Adler et al (2019) by adjusting changes in reserves for a wider range of central bank operations, including operations with residents and non-residents. Some simple examples can illustrate the importance of the latter adjustments. Consider a country that borrows from the IMF. Often, such an operation leads to an increase in the central bank's reserves but is not viewed as foreign exchange intervention as it does not entail purchases or sales of foreign currency. Similarly, an operation whereby a commercial bank deposits foreign currency at the central bank would also increase FX reserves but would not be viewed as an intervention. All the previous estimates of FXI mentioned above ignore these aspects, while our estimates fully adjust for these and other similar operations using a precise definition of FXI that is consistently applied across countries. Our estimates complement the recent work by Fratzscher et al (*forthcoming*), who focus on identifying periods when interventions took place through news searches for a smaller group of countries, although still relying on changes in reserves to quantify the magnitude of FXI. Finally, our estimates also cover operations in derivatives markets, which are important in some countries.

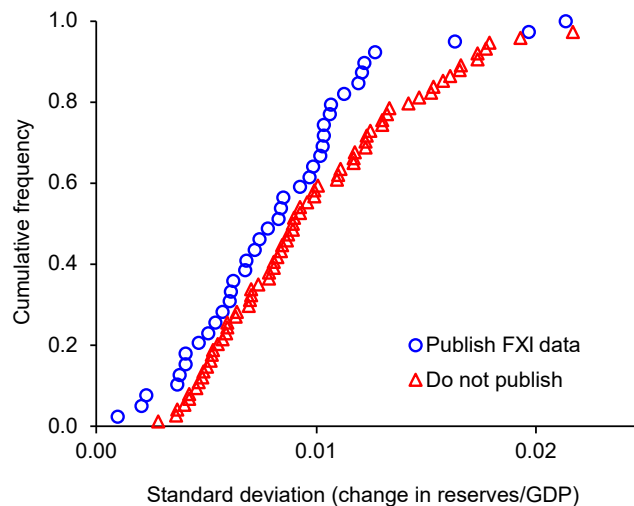
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<sup>6</sup> The time-series coverage varies across countries with data for a few of them going back to 1990, while others report only very recent data. Some countries report FXI data on a semi-annual or annual basis, see Appendix 1 Table 1.2. Given the low frequency of releases, data for the latter cases are not included in the dataset.

Our data on FXI is particularly useful for analysis on emerging market and developing economies (EMDEs) as the share of EMDEs that publish such data is still low. In fact, only about 16 percent of EMDEs publish data on FXI, in comparison to about 74 percent of (non-reserve currency issuing) AEs. Typically, countries that publish FXI data at least at quarterly frequency also do it monthly (see Appendix 1 Figure A1.1 for these facts).

More importantly, lack of publication of FXI data is not an indication of lack of use of FXI as a policy instrument. This is apparent from Figure 1, which indicates that non-publishing countries display at least as much, if not more, variation in the change in central bank reserves as countries that publish FXI data. This is consistent with the view that the decision to publish FXI is not random, another drawback of using only official data in empirical analysis of FXI. Thus, reliable estimates of foreign exchange intervention are key for any comprehensive and consistent cross-country analysis on exchange rate policy.

**Figure 1. Change in Reserves and FXI Publication**



Sources: IMF, International Finance Statistics; IMF, Information Notice Systems; International Reserves and Foreign Currency Liquidity Template; and authors' calculations.

Notes: The figure reports the cumulative distribution of the country-specific standard deviation of changes in reserves, distinguishing between countries that reported FXI data for most of the sample period and those that did not. Based on countries that report FXI data at least on a quarterly frequency.

In addition to providing a comparable measure of FXI across countries and time, our dataset also provides a classification of FXI according to the extent of sterilization, based on contemporaneous movements in the monetary policy rate, something we believe has not been done previously in the literature.

The new FXI estimates confirm some stylized facts previously discussed in the literature, extending them to a broader sample, and unveil some new stylized facts previously missed due to data limitations. In particular:

- Consistent with Dominguez et al (2012), the new FXI estimates indicate that the notion that EMDEs tend to intervene more heavily in FX markets than AEs does not hold beyond non-reserve issuing AEs. While as a group, EMDEs, relied significantly more on FXI before the

global financial crisis, in the post-GFC period the use of FXI in EMDEs has been comparable to that observed in non-reserve issuer AEs.

- The degree of exchange rate management (i.e., the observed use of FXI relative to the observed volatility of the exchange rate) is also similar across EMDEs and AEs. This contrasts with the finding of Hausmann et al (2001), who conclude that emerging markets are more interventionists than (non-G3) AEs.
- While interventions are typically conducted in spot markets, and the use of derivatives remains limited in the aggregate, the use of FX derivatives by central banks has become increasingly important in some countries, even beyond the case of Brazil documented by Nedeljkovic and Saborowski (2019).
- Some central banks, like previously documented by Newman et al (2011) for the case of Australia, simultaneously deploy spot and forward transactions that offset each other to manage FX market liquidity, without altering their foreign currency position.
- Interventions are found to be mostly asymmetric, with a bias towards FX purchases, in line with Adler et al (2021) although for a wider sample of countries.
- The novel comprehensive coverage of both published and estimated FXI reveals that countries that publish FXI data tend to intervene less in foreign exchange markets, indicating that lack of publication does not reflect a lesser use of FXI as a policy instrument.
- The novel classification of sterilized and unsterilized interventions uncovers that central banks with (*de jure*) flexible exchange rates sterilize their FXI operations most of the time but not always (85 percent of FXI operations are sterilized)...
- ...and that central banks are more likely to not fully sterilize FXI when they are leaning against appreciation than when leaning against depreciation of the local currency.

The rest of the paper is organized as follows: Section II explains in broad terms how our FXI estimates are constructed. Section III presents some stylized facts based on these estimates. Section IV describes our dataset of publicly available FX interventions. Section V assesses the performance of our estimates relative to other proxies. Section VI discusses the construction of our classification of FXI into 'fully sterilized' and 'not fully sterilized'. Section VII concludes.

## II. FXI ESTIMATES

### Definition of FXI

Although the literature on FXI is rich and long-dated, many papers overlook defining FXI. This paper defines FXI as '*any active transaction that changes the central bank's foreign-currency position regardless of intent.*' This definition has four key elements:

- i. A focus on active transactions, which means that changes in foreign currency positions that are passive, such as those arising from interest income on reserve assets or from changes in asset prices are not considered interventions. Such variations in foreign currency positions are not driven by policymaker decisions.
- ii. A focus on the central bank as the main entity conducting foreign exchange interventions. Thus, the definition excludes foreign currency operations by other public sector entities. While this is consistent with most of the literature, it implies a somewhat narrow focus due to severe data limitations on transactions or granular balance sheet data for public sector institutions other than the central bank. For most countries, the omission of FX transactions by other public sector institutions is likely to be innocuous as typically FXI is undertaken by central banks,

although there may be exceptions. See further discussion under “Limitations of this Dataset” in Section II.

- iii. A focus on the central bank’s foreign currency position, encompassing any exchange between foreign and domestic currency assets. This definition is consistent with the portfolio balance channel and delineates clear boundaries for FXI, avoiding mixing operations that entail an exchange of currencies (and could have material impact on exchange rates) with foreign currency borrowing/lending operations (whose impact on exchange rates is much less clear).
- iv. The definition encompasses all transactions that meet the above criteria, irrespective of the stated intent (for example, to accumulate reserves without aiming to affect the exchange rate), as the intent is not verifiable.<sup>7</sup>

The estimates of FXI encompass both operations in spot markets (“spot” proxy) as well as operations with derivatives (“derivative” proxy) as both affect the central bank’s foreign currency position. A “broad” proxy that includes both the spot and derivative transactions is also reported.

### Spot interventions

To arrive at an estimate of ‘spot’ FXI that fulfills the above definition, four adjustments are made to the available information on the change in the stock of reserves (the measure traditionally used in the literature). Specifically:<sup>8</sup>

- Valuation changes. We use available information on the composition of reserve assets by asset type and currency to estimate valuation changes. Specifically, we first rely on country-specific information on the breakdown of reserve assets into currency and deposits, securities, position at the IMF, SDR holdings, gold, and other foreign currency assets from the International Reserves and Foreign Currency Liquidity Template,<sup>9</sup> which is now available for close to 50 percent of the countries. Second, for countries without this information, we use the IMF’s Monetary and Financial Statistics (MFS) to get the breakdown of reserve assets into SDR holdings, gold, and all others. Regarding the currency composition of foreign currency reserves, we use information for individual countries from the International Reserves and Foreign Currency Liquidity Template, when available, or country-group aggregates from the Currency Composition of Official Foreign Exchange Reserves (COFER) dataset.<sup>10</sup> Estimates of valuation changes are necessary for the FXI proxy at *monthly* frequency as the starting point for this proxy is the change in the stock of reserves, which is “polluted” by valuation changes. At the quarterly frequency, on the other hand, our estimates are based on balance-of-payments (BOP) data—which are transaction-based—and, thus, do not require an adjustment for valuation changes, except where BOP data is not available and the change in the stock of reserves is used also for the quarterly estimates.
- Income. Estimates of investment income on reserve assets are also based on the available information on the composition of assets, combined with information on market interest rates as well as effective interest rates paid by issuers of reserve currencies (to approximate average

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<sup>7</sup> Ultimately, this is an empirical question to be explored and our dataset can serve that purpose.

<sup>8</sup> See further details in Online Appendix 1.

<sup>9</sup> Available at <https://data.imf.org/?sk=2DFB3380-3603-4D2C-90BE-A04D8BBCE237>. Reserve assets are decomposed into Currency and Deposits, Securities, Position at the IMF, SDR holdings, Gold and Other foreign currency assets.

<sup>10</sup> Available at <https://data.imf.org/?sk=E6A5F467-C14B-4AA8-9F6D-5A09EC4E62A4>.

coupon rates on longer-term securities). At the quarterly frequency, we use investment income on reserves reported by some countries as part of their BOP statistics. Estimates of investment income are applied to both the monthly and quarterly FXI estimates.

- Other foreign currency assets and liabilities vis-à-vis nonresidents. The estimates adjust for changes in other foreign assets and liabilities based on information in the Standardized Report Forms of the IMF's Monetary and Financial Statistics, some of which is provided to the Fund on a confidential basis. This includes holdings of non-reserve foreign assets as well as liabilities vis-à-vis all foreign creditors, including IMF and other official creditors.
- Other foreign currency assets and liabilities vis-à-vis residents. Finally, the estimates adjust for variations in foreign currency assets and liabilities vis-à-vis domestic entities, also using information available from the IMF's Monetary and Financial Statistics (in some cases provided on a confidential basis). As discussed below, this is a key improvement vis-à-vis proxies used in the literature up to now.<sup>11</sup>

Why is it important to adjust for these factors? As discussed in the introduction, most of the literature on the macroeconomic implications of FXI has focused on coarse proxies, primarily based on the change in the stock of international reserves. Such measures, however, can deviate from the definition of FXI above in meaningful ways. In particular:

- *Valuation changes.* Changes in the stock of reserves may reflect FXI but also valuation changes due to varying market prices of reserve assets or exchange rate movements among reserve currencies.<sup>12</sup> These variations affect the central bank's foreign currency position but are not a product of active transactions. As shown in Figure 2 below, valuations changes can be significant.
- *Investment income.* Similarly, changes in the stock of reserves partly reflect the passive return on investments. While this component is slow-moving and smaller on average than valuation changes (Figure 2), it also needs to be stripped out from changes in reserves to capture more accurately actual FXI. This adjustment is particularly important when assessing whether FXI is one-sided or two-sided, as income flows are positive by definition and thus always contribute to increasing reserves. Such income flows can be particularly important in economies with large reserve holdings. Dominguez et al (2012) are a notable early example of a proxy of FXI that adjusted for both valuation and investment income changes.
- *Other foreign currency assets and liabilities vis-à-vis nonresidents.* Changes in reserves can also reflect reallocation of foreign assets between reserve and non-reserve assets. This is particularly relevant for economies that have accumulated significant reserve assets and where reserve holdings may exceed levels consistent with precautionary liquidity buffers. In these cases, central banks often choose to invest part of their foreign currency holdings in less liquid (non-reserve) assets. Thus, portfolio management operations affect the level of reserves without altering the central bank's foreign currency position. Similarly, reserve levels may vary as central banks borrow or repay loans from foreign entities (in foreign currency), without entailing interventions in

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<sup>11</sup> Reclassifications or definitional changes in the IMF's Monetary and Financial Statistics can reduce the accuracy of the FXI proxies if not adjusted for. Series were checked comprehensively and adjusted to exclude datapoints corresponding to identified breaks. See Online Appendix 1 Table 6 for a list of adjustments.

<sup>12</sup> The accounting principle for the stock of reserves is that of market valuation, see Balance of Payments and International Investment Position Manual, Sixth Edition, 3.84, and The Monetary and Financial Statistics Manual and Compilation Guide, 5.38.

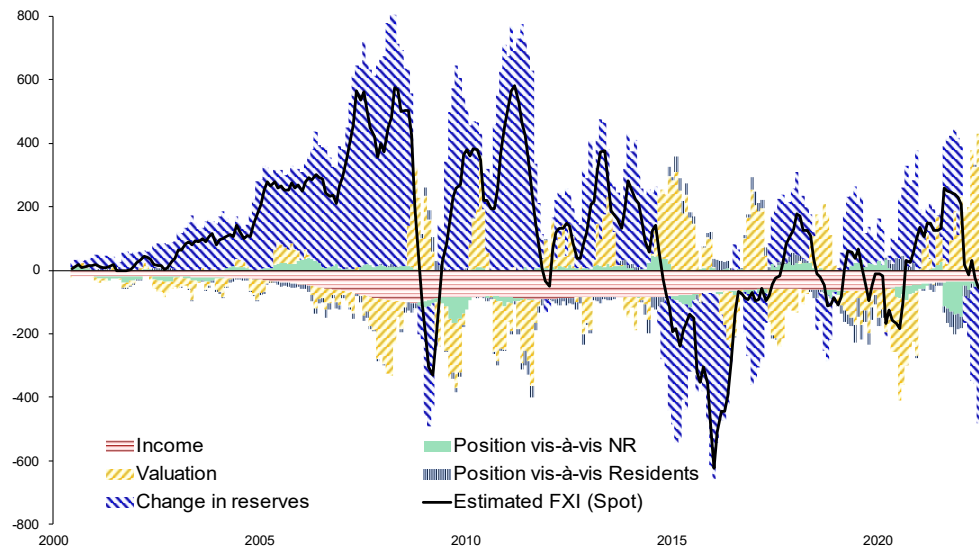


the foreign exchange market or changes in the overall foreign currency position. The latter typically include loans from the International Monetary Fund and other official creditors.

- *Foreign currency assets and liabilities vis-à-vis residents.* Changes in reserves (or foreign assets more broadly) may also reflect foreign currency operations vis-à-vis residents but do not necessarily affect the overall foreign currency position of the central bank. For example, operations on behalf of other domestic entities (e.g., the general government) entail changes in foreign assets but with an offsetting change in the liabilities vis-à-vis the domestic counterpart. Similarly, new foreign currency deposits (and withdrawals) at the central bank by the government or by financial institutions imply variations in reserves without changes in the foreign currency position. The literature has so far not adjusted for changes in these positions, due to lack of data. As indicated above, this can be done with central bank balance sheet data provided by countries to the IMF, in some cases on a confidential basis.

Figure 2 illustrates how important the above-mentioned adjustments can be in terms of changing the global picture of the use of FXI, relative to the patterns suggested by the traditional proxy of the change in reserves. As shown, the estimated spot FXI measuring the change in the central bank's foreign currency position (black line) can be considerably different from the change in reserves (blue left-stripped bar) for various reasons, including valuation changes, income flows and offsetting transactions vis-à-vis domestic and foreign residents. During certain periods, these adjustments change our understanding of the global pattern of FXI. A recent example is the period 2021-22 during which reserve changes suggest that EMDEs undertook large FX sales. In reality, however, this mainly reflected valuation losses on holdings of fixed income reserve assets due to the rise of global interest rates. Once this is accounted for by our adjustments, the conclusion is that there was little to no FXI during this period. A similar pattern during the 2008 global financial crisis was documented by Dominguez (2012) and Dominguez et al (2012).

**Figure 2. Estimated FXI and Change in Reserves. Aggregate for EMDEs (US\$ billions)**



Sources: authors' estimations.

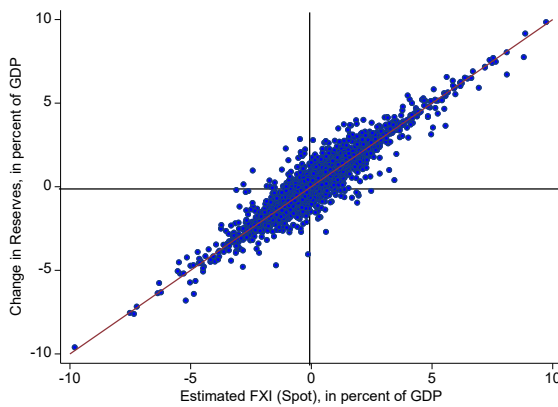
Notes: This figure decomposes our spot FXI estimate (i.e. "Estimated FXI (Spot)"), into its various components: change in reserves, valuation effects, income effects, and adjustments for changes in foreign currency positions vis-à-vis non-residents (NR) and residents. The six-month moving sum all countries in our sample is reported.

Figure 3 further illustrates the difference between changes in reserves and our FXI estimate at the country-month level. As shown in panel A, while there is a strong correlation between the two

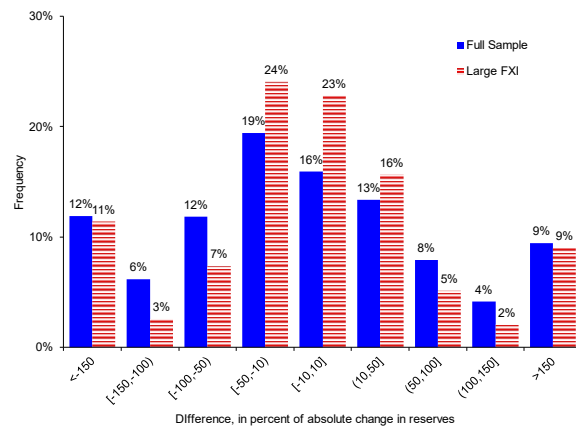
measures, there is a significant number of observations far from the 45-degree line. This is also evident in some summary statistics (see Appendix Table A1.1). For example, while the mean absolute value of the monthly change in reserves (in percent of GDP) is 0.18, the corresponding mean of our FXI estimate is 0.11, indicating that a coarser measure based on the changes in reserves tends to overstate the extent of FXI. Similarly, FXI based on our estimates is relatively more symmetric than if based on changes in reserves, indicating that interventions are less one-sided than indicated by the coarser proxy. Panel B further highlights the difference between changes in reserves and our estimates, expressed in percent of the (absolute) value of changes in reserves. For the full sample (blue solid bars), only 16 percent of observations entail differences that are smaller than 10 percent of the coarse proxy, 32 percent of observations entail differences between 10 and 50 percent, and 52 percent of the observations display differences that are more than 50 percent of the observed value of the coarse proxy. While somewhat smaller, these large differences between the two estimates remain even if small values of our estimate (less than 0.25% of GDP in absolute terms) are excluded from the sample (red striped bars), indicating that even large changes in our estimates can be very different from the simple change in reserves.

**Figure 3. Estimated FXI and Change in Reserves**

**A. FXI Estimate versus Change in Reserves**



**B. Distribution of differences**

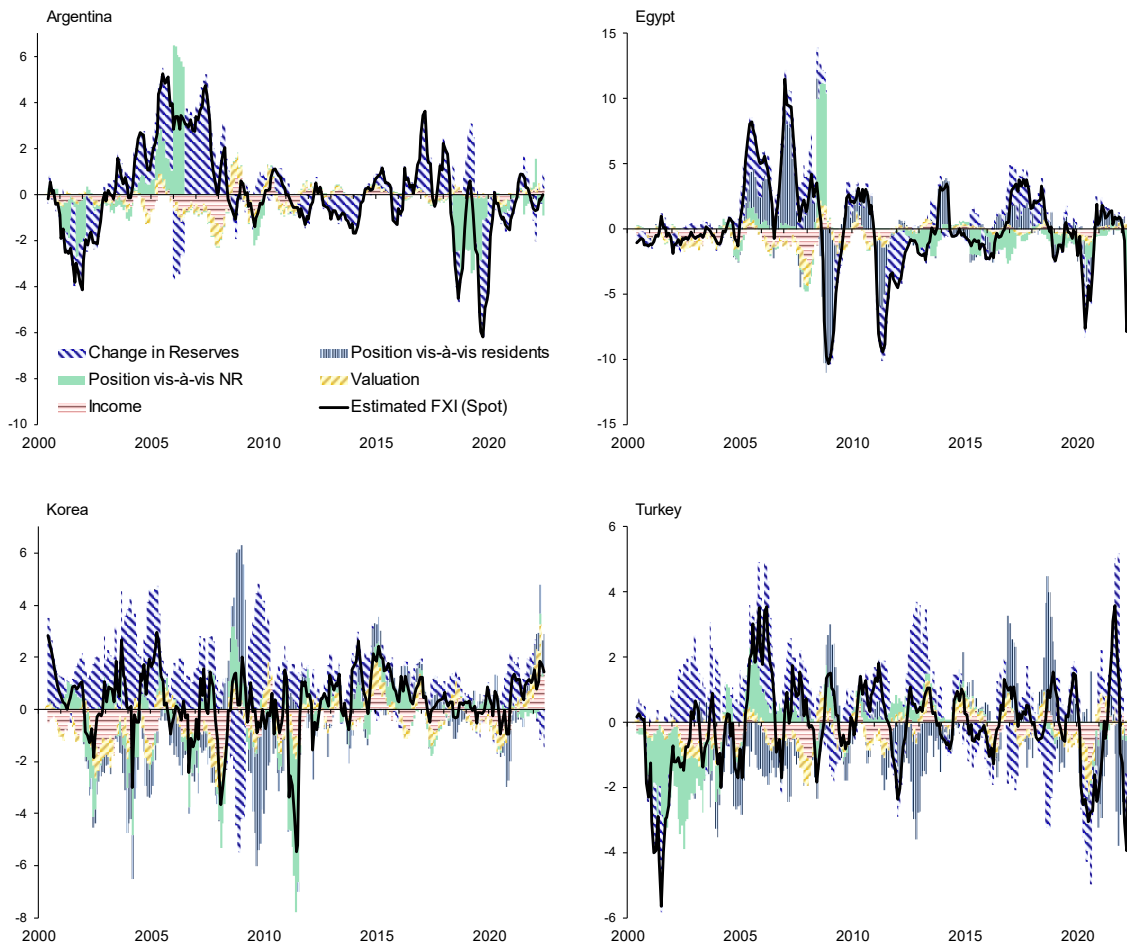


Sources: authors' estimations.

Notes: Panel A shows our estimate of spot FX intervention against the corresponding change in reserves at the country-month level, both in percent of the respective country's GDP. The red line is the 45-degree line. Panel B shows the distribution of the difference between estimate of FXI and the change in reserves divided by the absolute change in reserves at the country-month level, "Full Sample" denotes the case in which all observations are used, while "Large FXI" focuses only when our estimates are larger than 0.25 percent of GDP in absolute terms.

The difference between FXI proxies is particularly noticeable in some cases, as shown in Figure 4. For example, for Argentina, accurately capturing FXI requires accounting for large transactions vis-à-vis non-residents (including the IMF). Similarly, adjusting both for positions vis-à-vis residents and non-residents is key in the cases of Egypt, Korea, and Turkey.

**Figure 4. Selected Countries. Estimated FXI versus Change in Reserves**  
(in percent of GDP)



Sources: authors' estimations.

Note: This figure decomposes the spot FXI estimate into its various components: change in reserves, valuation effects, income effects, and adjustments for changes in the foreign currency position vis-à-vis non-residents (NR) and residents for each country. All variables are reported using a six-month moving sum.

### FXI through Currency Derivatives

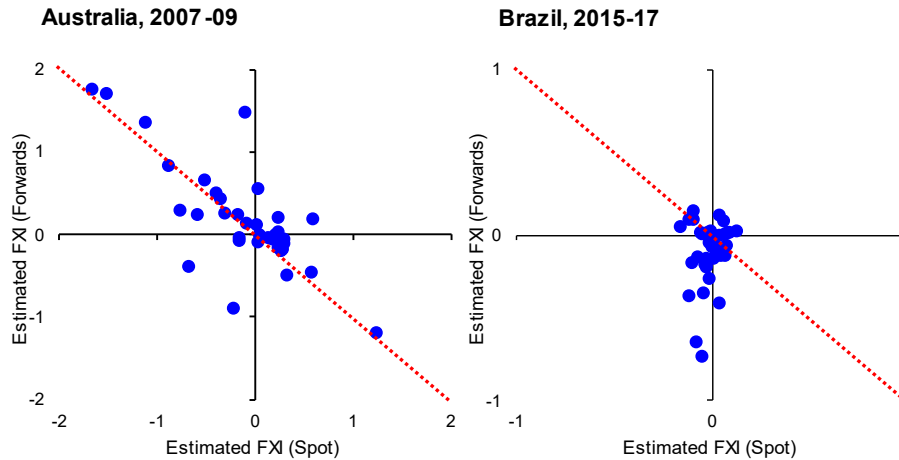
Foreign exchange derivatives have also become increasingly important instruments for intervention in foreign exchange markets. With varying magnitudes, these have been commonly used by AEs and are increasingly used in EMDEs (see Appendix 1, Figure A1.2). Capturing interventions with derivatives is key as they often entail similar effects on exchange rates than interventions in spot markets (see Nedeljkovic and Saborowski, 2019; and Chapter 5 in Chamon et al, 2019).

In practice, it is very important to distinguish between central banks that use FX swaps, without altering their net FX position (often to manage FX market liquidity and smooth market functioning)<sup>13</sup> (e.g., Australia or New Zealand) from central banks that actively use derivatives as part of their FXI operations (e.g., Brazil, Thailand, Turkey). Figure 5 illustrates that, for countries in the first group, spot

<sup>13</sup> These FX swaps are combinations of spot and mirroring forward interventions and do not necessarily affect the central bank's FX position once both elements (the spot and forward legs) are taken into account.

interventions typically offset changes in the forward position, while for the second group changes in forward positions are typically not related to spot interventions.

**Figure 5. Spot and Derivative FXI**  
(percent of GDP)



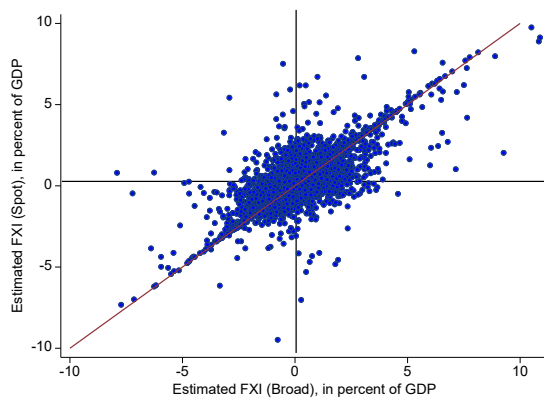
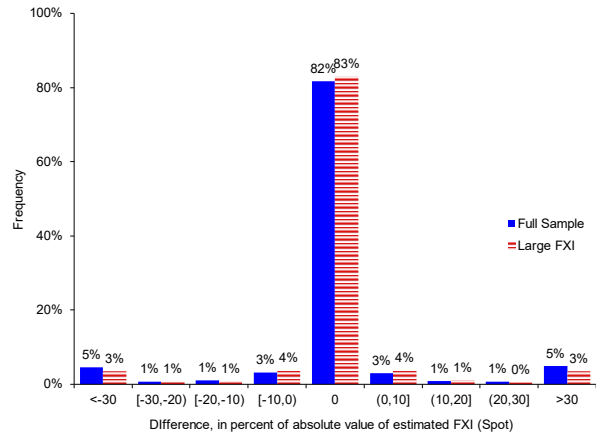
Sources: authors' estimations.

Note: The figure contrasts estimated spot FXI with estimated FXI in the forward/futures market for selected periods. Observations on the negative 45-degree line, in red, indicate that operations with derivatives fully offset spot interventions.

In order to properly capture changes in the FX position of the central banks, our dataset includes estimates of FXI with derivatives—“derivative” proxy, reported separately—that encompass changes in the aggregate short and long positions in forwards and futures in foreign currencies vis-à-vis the domestic currency (including the forward leg of currency swaps), and financial instruments denominated in foreign currency but settled by other means (e.g., in domestic currency), as reported in the International Reserves and Foreign Currency Liquidity Template.<sup>14</sup>

As shown in Figure 6 Panel A, including derivatives is a key refinement of our FXI estimate as the picture on the use of FXI can be quite different for some countries once derivatives are taken into account, as reflected in our ‘broad FXI’ estimate. A non-trivial number of observations fall far and to both sides of the 45-degree line, indicating that derivatives sometimes offset spot operations and sometimes add to them. Figure 6 Panel B further illustrates the role of derivatives, by plotting the distribution of the difference between the broad and spot estimate, in percent of the (absolute) value of the spot estimate. As shown, 17-18 percent of observations exhibit non-zero differences between the two measures, indicating some use of derivatives. Moreover, this figure is likely to underestimate the true use of FXI through derivatives as it is based on data reported to International Reserves and Foreign Currency Liquidity Template and some countries only started reporting such data in recent years (in absence of reported data, derivative transactions are treated as zeros).

<sup>14</sup> For countries using FX swaps frequently, it is advisable to use the “broad” proxy as it combines the spot and forward legs of the swap and, thus, provides a more accurate read of the change in the central bank’s net foreign currency position.

**Figure 6. Spot versus broad FXI estimate****A. FXI Spot versus FXI Broad****B. Distribution of differences**

Sources: authors' estimations.

Notes: Panel A shows our estimate of FXI (including derivatives) against the corresponding change in reserves at the country-month level, in percent of country's GDP. The red line is the 45-degree line. Panel B shows the distribution of the difference between our estimate of FXI including derivatives and our estimate including only spot market interventions divided by the absolute estimate of spot FXI at the country-month level, "Full Sample" indicates that all observations are used, while "Large FXI" focuses only observations corresponding to spot FXI estimates larger than 0.25 percent of GDP in absolute terms.

**Limitations of this Dataset**

While our FXI estimates entail a refinement relative to previous measures, there is scope for further improvements along several dimensions, once more granular data become available. Specifically:

- The computation of valuation changes is constrained by the limited country-specific information on the currency composition of central banks reserves (and foreign assets more broadly). The available information is currently provided by country authorities to the IMF as part of their submissions to Currency Composition of Official Foreign Exchange Reserves (COFER) database, but the individual country data is confidential. Some progress has been made with individual reporting and publication of data under the International Reserves and Foreign Currency Liquidity Template, although the current set of countries remains small. Thus, valuation changes for most countries are estimated on the basis of aggregate currency shares. For many countries, especially for the early years of the sample, this assumption is likely innocuous as the US dollar vastly dominates reserve holdings. For countries with close economic ties to economic areas that issue other reserve currencies, however, other reserve assets may play a greater role (e.g., Eastern European economies may hold larger than average reserve shares in Euro-denominated assets).<sup>15</sup> In addition, while still relatively low, some currencies (like the Swiss Franc, Canadian dollar, Australian dollar) have gained some ground in reserve holdings over time.
- As foreign currency holdings grow, investment diversification towards higher return and less liquid assets, including equity, is likely to take place. Consequently, valuation changes may become more volatile and difficult to estimate unless granular data on such investments are made available.
- In line with the rest of the literature, our work focused on foreign currency transactions by the central bank. In some cases, however, operations by other public entities (like the central

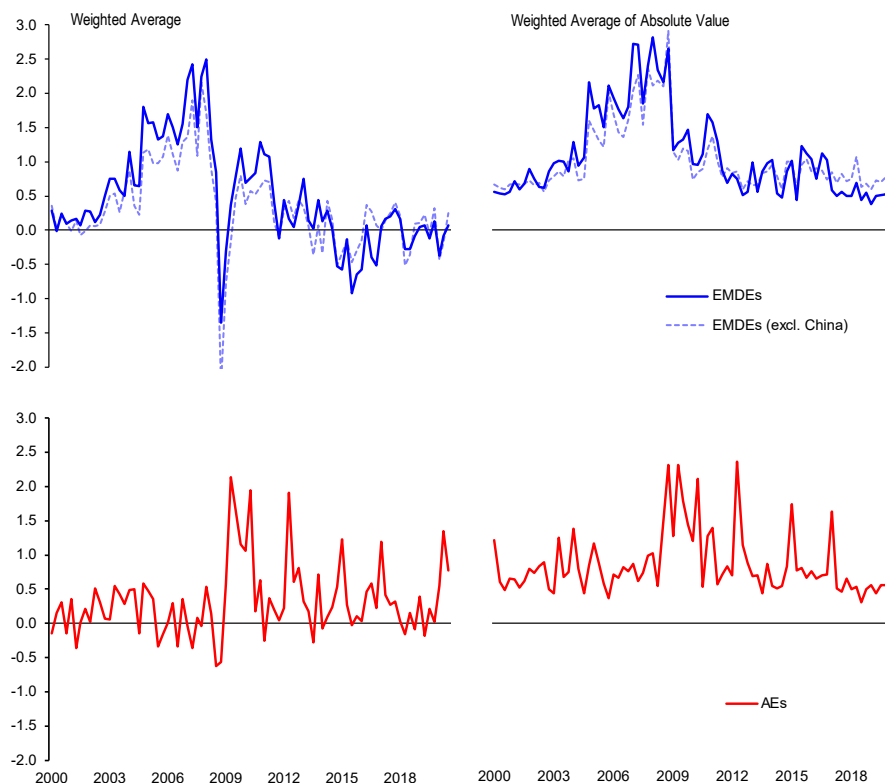
<sup>15</sup> See Anderson et al (2020).

government, public banks, sovereign wealth funds or state-owned enterprises) share some of the key characteristics of central bank interventions (Bayoumi et al, 2015). Limited data on the balance sheets of these public entities, especially at monthly or quarterly frequency and breaking down positions by currency, precludes a broader coverage of foreign currency transactions at this point.

### III. STYLIZED FACTS FROM OUR FXI ESTIMATES

Our dataset provides a comprehensive and comparable view on the use of FXI across countries and over the last two decades, extending previous stylized facts to a broader sample and unveiling some new insights (previously missed due to data limitations).

**Figure 7. Foreign Exchange Intervention by Group of Countries**  
(broad proxy, in percent of GDP)



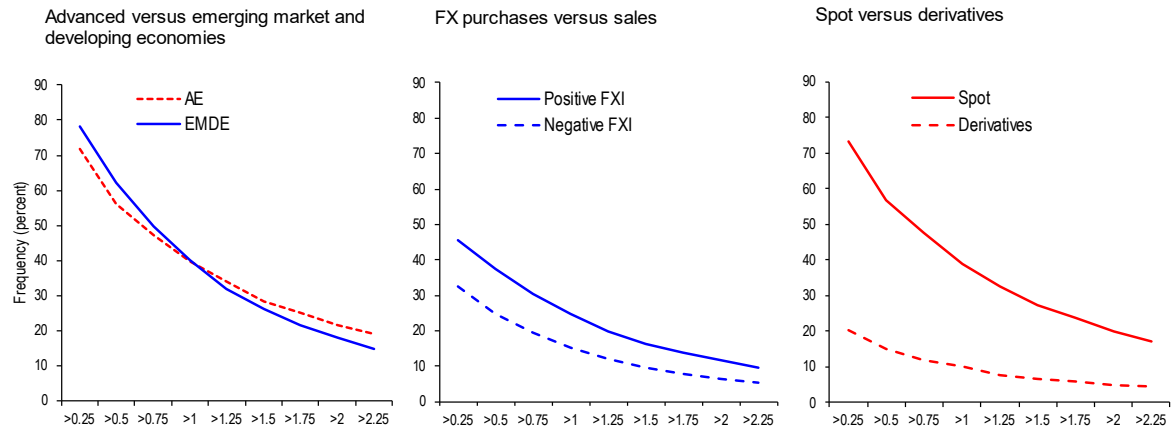
Sources: authors' estimations.

Notes: This figure shows the estimated average quarterly foreign exchange intervention (using "broad" proxy=spot plus derivatives) weighted by 3-year moving average nominal GDP across major types of countries (EMDEs and EMDEs excluding China in the top two charts, and AEs in the bottom charts). Positive (negative) values indicate FX purchases (sales).

Consistent with Dominguez et al (2012), the new FXI estimates indicate that the notion that EMDEs tend to intervene more heavily in FX markets than AEs does not always hold. As a group, EMDEs, relied significantly more on FXI than AEs before the global financial crisis (GFC), and this holds even after excluding China (see Figure 7). In the post-GFC period, however, the extent of foreign exchange intervention in EMDEs has been comparable to that observed in (non-reserve issuer) AEs. The FXI patterns in the latter group have been dominated by economies with large financial sectors which have deployed significant FXI to cope with sizable capital flows (e.g., Hong Kong SAR, Singapore,

Switzerland).<sup>16</sup> Note that Fratzscher et al (2019) equate narrow band regimes with emerging and developing markets to conclude that interventions are more frequent in EMDEs. Our findings differ because many AEs in our dataset seem, in fact, to pursue narrow band regimes (examples include Hong Kong SAR, Macau SAR, Singapore, Denmark, or Taiwan POC, see also Figure 8 and the discussion therein).

**Figure 8. Patterns of Foreign Exchange Intervention**  
(frequency of FXI larger than the absolute value indicated in x-axis)



Sources: authors' estimations.

Notes: The figure shows the relative frequency (y-axis) of absolute FXI that falls in the buckets in the x-axis. The left most bucket in each chart denotes the share of interventions that exceed 0.25 percent of GDP in absolute terms in a quarter, the second bucket is the share of interventions that exceed 0.5 percent of GDP in absolute terms, and so forth up to interventions larger than 2.25 percent of GDP in absolute terms. Based on quarterly observations for non reserve-issuing countries.

Figure 8 illustrates how frequently countries use FXI based on our estimates. As discussed above, both EMDEs and AEs intervene frequently, conducting interventions of absolute size of at least 0.25 percent of GDP per quarter nearly  $\frac{3}{4}$  of the time. Our dataset also reveals that, even after adjusting for investment income, there is significant asymmetry in the use of FXI, with purchases of foreign currency being significantly more frequent than sales, as noted also by Fratzscher et al (2019). This is visible for EMDEs as well as AEs, as shown in Appendix 1 Figure A1.3. The use of derivatives, on the other hand, remains limited in comparison to spot interventions, although it is more prevalent in AEs than EMDEs.<sup>17</sup> Within AEs, financial centers display a particularly extensive use of FXI, especially through derivatives (see Appendix 1, Figure A1.4). The patterns of FXI for other AEs are similar to those observed in EMDEs.

<sup>16</sup> The analysis focuses on AEs that are not major reserve currency issuers, as the latter are known for intervening very little or nothing (except in extraordinary circumstances). While the cutoff for defining *major* reserve currency issuers is somewhat arbitrary, it is clear that the currencies of the US, Euro Area, UK and Japan are much more widely used as reserves than any other currency, as shown in the [IMF's COFER data](#). The picture for all AEs, including major reserve issues, would point to more limited use of FXI in AEs, reflecting the near absent FX operations by these four reserve-currency issuers.

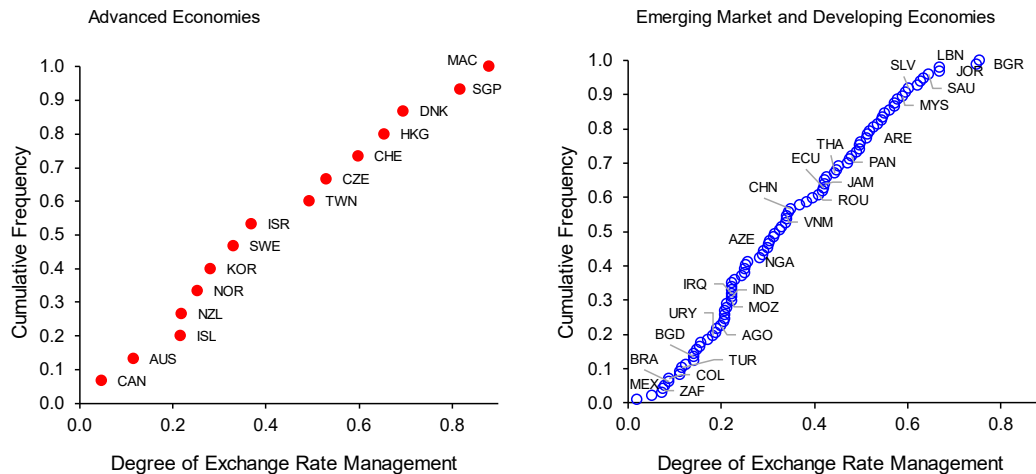
<sup>17</sup> The apparent symmetry in FXI through derivatives should be interpreted with caution as it may reflect the unwinding of positions as they come due. In addition, some central banks use swaps (involving a spot and a forward intervention) to manage liquidity in the FX market without altering their FX position. In these cases, spot and derivative FXI may fully offset each other. Thus, the broad FXI measure, encompassing both spot and derivatives, may provide a more accurate representation of FXI in these cases. See further discussion in Online Appendix 1.

While there is significant variation within groups, the degree of exchange rate management in EMDEs and AEs is similar, in contrast to the findings of Hausmann et al (2001). Using our estimates of FXI, we can characterize countries' degree of exchange rate management computing an index of the following form:

$$\rho_i = \frac{\sigma_i^{FXI}}{\sigma_i^{FXI} + \sigma_i^{NEER}} \quad (1)$$

where  $\sigma_i^{FXI}$  is the standard deviation of our broad FXI proxy (in percent of GDP) and  $\sigma_i^{NEER}$  is the standard deviation of the change in the nominal effective exchange rate, both for the full sample period.<sup>18</sup> The index takes the value 0 for countries that do not intervene (pure floating) and 1 for those that intervene and whose nominal effective exchange rate does not move (de facto pegs).<sup>19, 20</sup> Figure 9 displays the values of equation (1) for AEs and EMDEs. While on average AEs allow for slightly greater exchange rate flexibility in comparison to EMDEs, the distributions are not very different and there is considerable variation within both groups. Among AEs, economies with large financial sectors (like Hong Kong SAR, Iceland, Singapore, Switzerland, etc.) tend to display a higher degree of exchange rate management than other AEs. Within EMDEs, there is also a wide range of values, with some large EMDEs displaying flexible regimes comparable to the most flexible AEs (Mexico, South Africa, Colombia, Brazil, Turkey), while others displaying highly managed regimes (including because they have de jure fixed exchange rate regimes, like Bulgaria and Saudi Arabia).

**Figure 9. Degree of Exchange Rate Management, 2000-20**  
(Index)



Sources: authors' estimation.

Notes: The figure reports the index  $\rho$  as defined in equation (1) computed over the full sample period (thus, the index may not reflect the most recent pattern of exchange rate management). It varies from 0 (pure floating) to 1 (peg). Major reserve-issuing countries (Euro area economies, Japan, the U.K. and the U.S.) are excluded.

<sup>18</sup> Hausmann et al (2001) and Adler et al (2019) construct broadly similar ratios.

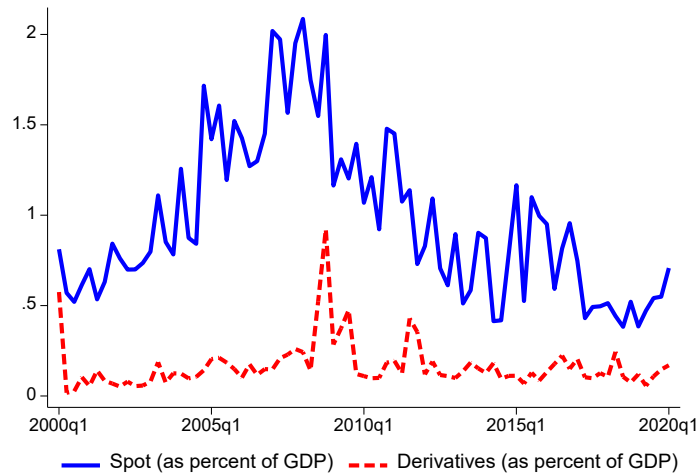
<sup>19</sup> The sample of countries includes *de jure* pegs which are expected to display a high degree of exchange rate management by the nature of the regime.

<sup>20</sup> Strictly, economies with pegs can display movements in the NEER as they normally fix their currencies relative to one (or a basket of) currencies different from the basket used to compute the NEER. In practice, the index shows intuitive results at least in terms of relative values among countries (see also Adler et al, 2019).



Interventions remain dominated by transactions in spot markets. While interventions in foreign currency derivatives have become more frequent (see Appendix Figure A1.2) and there are prominent cases of the use of FXI with derivatives (see Nedeljkovic and Saborowski, 2019 for Brazil), their size remains smaller than interventions in spot markets. At the same time, we find that derivatives are used significantly during periods of stress, as shown by the spikes during the Global Financial and European crises (Figure 10). This allows central banks to preserve liquidity buffers while providing foreign currency hedging during episodes of heightened exchange rate market pressures.

**Figure 10. Spot versus Derivatives**  
(absolute value, percent of GDP)

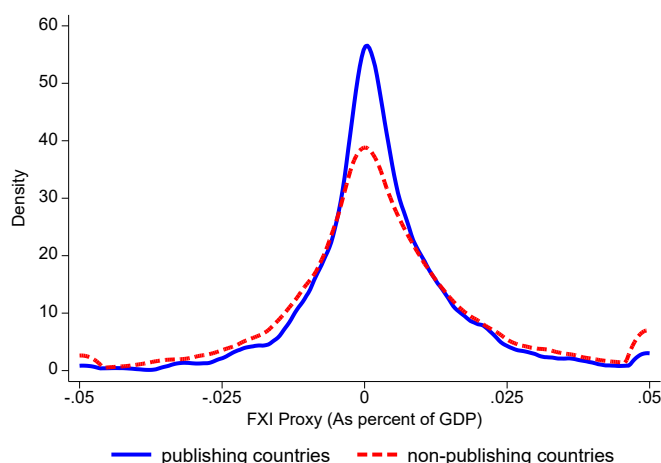


Sources: authors' estimation.

Notes: This figure presents our estimates of spot and derivatives absolute FX interventions at the quarterly level aggregated across countries weighting by 3-year moving average GDP.

Countries that intervene less are more inclined to publish their FXI operations. As shown in Figure 11, our data indicate that countries that publish FXI data also intervene less in foreign exchange markets, as illustrated by the greater mass of the density function around zero (blue solid line), in comparison to countries that do not publish FXI data (red dashed line). That is, the lack of publication does not indicate a lack of use of FXI as a policy instrument, quite on the contrary. This evidence is new to the best of our knowledge and highlights the usefulness of having both official data and estimates of FXI.

**Figure 11. FXI Estimates for Publishing and Non-publishing Economies**  
(percent of GDP, broad FXI proxy)



Sources: Country authorities and authors' estimation.

Note: This figure shows the density of our broad FXI estimate (spot plus derivatives) at quarterly frequency depending on whether countries publish or not FX intervention data at least at the quarterly frequency. The support of the distributions is limited to  $\pm 0.05$ , and thus absolute interventions beyond that value appear as a mass in the extremes of the chart.

#### IV. OFFICIALLY PUBLISHED DATA

In addition to our FXI estimates, the dataset includes time-series of publicly available official information on FXI. To our best knowledge, we are providing the most comprehensive dataset of officially published FXI. Putting these data together entailed a multi-stage process. First, we searched through central bank websites, aided by the information reported in the IMF's AREAER.<sup>21</sup> The format of available data varies significantly across countries as some central banks provide time-series directly in a usable format while others report scattered FXI information through separate reports, for example monthly or quarterly reports on monetary and exchange rate policies. Thus, a second effort entailed hand-collecting information from such reports. Country-specific details, including sources, are available in Appendix Table A1.2. Finally, the collected information was shared and discussed with various IMF country teams. In some cases, central banks were contacted to corroborate the collected information.

The dataset includes officially published FXI for 43 countries at quarterly frequency and for 39 countries at monthly frequency.<sup>22, 23</sup>

<sup>21</sup> See Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) at <https://www.imf.org/~media/Files/Publications/AREAER/areaer-2018-overview.ashx>.

<sup>22</sup> See a summary of county-by-country metadata in Online Appendix 2.

<sup>23</sup> Fourteen of these countries also publish weekly data. On other hand, some countries report FXI data on an annual basis. These are not included in the dataset.

As discussed in detail in the introduction, an important issue regarding official FXI data is the definition of FXI may not be uniform across countries (and, in some cases, it may not correspond to the concept of FXI considered in this paper, i.e., transaction-based changes in the foreign-currency position of the central bank). In fact, in most cases, there is no easily accessible and clear definition of the published FXI series (some exceptions are Australia, Costa Rica and Mexico). This means that the treatment of certain FX transactions is unclear in many cases. For example, the treatment of operations done with or on behalf of the government or state-owned enterprises<sup>24</sup> or the treatment of export surrender requirements can be different across countries. Also, in some cases, reported series may only encompass operations in FX markets (excluding bilateral transactions with other, private or public, entities) while in others the series may report any exchange of foreign and domestic currency assets. Whether excluding some operations is warranted (e.g., when they reflect commercial transactions, as opposed to exchange rate policy) or a desire to maintain a certain level of secrecy is difficult to identify. This highlights the complexities of establishing a unique and measurable definition of FXI.

## V. COMPARING ESTIMATES AND OFFICIAL FXI DATA

This section compares published official spot FXI data with commonly used measures of FXI and our estimate of spot FXI to assess whether the latter approximates officially published FXI better.<sup>25</sup> However, the analysis should be interpreted with caution. It is based on the premise that official FXI series encompass all transactions of the central bank that alter its foreign exchange position (consistent with the definition of FXI used in this paper) although it cannot be ruled out that, in some cases, reported series may be defined differently. To mitigate this, official FXI data were not used when definitional differences between our proxy and the official FXI data were likely. Specifically, two main criteria were used to exclude official FXI data from the analysis in this section. Firstly, countries classified as freely floating for at least 10 years in the AREAER dataset (which overwhelmingly report zero official interventions) were excluded. This encompassed United States, United Kingdom, Canada, Japan, Euro area, Australia, New Zealand, and Mexico. Secondly, Angola, Bolivia, Nicaragua, Nigeria, and Turkey were also excluded on account of large discrepancies between official FXI and the change in reserves (e.g., published interventions are mostly one-sided while the stock of reserves drifts in the opposite direction over time, see Appendix 1, Figure A1.5). Users of our dataset are advised to treat the data for these countries with caution as proxies and official FXI series may correspond to different FXI definitions.<sup>26</sup> This section, thus, focuses on a sample of countries that are non-pure floaters and publish intervention data.

<sup>24</sup> Transactions with the government and SOEs as counterparts are considered FXI under the definition used in this paper, while FX transactions done on behalf of these other entities do not qualify as FXI.

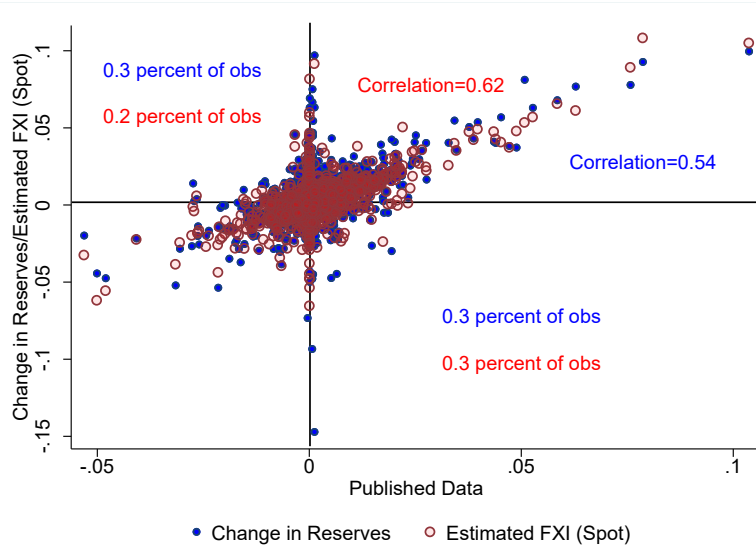
<sup>25</sup> A caveat to the analysis in this section is that it can only be done for countries that published official FXI data. As these economies may be more transparent and provide more granular data to construct our spot proxy, a selection bias may influence the results.

<sup>26</sup> To aid users of the dataset, Appendix Table A1.3 reports results of country-by-country regressions of the type:

$x_{i,t} = \alpha_i + \beta_i x_{i,t}^* + \varepsilon_{i,t}$ , where  $x_{i,t}^*$  is official FXI data,  $x_{i,t}$  is either the change in reserves or our spot proxy for country  $i$  and period  $t$ , both expressed in percent of GDP and  $\varepsilon_{i,t} \sim N(0, \sigma_i)$ . These regressions span 2000-19. In principle,  $\alpha_i = 0$  and  $\beta_i = 1$  if proxies and official data are consistent up to idiosyncratic measurement error. However, some countries reported in Appendix Table A1.3 show systematic departures between the change in reserves or our spot proxy and official data as well as very low correlation, or even negative, between proxies and official FXI. See further details on the methodology in the section below.

A first glance at the data indicates that our spot FXI estimate matches official intervention data—where available—more closely than the change in the stock of reserves (see Figure 12 for a comparison at the monthly frequency). The raw correlation between the estimated and official FXI is 0.61 while that of changes in reserves and official FXI is 0.54. Moreover, the estimated and official interventions rarely have different signs, with only about 0.5 percent of country/month observations having a meaningfully different sign.<sup>27</sup> The relatively low correlation is driven by a few outliers for which official FXI is reported to be zero but our proxies assign it a non-zero value, with the difference possibly reflecting a narrower definition of FXI used by some of these central banks.<sup>28</sup>

**Figure 12. Correlation with official FXI. Spot estimate vs. change in reserves**  
(percent of GDP, monthly frequency)



Sources: IMF International Financial Statistics and authors' estimates.

Note: This figure shows how our estimate of spot FX intervention and the change in reserves (y-axis) compares to published spot FX intervention at the country-month level, both in percent of the respective country's GDP.

## A. Comparing Proxies: Univariate Regressions

In what follows, we compare our spot estimate as well as other coarser proxies with official FXI data more formally to learn about the information content in these different measures, and to identify which specific adjustments to the coarse measures are useful to provide a more accurate picture of FXI.

We start by using a classic measurement error framework (see, for example, Greene, 2000) to compare more formally the accuracy of our spot estimate versus coarser measures traditionally used. Specifically, consider the following measurement error equation:

<sup>27</sup> A meaningful difference in sign is one in which the same country/month observation has different signs of official and proxied FXI, defined relative to the variable's country-specific standard deviation. An observation is said to be positive if it is larger than its country-specific standard deviation, while it is said to be negative if it is smaller than its country-specific standard deviation multiplied by -1.

<sup>28</sup> Figure 12 does not control for country-specific differences in the average level of proxy and official data, although correlations are broadly similar to the ones reported above when using country-demeaned data.

$$x_{i,t} = \alpha_i + \beta x_{i,t}^* + \varepsilon_{i,t} \quad (2)$$

where  $x_{i,t}^*$  is official FXI data,  $x_{i,t}$  is the FXI proxy for country  $i$  and period  $t$ , both expressed in percent of GDP<sup>29</sup> and  $\varepsilon_{i,t} \sim N(0, \sigma^\varepsilon)$ . In this specification,  $\alpha_i$  captures any systematic deviation between proxied and official data and the error term is assumed to be random measurement error. If proxies are polluted only by classic measurement error,  $\alpha_i \approx 0$ ,  $\beta \approx 1$ . In addition, if there is no measurement error, then  $\sigma^\varepsilon \approx 0$ .<sup>30</sup>

The coefficient  $\beta$  above is estimated using a panel fixed effects estimator for the changes in reserves as well as for our spot estimate. These comparisons are done both for the monthly and quarterly proxies as the construction of each of these proxies varies (due to availability of balance of payments data, which are purged of valuation effects, at different frequencies) as explained before.

The spot estimate displays a coefficient closer to 1, including statistically, compared to the regressions using the change in reserves or BOP flows, although the difference is small (see Table 1). The R-squared of the regressions using the spot estimate are also considerably higher, pointing to greater accuracy of the latter vis-à-vis the other, coarser, measures. Moreover, the weighted average country constant, denoted by “constant” in the table, is several times smaller in the case of the spot estimate, indicating that the latter displays significantly smaller systematic deviations on average from the official data than the other proxies, partly due to the spot estimate stripping out investment income from the growth in international reserves. If running country-by-country regressions of equation (2), the median estimated  $\beta$  goes from 0.77 when considering changes in reserves to 0.83 and 0.83 for our spot and broad proxies, respectively (see Appendix Table A1.3).

**Table 1. Officially Published and Estimates of FXI. Full Sample (2000-19)**

	Monthly		Quarterly		
	(1) Change in Reserves	(2) Spot Estimate	(3) BOP Flow	(4) Change in Reserves	(5) Spot Estimate
Official Data	0.927*** (0.054)	0.940*** (0.031)	0.865*** (0.048)	0.892*** (0.052)	0.918*** (0.048)
Constant	0.001*** (0.000)	0.000*** (0.000)	0.002*** (0.000)	0.003*** (0.000)	0.001*** (0.000)
Observations	4177	4177	1503	1503	1503
# Countries	23	23	26	26	26
R-squared	0.294	0.391	0.500	0.462	0.626
Adjusted R-squared	0.294	0.391	0.500	0.462	0.626
P-value ( $\beta = 1$ )	0.193	0.067	0.009	0.048	0.101

Source: authors' estimations

Notes: All regressions include country fixed effects. Standard errors clustered at the country level in parentheses.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>29</sup> The three-year backward moving-average level of yearly GDP in the denominator is used to ensure that monthly or quarterly variations come primarily from changes in the numerator.

<sup>30</sup> Alternatively, the official data can be regressed on the different proxies and our conclusions hold. Since the variance of any of the proxies tends to be higher than the variance of the official data (in part, reflecting non-zero variations in the spot proxy during periods of no intervention), beta coefficients are smaller for all proxies under this alternative specification.

As shown in Table A1.4, the advantage of the spot estimate vis-à-vis the coarser measures is even more evident when the sample period is restricted to the last decade (2010-19). This is visible in the larger differences in the  $\beta$  coefficient and the R-squared, and reflects the fact that, with growing stocks of reserves (and foreign currency assets more broadly) over time, valuation changes have become larger and, thus, leading to a lower accuracy of the change in the stock of reserves as a proxy for FXI. Moreover, this more recent sample is close to balanced (18 countries available in 2010m1) while the earlier was more unbalanced (10 countries available in 2000m1). A similar notion applies to the investment income component, although the secular decline in global interest rates has reduced the importance of this component over time (see also Online Appendix 1). Finally, the adjustments made due to changes in central bank FX positions are also typically available only after 2002, and for some cases later, making the spot estimate more accurate in more recent years.

## B. Dissecting the Spot Estimate: Horse Races

An alternative approach to evaluate the usefulness of our estimate vis-à-vis changes in reserves is through 'horse race' regressions of the following type:

$$x_{i,t}^* = a_i + \gamma_1 x_{i,t}^1 + \gamma_2 x_{i,t}^2 + \xi_{i,t} \quad (3)$$

where  $x_{i,t}^*$  is official FXI data;  $x_{i,t}^1$  is the change in reserves; and  $x_{i,t}^2$  is our spot estimate, all expressed in percent of GDP. For quarterly data, we also compare changes in reserves against reserve transactions as recorded in the balance of payments.

The results point to the superiority of our spot estimate over the change in reserves (Table 2). Specifically, our spot estimate adds significantly to the R-squared of the regression at the monthly frequency (going from column 1 to 2). Also, its coefficient in column 2 is positive and significant at 1 percent level, meaning that an upward change in our spot estimate correlates with purchases reported in official FXI, controlling for changes in reserves. That is, there is significant additional informational content in our proxy in relation to the information included in the changes in reserves. The same holds for quarterly data, where also reserve transactions as recorded in the BOP seem to improve on the change in reserves (column 4 compared to 3). Our spot estimate, though, dominates the BOP reserve flow since its coefficient becomes insignificant in a three-way regression (column 5). The R-squared again is also considerably larger when the spot estimate is introduced.

A similar approach can be used to assess the value of specific elements of our measure. This entails dissecting the spot estimate into its different components to assess their individual contributions. To this end, we construct "intermediate" estimates to be included in equation (3), one for each main adjustment made to the changes in reserves as part of the construct of our spot estimate, introducing adjustments incrementally. Such a 'horse race' allows to evaluate the individual importance of each adjustment in terms of providing information that correlates with official FXI data that is not already embedded in the change in reserves. A significant coefficient on any one of these intermediate estimates indicates that each additional adjustment has marginal information and is helpful in getting our spot estimate closer to official FXI data. Moreover, changes in the value and statistical significance of the coefficient of the change in reserves serve as a test on whether the spot (intermediate or final) estimates subsume the information embedded in the change in reserves.

**Table 2. Horse Race: Changes in Reserves vis-à-vis Spot Estimate (2000-19)**

	Monthly		Quarterly		
	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Official Data				
Change in reserves	0.317*** (0.080)	0.132** (0.056)	0.518*** (0.095)	0.150** (0.070)	0.161** (0.077)
BOP flow				0.431** (0.157)	0.011 (0.152)
Spot Estimate		0.316*** (0.059)			0.541*** (0.089)
Constant	0.001*** (0.000)	0.000*** (0.000)	0.000 (0.001)	0.000 (0.001)	0.000 (0.000)
Observations	4177	4177	1503	1503	1503
# Countries	23	23	26	26	26
R-squared	0.294	0.420	0.462	0.507	0.649
Adjusted R-squared	0.294	0.419	0.462	0.506	0.649

Source: authors' estimations.

Notes: All regressions include country fixed effects. Standard errors clustered at the country level. \*\*\* p&lt;0.01, \*\* p&lt;0.05

**Table 3. A Horserace between Proxies. (2000-19, monthly frequency)**

	Dependent Variable: Official Data				
	(1)	(2)	(3)	(4)	(5)
Change in reserves	0.317*** (0.080)	0.122 (0.088)	0.142 (0.087)	0.141 (0.087)	0.130 (0.100)
Adjustment added: Valuation and income effects		0.217 (0.137)	-0.222* (0.119)	-0.224* (0.120)	-0.191 (0.131)
Adjustment added: CB position relative to IMF			0.447*** (0.074)	0.410*** (0.092)	0.468*** (0.088)
Adjustment added: Position relative to other non-residents				0.040 (0.026)	-0.329*** (0.069)
Adjustment added: Position relative to residents					0.425*** (0.047)
Constant	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.000*** (0.000)
Observations	4177	4177	4177	4177	4177
# Countries	23	23	23	23	23
Within R-squared	0.294	0.304	0.331	0.332	0.464
Adjusted R-squared	0.294	0.304	0.331	0.332	0.463

Source: authors' estimations.

Notes: All regressions include country fixed effects. Standard errors clustered at the country level. \*\*\* p&lt;0.01, \*\* p&lt;0.05.

Table 3 displays horse races at monthly frequency across the different adjustments made to arrive at our final estimate, confirming that several of our adjustments to changes in reserves improve the FXI estimate, bringing it closer to the official FXI data. First, we evaluate the adjustments for investment income and valuation changes (column 2). Although the coefficient of the corresponding intermediate estimate that adjusts for income and valuation effects is not significant at the 10 percent level, partly reflecting collinearity, it is significant at 15 percent level and it increases the R-squared, suggesting that while the contribution may be small, it adds information. Adjusting for the position of the central bank vis-à-vis the IMF (column 3) moves the FXI estimate substantially closer to official data as

indicated by the highly significant coefficient of the intermediate estimate and the higher R-squared.<sup>31</sup> Column (4) shows that adjustments to the net position of the central bank vis-à-vis other non-residents do not seem to add much on their own (the coefficient is insignificant and the R-squared is broadly unchanged). Finally, the adjustment for central bank's positions vis-à-vis residents (column 5), is found to have the largest impact, with a coefficient that is highly significant and a material impact on the R-squared. Note that, in this case, the coefficient on the adjustment vis-à-vis other non-residents becomes negative (and highly significant), denoting some offsetting between the two adjustments for central bank positions relative to non-residents and residents. Finally, note that the coefficient on the change in reserves is always insignificant in columns (2)-(5) indicating that all the relevant information in the change in reserves (and more) is contained in our estimate. Appendix Table A1.5 shows similar findings for the proxies at quarterly frequency, as do Appendix Tables A1.6 and A1.7 focused on most recent years (2010-19).

## VI. STERILIZATION

The literature has long sought to distinguish FXI operations that are sterilized from those that are not sterilized. Unsterilized interventions, or those that induce a change in the monetary base or the policy rate, are widely believed to affect the exchange rate as they directly shift the supply of local currency vis-à-vis foreign currency assets affecting, *ceteris paribus*, the domestic interest rate and asset prices. Sterilized interventions, on the other hand, can only be effective if they affect currency risk premia, the future path of interest rates or both, while having no effect on either the current monetary base or policy rate.

To the best of our knowledge, there has been no attempt in the existing literature on FXI proxies to distinguish between sterilized and not sterilized FXI. Hence, our dataset also aims to fill this gap by providing a binary classification of our FXI estimates into 'fully sterilized' and 'not fully sterilized'.

As a first step, we take into account the existing *de jure* exchange rate regime. Specifically, when FXI is undertaken under a fixed exchange rate regime, it is classified as 'not fully sterilized', consistent with the working of such monetary arrangement (provided there is some degree of capital account openness). We construct a measure of *de jure* monetary regimes by going over country-by-country detailed information in the IMF's AREAER annual reports and extracting information on their *de jure* arrangements. We classify as pegs all exchange rate arrangements listed in the reports as having no legal tender, a currency board, a conventional peg, a pegged exchange rate within horizontal band, a crawling peg, a crawl-like arrangement and stabilized arrangements. Free floating, floating and other managed arrangements are classified as non-pegs.

Second, we follow two alternative approaches to classify interventions under non-pegged regimes which involve looking at either contemporaneous changes in short-term interest rates or in the monetary base. This follows the practice in the literature of assessing sterilized intervention by adding said variables as controls (see, for example, Fratzscher et al 2019, Tables A10 and A13).

The interest rate approach entails classifying FXI on the basis of the contemporaneous behavior of the monetary policy rate (a measure of the monetary policy stance). Specifically, an FX purchase (sale) is considered 'fully sterilized' when the monetary policy rate remains unchanged or increases

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<sup>31</sup> While the contribution to the r-squared is small—reflecting that transactions vis-à-vis the IMF are infrequent—the coefficient is highly significant, pointing to the importance of this adjustment to get a more accurate measure of FXI.



(decreases) during the same period. Observations that do not fulfill this criterion are classified as ‘not fully sterilized’.<sup>32, 33, 34</sup>

The monetary base approach entails classifying FXI on the basis of the contemporaneous behavior of the monetary base. Specifically, an FX purchase (sale) is considered ‘fully sterilized’ when the monetary base remains unchanged or decreases (increases) during the same period.

As show in Table 4 below, the interest rate approach indicates that 84 percent of FXI operations conducted under non-pegged exchange rate regimes are fully sterilized while only 16 percent are not fully sterilized. The share of sterilized operations reaches 90 percent for AE and 83 percent of EMDEs (not shown). The share of fully sterilized observations is considerably smaller (42 percent) when using the monetary base approach. While the two approaches deliver similar results for about 45 percent of observations (descending diagonal), FXI often is more often associated with no contemporaneous movement in the interest rate but contemporaneous variations in the monetary base (49 percent). This suggests that the monetary base moves considerably without movements in the policy rate, reflecting changes in the demand for money (including for seasonal reasons). For this reason, the classification provided in the dataset follows the interest rate approach.

**Table 4. Sterilization**

Monetary Base Approach	Interest Rate Approach		All
	Fully Sterilized	Not Fully Sterilized	
Fully Sterilized	36%	6%	42%
Not Fully Sterilized	49%	9%	58%
All	84%	16%	100%

Source: authors' estimations.

Notes: Classification of FXI observations that are larger than 0.25 percent of GDP in absolute terms for countries with exchange rate regimes other than pegs (or similar).

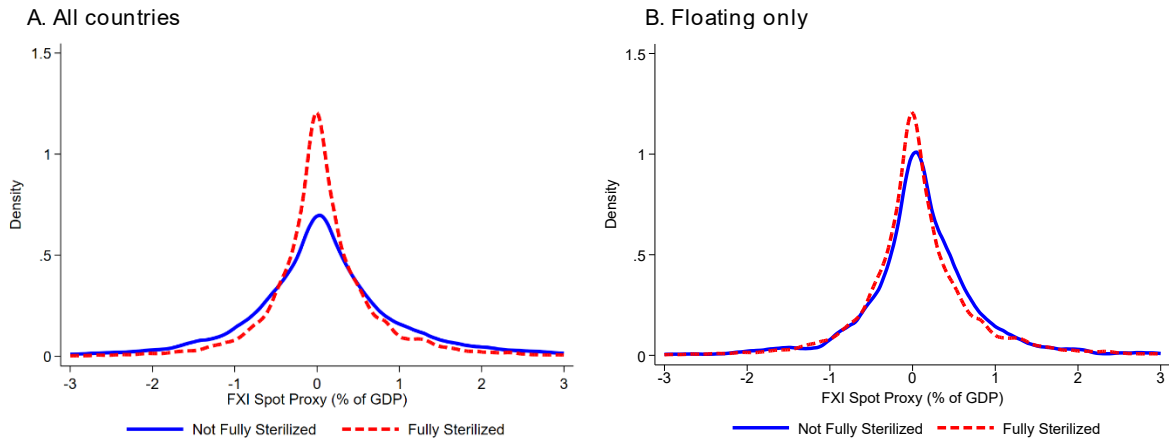
A plot of the density function for fully sterilized and not-fully sterilized interventions (based on the interest rate approach) highlights that large interventions are commonly not fully sterilized, as indicated by the fatter tails of the distribution of not-fully sterilized FXI in Figure 14 Panel A. However, this largely reflects the use of FXI under de jure peg regimes which, by their own nature, are not fully sterilized. Focusing on countries with a de jure floating exchange rate regime (i.e., excluding countries with pegs), we find that the two distributions are more similar, although the distribution of not-fully sterilized FXI is tilted to the right, pointing to a bias in sterilization as positive FX interventions are more likely to be sterilized relative to negative interventions. A formal test confirms that this difference is statistically significant, indicating that central banks are less likely to sterilize FXI when leaning against appreciation than when leaning against depreciation of the local currency.

<sup>32</sup> Only changes in policy rates greater or equal than 25 basis points in absolute value are considered.

<sup>33</sup> While some of the FXI may be partially sterilized, the extent of sterilization is difficult to ascertain as it requires establishing how unsterilized FXI affects the short-term interest rate. For this reason, a binary classification (of ‘fully sterilized’ and ‘not fully sterilized’) is used.

<sup>34</sup> We note that changes in the monetary policy stance are not completely captured by changes in short-term interest rates as the neutral rate may also change over time. Assessing the neutral rate for many countries, though, is well outside the scope of this paper.

**Figure 14. Sterilized versus non-sterilized FXI**  
(percent of GDP, monthly frequency)



Source: authors calculations.

Notes: This figure presents the density of the spot FXI estimate depending on whether the intervention is fully (dashed line) or not fully sterilized (solid line). The left chart uses the full sample, while the right uses only countries with floating exchange rate arrangements.

## VII. CONCLUSIONS

This paper provides a new database of publicly available official data and newly constructed estimates of FXI—for both operations in spot and derivative markets, at monthly and quarterly frequencies. Focusing on any transaction that alters the central bank's foreign currency position, this dataset offers comprehensive and comparable data across a large number of countries and time that should prove useful for cross-country macroeconomic analysis. The paper also distinguishes between sterilized and not sterilized FXI, a key dimension for economic analysis, largely overlooked until now.

## APPENDIX 1: ADDITIONAL TABLES AND FIGURES

Table A1.1. FXI estimates. Summary statistics

	Intermediate adjustments				
	Coarse proxy (change in reserves)	Adj. for Valuation, Income and IMF position	Adj. also for FC positions vis-à-vis other Non-residents	Spot FXI estimate (adj. also for FC positions vis-à-vis residents)	Broad FXI (inc. deriv.)
<b>All countries</b>					
Mean 1/	0.175	0.108	0.113	0.105	0.106
Standard Deviation 2/	0.991	0.927	1.001	0.942	0.957
Symmetry 3/	0.254	0.172	0.171	0.163	0.160
<b>AEs</b>					
Mean	0.244	0.150	0.150	0.166	0.171
Standard Deviation	1.163	1.074	1.262	1.149	1.180
Symmetry	0.282	0.187	0.151	0.166	0.159
<b>EMDEs</b>					
Mean	0.159	0.098	0.105	0.091	0.091
Standard Deviation	0.951	0.892	0.940	0.894	0.906
Symmetry	0.247	0.168	0.176	0.162	0.160

Source: Authors' calculations.

Notes: 1/ Mean of monthly FXI, in percent of GDP. 2/ Cross-country mean of standard deviation of monthly FXI. 3/ Cross-country mean of symmetry index computed as  $S_i = \sum_t FXI_{it} / \sum_t |FXI_{it}|$ . The symmetry index varies from -1 (all FX sales), to 1 (all FX purchases).

Table A1.2. Countries that Publish Foreign Exchange Intervention Data

IFS Code	Country Name	Frequency	Intervention Type			Source
			Spot	Forward-like (forward/futures/swaps)	Other derivatives (options, repos, reverse repos...)	
914	Albania	D, Q	√			CB Website time series + Time series compiled from multiple reports
614	Angola	M	√			CB Website time series
213	Argentina	D	√			CB Website time series
193	Australia	D	√			CB Website time series
513	Bangladesh	Q	√			Time series compiled from multiple reports
218	Bolivia	M	√			CB Website time series
963	Bosnia and Herzegovina	M	√			CB Website time series
223	Brazil	D	√	√	√	CB Website time series
156	Canada	M	√			Time series compiled from multiple reports
233	Colombia	D	√	√	√	CB Website time series
238	Costa Rica	D	√			CB Website time series
960	Croatia	D	√		√	CB Website time series
935	Czech Republic	M	√	√		CB Website time series
128	Denmark	M	√			Time series compiled from multiple reports
163	Euro area	D	√			CB Website time series
644	Ethiopia	Q	√			Time series compiled from multiple reports
915	Georgia	D	√			CB Website time series
336	Guyana	M	√			Time series compiled from multiple reports
532	Hong Kong SAR	D	√			CB Website time series
176	Iceland	M	√			CB Website time series
534	India	M	√	√		CB Website time series
436	Israel	M	√			Time series compiled from multiple reports
343	Jamaica	D, Q	√			Time series compiled from multiple reports
158	Japan	M	√			Time series compiled from multiple reports
916	Kazakhstan	M	√			CB Website time series
542	Korea	Q, HY	√			Time series compiled from multiple reports
684	Mauritius	M	√			CB Website time series
273	Mexico	M	√			CB Website time series
921	Moldova	M	√	√		Time series compiled from multiple reports
686	Morocco	M	√			CB Website time series
196	New Zealand	M	√			CB Website time series
278	Nicaragua	M	√			Time series compiled from multiple reports
694	Nigeria	M	√			CB Website time series
288	Paraguay	D	√			CB Website time series
293	Peru	D	√			CB Website time series
922	Russia	M	√			CB Website time series
576	Singapore	HY	√			CB Website time series
146	Switzerland	Q, A	√			CB Website time series
186	Turkey	M	√		√	CB Website time series
926	Ukraine	W	√			CB Website time series
112	United Kingdom	M	√			Time series compiled from multiple reports
111	United States	M	√			Time series compiled from multiple reports
927	Uzbekistan	M	√			Time series compiled from multiple reports
754	Zambia	W	√			CB Website time series

Sources: Various.

Notes: "Time series compiled from multiple reports" indicates that information on FXI was collected from multiple, scattered sources. Typically, these are monthly or quarterly reports on monetary and exchange rate policies. This table reflects our best knowledge as of December 2020 and may not reflect all countries that publish FXI data.

Table A1.3. Country-by-country Regressions of Officially Published on FXI Estimates

Economy	Change in Reserves		Spot Estimate		Broad Estimate	
	alpha	beta	alpha	beta	alpha	beta
Albania	0.00	0.75	0.00	0.64	0.00	0.64
Angola	0.00	0.06*	0.01	0.44*	0.01	0.44*
Argentina	-0.00	0.7	-0.00	0.98	-0.00	1.00
Australia	0.00	-0.5	0.00	-0.72	0.00	3.35
Bangladesh	0.00*	0.83	0.00*	0.83*	0.00*	0.83*
Bolivia	0.01*	0.79	0.00*	0.86	0.00*	0.86
Bosnia and Herzegovina	0.00	1.1	-0.00*	1.01	-0.00*	1.01
Brazil	0.00*	0.94	-0.00	1.04	-0.00	1.09
Canada	0.00	-21.03*	0.00	-14.5*	0.00	-13.45*
Colombia	0.00*	0.64*	0.00*	0.62*	0.00	0.6*
Costa Rica	0.00	0.86	-0.00	1.05	-0.00	1.05
Croatia	0.00*	0.67	0.00	0.51*	0.00	0.51*
Czech Republic	0.00*	0.99	0.00*	1.1*	0.00*	1.1*
Denmark	-0.00	0.82*	-0.00	1.06	-0.00	1.06
Ethiopia	0.00	0.67	0.00	0.85	0.00	0.85
Georgia	0.00	0.85	0.00	0.83	0.00	0.82
Guyana	0.00	-0.1*	0.00	-0.11*	0.00	-0.11*
Hong Kong SAR	0.01*	0.98	0.00*	0.88	0.00*	0.88
Iceland	0.00	0.49*	-0.00	0.9	-0.00	0.9
India	0.00	1.22*	0.00*	0.98	0.00	1.07
Israel	0.00	0.96	-0.00	0.8	-0.00	0.81
Jamaica	0.00*	0.57*	0.00	0.24*	0.00	0.24*
Kazakhstan	0.00*	0.73*	0.00	0.74*	0.00	0.77*
Mauritius	0.00	0.9	0.00	0.73*	0.00	0.73*
Mexico	0.00*	0.85	0.00*	0.7	0.00*	0.69
Moldova	0.00	1.23*	-0.00	0.94*	-0.00	0.94*
New Zealand	0.00	0.53	0.00	0.56	0.00	0.73
Nicaragua	0.00*	0.77	0.00	0.46*	0.00	0.46*
Nigeria	0.00*	0.42*	0.00	0.48*	0.00	0.48*
Paraguay	0.00	1.2	0.00	0.97	0.00	0.97
Peru	0.00*	0.8*	-0.00	1.02	-0.00	1.03
Russia	-0.00	0.88*	-0.00	0.83*	-0.00	0.86*
Turkey	-0.00	0.04	0.00*	1.19	0.00	1.14
Uzbekistan	-0.00	-0.3*	0.01	0.68	0.01	0.68
Zambia	-0.00	0.28	-0.00	-0.03*	-0.00	-0.03*
Median	0.00	0.77	0.00	0.83	0.00	0.83

Notes: This table reports country-specific constant and slope coefficients of regressions of proxy on official FXI at the quarterly-frequency, i.e. running equation (2) country-by-country. A star denotes p-value smaller than 0.05 for the hypothesis that alpha = 0 and beta = 1, respectively, using robust standard errors. All non-reserve issuing countries that report published FXI at the quarterly level are included.

**Table A1.4. Officially Published and Estimates of FXI. Recent years (2010-19).**

	Monthly		Quarterly		
	(1) Change in Reserves	(2) Spot Estimate	(3) BOP Flow	(4) Change in Reserves	(5) Spot Estimate
Official Data	0.869*** (0.049)	0.933*** (0.054)	0.839*** (0.067)	0.831*** (0.074)	0.931*** (0.072)
Constant	0.001*** (0.000)	0.000** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)
Observations	2538	2538	926	926	926
# Countries	23	23	26	26	26
R-squared	0.209	0.318	0.410	0.354	0.570
Adjusted R-squared	0.209	0.318	0.409	0.353	0.569
P-value ( $\beta = 1$ )	0.014	0.222	0.024	0.031	0.346

Source: authors' estimations.

Notes: All regressions include country fixed effects. Standard errors clustered at the country level in parentheses.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table A1.5. A horserace between proxies. Full sample (2000-19, quarterly frequency)**

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Official FXI					
Change in reserves	0.518*** (0.095)	0.150** (0.070)	0.440 (0.589)	-0.054 (0.509)	-0.066 (0.511)	-0.212 (0.437)
Adjustment added: BOP flows		0.431** (0.157)	-0.145 (1.120)	0.238 (0.990)	0.262 (0.991)	0.623 (0.874)
Adjustment added: Valuation and income effects			0.287 (0.574)	-0.227 (0.502)	-0.236 (0.503)	-0.395 (0.435)
Adjustment added: CB position relative to IMF				0.654*** (0.084)	0.593*** (0.118)	0.570*** (0.140)
Adjustment added: Position relative to other non-residents					0.056 (0.087)	-0.479*** (0.158)
Adjustment added: Position relative to residents						0.643*** (0.052)
Constant	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	-0.000 (0.001)
Observations	1503	1503	1503	1503	1503	1503
# Countries	26	26	26	26	26	26
Within R-squared	0.462	0.507	0.507	0.539	0.540	0.675
Adjusted R-squared	0.462	0.506	0.506	0.538	0.538	0.674

Source: authors' estimations.

Notes: Standard errors clustered at the country level in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Table A1.6. A horserace between proxies. (2010-19, monthly frequency)**

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Official FXI				
Change in reserves	0.241** (0.094)	0.052 (0.068)	0.078 (0.065)	0.073 (0.067)	0.078 (0.090)
Adjustment added: Valuation and income effects		0.205 (0.136)	-0.190** (0.089)	-0.179* (0.091)	-0.104 (0.112)
Adjustment added: CB position relative to IMF			0.390*** (0.119)	0.330** (0.128)	0.381*** (0.134)
Adjustment added: Position relative to other non-residents				0.053* (0.026)	-0.312** (0.111)
Adjustment added: Position relative to residents					0.392*** (0.094)
Constant	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.000*** (0.000)
Observations	2538	2538	2538	2538	2538
# Countries	23	23	23	23	23
Within R-squared	0.209	0.221	0.238	0.240	0.386
Adjusted R-squared	0.209	0.220	0.237	0.239	0.385

Source: authors' estimations.

Notes: Standard errors clustered at the country level in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Table A1.7. A horserace between proxies. (2010-19, Quarterly frequency)**

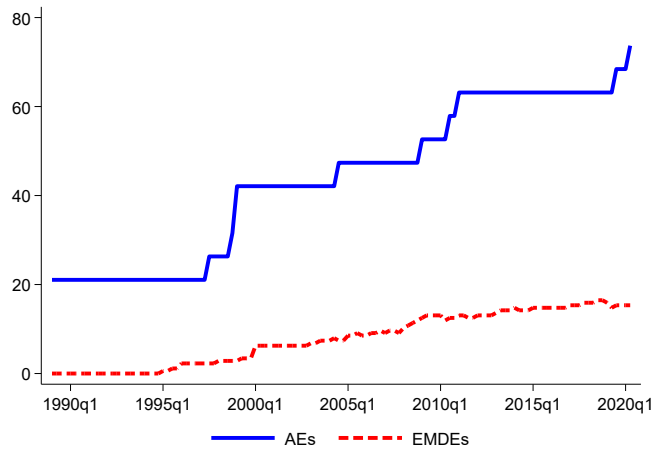
	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Official FXI					
Change in reserves	0.426*** (0.141)	0.045 (0.065)	1.760** (0.667)	1.120 (0.684)	1.199 (0.714)	0.871 (0.622)
Adjustment added: BOP flows		0.445** (0.204)	-2.979** (1.406)	-2.299 (1.393)	-2.452 (1.447)	-1.603 (1.249)
Adjustment added: Valuation and income effects			1.709** (0.662)	1.048 (0.674)	1.138 (0.703)	0.796 (0.618)
Adjustment added: CB position relative to IMF				0.654*** (0.148)	0.451** (0.178)	0.512*** (0.134)
Adjustment added: Position rel. to other non-residents					0.180* (0.104)	-0.530*** (0.132)
Adjustment added: Position relative to residents						0.659*** (0.114)
Constant	0.001 (0.001)	0.001 (0.001)	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)	0.001 (0.001)
Observations	926	926	926	926	926	926
# Countries	26	26	26	26	26	26
Within R-squared	0.354	0.411	0.413	0.444	0.450	0.620
Adjusted R-squared	0.353	0.409	0.412	0.442	0.447	0.618

Source: authors' estimations.

Notes: Standard errors clustered at the country level in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1



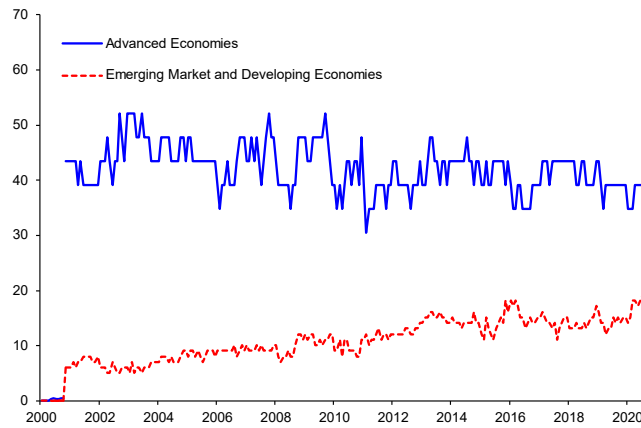
**Figure A1.1 Coverage of publicly available FXI data**  
(percent of countries)



Sources: Various. See Appendix Table A1.2 for further details.

Notes: Based on countries that report FXI data at least on a quarterly frequency. Statistics for AE and EMDE groups are based on quarterly FXI publication.

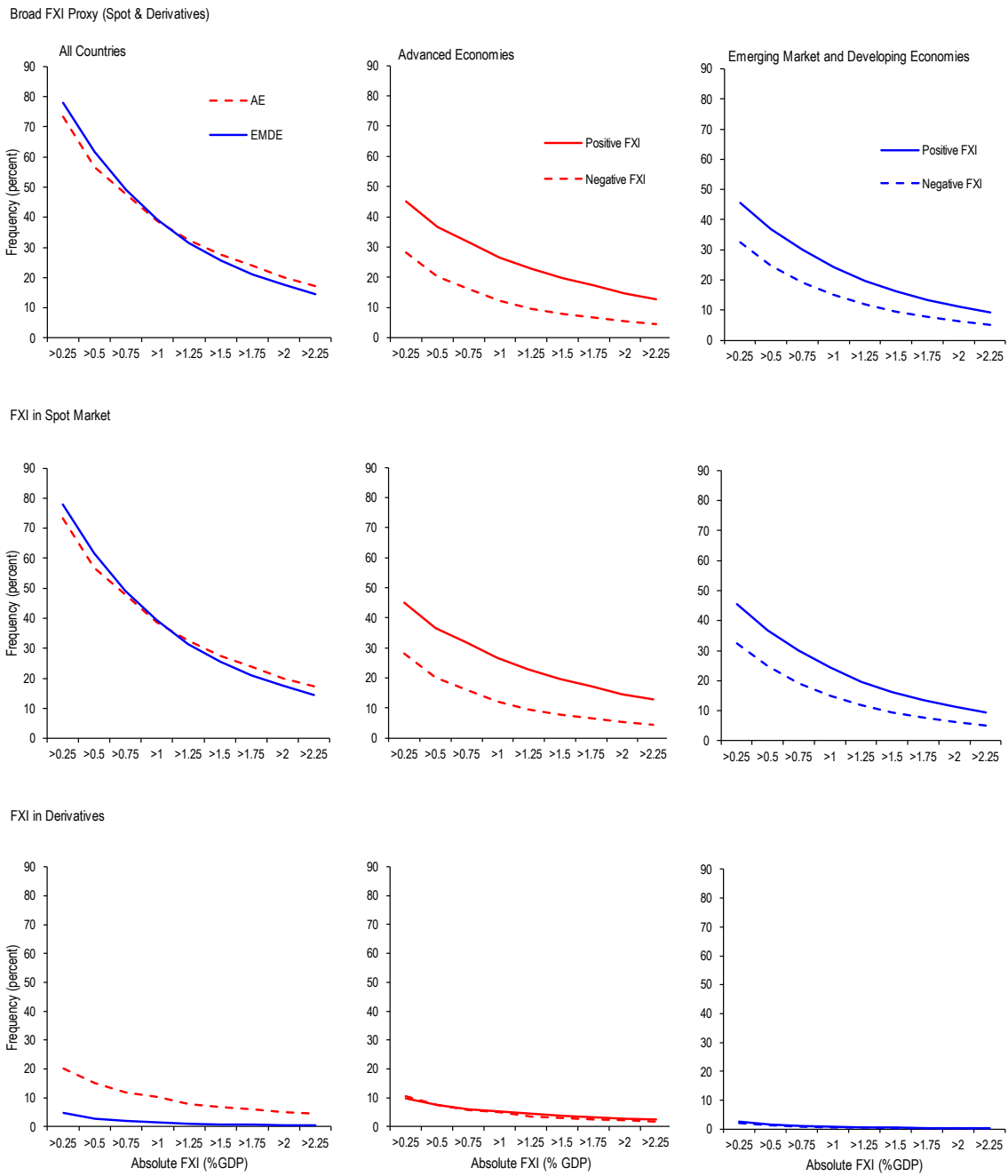
**Figure A1.2. Frequency of Changes in FX Derivative Positions**  
(percent of group sample)



Sources: IMF, International Reserves and Foreign Currency Liquidity Template (IRFCLT); and IMF staff calculations.

Note: Based on reported changes in short and long positions in forwards and futures in foreign currencies vis-à-vis the domestic currency (including the forward leg of currency swaps), and financial instruments denominated in foreign currency but settled by other means. These may underestimate the true extent of FXI with derivatives if economies that do not report to the IRFCLT also use FX derivatives.

**Figure A1.3. Size and Symmetry of Foreign Exchange Intervention (frequency)**

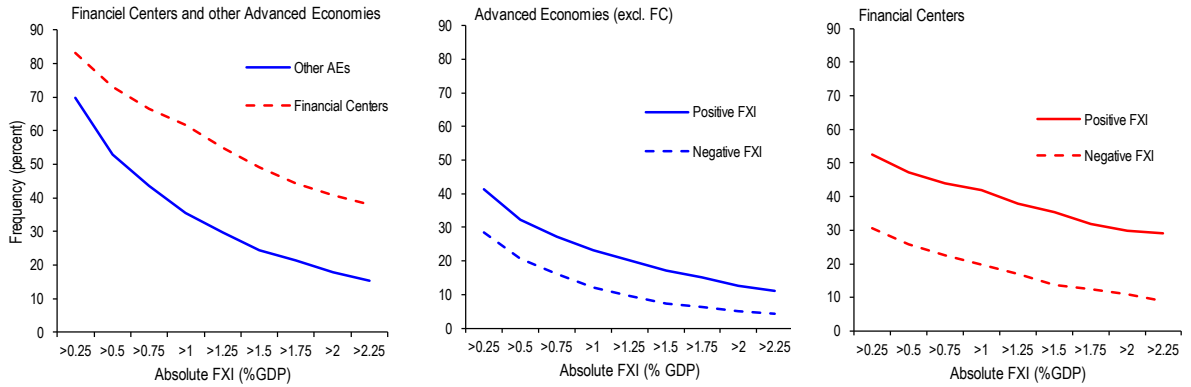


Sources: authors' estimations.

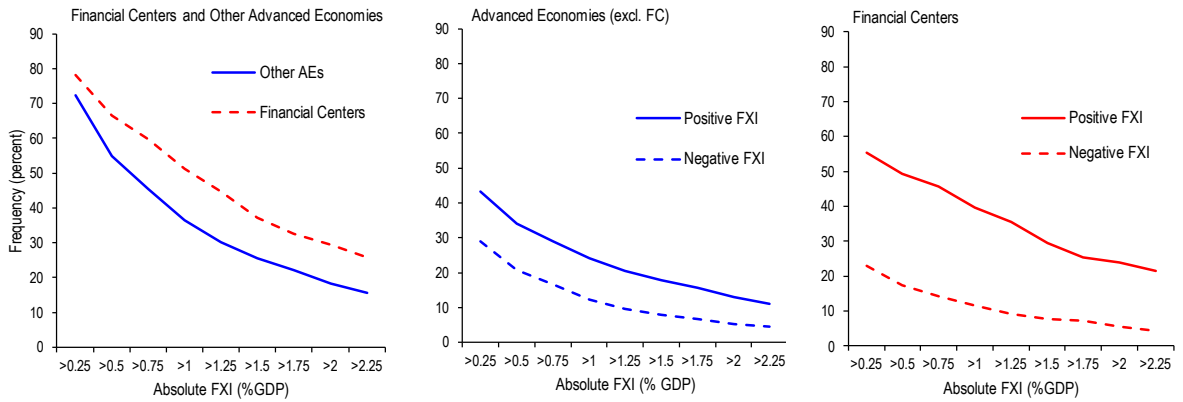
Notes: The figure shows the relative frequency of FXI (y-axis) by size buckets (x-axis) for the “broad” proxy (top), spot proxy (middle) and derivatives proxy (bottom), splitting also between all countries (left), AEs (middle) and EMDEs (right). The left most bucket in each chart denotes the share of interventions that exceed 0.25 percent of GDP in a quarter, the second bucket is the share of interventions that exceed 0.5 percent of GDP, and so forth up to interventions larger than 2.25 percent of GDP. Based on quarterly observations for non reserve-issuing countries

**Figure A1.4. Size and Symmetry of Foreign Exchange Intervention. Financial Centers and other AEs.**  
(frequency)

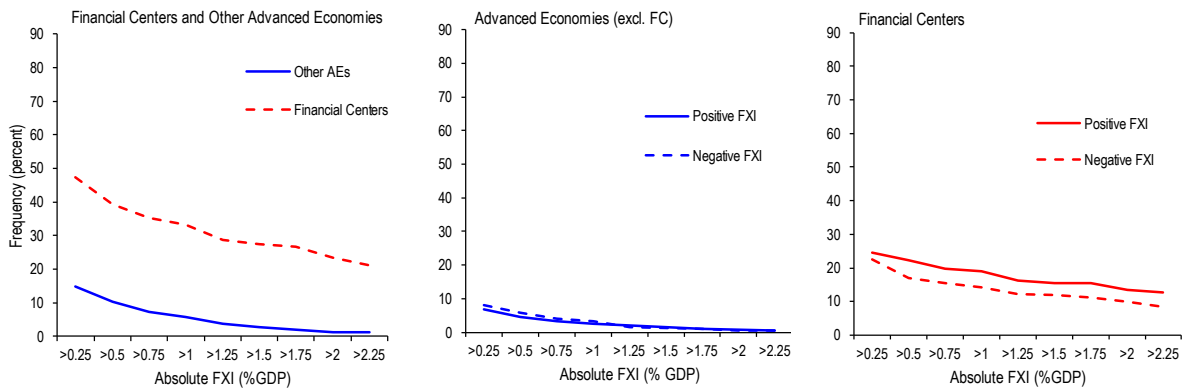
Broad FXI Proxy (Spot & Derivatives)



Spot FXI Proxy



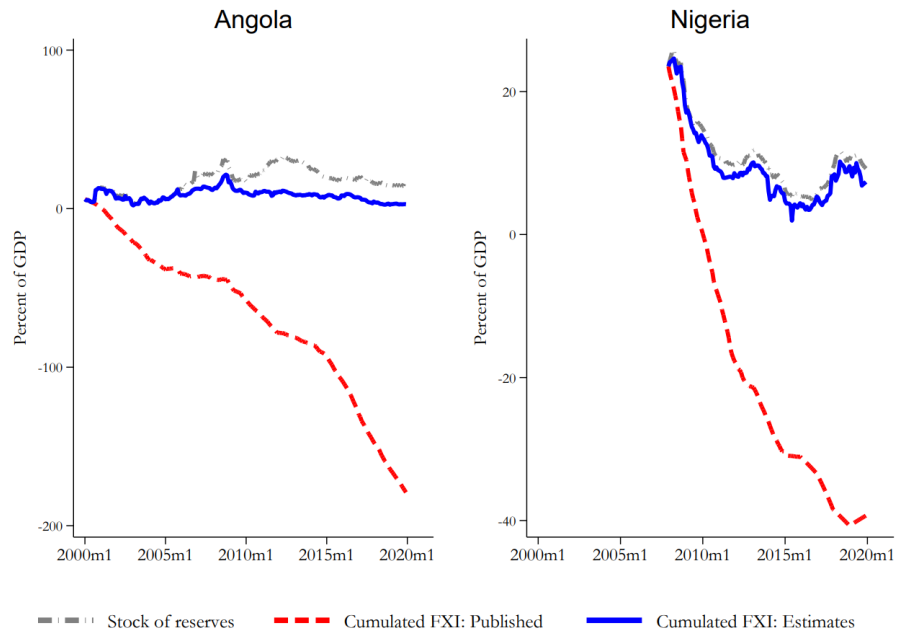
Derivatives FXI Proxy



Sources: authors' estimations.

Notes: Based on quarterly observations and using our "broad" estimate=spot plus derivatives transactions.

**Figure A1.5. Examples of Large Discrepancies Between Official and Estimated FXI**  
(cumulative, in percent of GDP)



Sources: IMF International Financial Statistics and authors' estimates.

Note: The figure reports cumulative changes anchored on the initial level of international reserves.

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**ONLINE APPENDIX FOR**

**Foreign Exchange Intervention:  
A Dataset of Official Data and Estimates**

Gustavo Adler, Kyun Suk Chang, Rui C. Mano, Yuting Shao

*July 2023*

**ONLINE APPENDIX 1: GENERAL METHODOLOGY FOR BUILDING THE PROXIES**

**A. Conceptual Framework**

As discussed in the main text, we are interested in a concept of foreign exchange intervention that captures central bank's transactions that alter its net foreign currency position. To derive a proxy for such a concept, consider a simplified version of a central bank's balance sheet (expressed in local currency):

$$RES + OFA + FCDA + LCDA = FL + FCDL + LCDL + EQ$$

where  $RES$  denotes foreign currency reserves;  $OFA$  are other foreign assets;  $FCDA$  denotes foreign currency domestic assets;  $LCDA$  are Local-Currency Domestic Assets;  $FL$  are foreign liabilities;  $FCDL$  are foreign currency domestic liabilities;  $LCDL$  are domestic currency domestic liabilities; and  $EQ$  denotes equity or net worth. This expression can also be written in terms of the net foreign and local currency positions, as:

$$NFCP = NLCP + EQ$$

where  $NFCP = RES + OFA + FCDA - FCDL - FL$  and  $NLCP = LCDA - LCDL$ . It follows that:

$$dNFCP = dNLCP + dEQ$$

Our interest lies only in changes of  $NFCP$  arising from transactions and thus have a counterpart on change in the  $NLCP$  (not in the equity position,  $EQ$ ):

$$dNFCP^{FXI} = dNLCP^{FXI}$$

In many cases, only the overall change in the net foreign currency position, which includes investment income and valuation changes, is observed:

$$dNFCP = FXI + NFCP\_InvIncome + NFCP\_Val$$

Thus, an estimate of  $FXI$  can be built from the observed change in  $NFCP$  and the estimated investment income and valuation changes.

$$Est[FXI] = dNFCP - Est[NFCP\_InvIncome] - Est[NFCP\_Val]$$

Since reserve assets tend to dominate  $NFCP$ , valuation changes and income flows will be primarily driven by reserve assets. This means that  $FXI$  can be estimated as:

$$Est[FXI] = dNFCP - Est[RES\_InvIncome] - Est[RES\_Val]$$



This can also be written as:

$$\begin{aligned} Est[FXI] &= dRES \\ &+ d(OFA - FL) \\ &+ d(FCDA - FCDL) \\ &- Est[RES\_InvIncome] - Est[RES\_Val] \end{aligned}$$

The latter equation highlights how a refined proxy of FXI departs from the coarse measure of changes in reserves ( $dRES$ ) to include changes in other foreign assets and liabilities, changes in foreign-currency assets and liabilities vis-à-vis residents; and estimated investment income and valuation changes. These adjustments are key as changes in reserves can vary for a number of reasons without entailing a transaction that alters the central bank's NFCP (i.e., FXI):

- Changes in reserves can reflect reallocation between reserve and non-reserve foreign assets. This is particularly relevant in economies with significant reserve assets—where reserve holdings may exceed levels consistent with precautionary liquidity buffers and, thus, central banks may choose to invest part of their foreign currency holdings in less liquid assets.
- Similarly, reserve levels may vary as central banks borrow from or repay loans to foreign entities, without entailing changes in the foreign currency position.
- In some economies, the central bank conducts operations with foreign exchange on behalf of other domestic entities (most commonly the central government). This can temporarily affect the holdings of reserve and non-reserve foreign currency assets, but they also entail a corresponding foreign currency liability vis-à-vis those domestic entities.
- Similarly, in many emerging and developing economies, banks are allowed to take on deposits in foreign currency, with associated reserve requirements. This can translate in changes in foreign currency (reserve or non-reserve) holdings of the central bank with corresponding foreign currency liabilities vis-à-vis domestic banks.

## B. Estimating FXI

This section describes how different sources of data are used to construct an estimate of FXI with the adjustments described above.

### **Non-reserve foreign currency asset and liabilities**

Information on reserve assets comes from the Fund's International Financial Statistics (IFS). Non-reserve foreign assets and liabilities as well as foreign currency position vis-à-vis residents are obtained from the IMF's Monetary and Financial Statistics (MFS), some of which are provided to the Fund on a confidential basis. Online Appendix 1 Table 1 provides details of the data coverage.

### **Valuation changes and investment income**

Estimating investment income and valuation changes entails using available information on the structure of assets and liabilities in terms of their currency and asset composition. In order to understand how different sources of information are combined, consider the stock of reserves which can be written as the sum of its components as follows:

$$RES = \sum_c \sum_a S^c P_a^c H_a^c$$

where  $S^c$  denotes the exchange rate US dollar per currency  $c$ ;  $P_a^c$  is the price of asset type  $a$  expressed in currency  $c$ ; and  $H_a^c$  is the (quantity) holding of asset type  $a$  denominated in currency  $c$ .

The investment income on reserves can, therefore, be written in terms of investment income on the individual components:

$$RES\_InvIncome = \sum_c \sum_a i_a^c w_a^c$$

where  $w_a^c = \frac{S^c P_a^c H_a^c}{\sum_c \sum_a S^c P_a^c H_a^c}$  is the share of currency - asset type  $a$  in total reserves.

The International Reserves and Foreign Currency Liquidity Template (*IRFCLT*) provides information on the composition of assets. Information on the currency structure is available from the Currency Composition of Official Foreign Exchange Reserves (*COFER*) dataset and *IRFCLT*. However, for most categories of asset types, there is no information of the currency structure within the asset type. The only exceptions are the IMF position and SDR holdings, which are denominated in SDRs (and gold holdings, which can be valued at the price of gold in US dollars). Thus, for all other asset types, the currency structure is assumed to be invariant. That is,  $S^c P_a^c H_a^c = S^c P^c H^c$ , which implies that

$$\frac{S^c P_a^c H_a^c}{\sum_a S^c P_a^c H_a^c} = w^c \text{ and therefore } w_a^c = w^c w_a .$$

The above expression for the income on reserves can, thus, be written as:

$$RES\_InvIncome = \sum_c \sum_a i_a^c w^c w_a$$

In turn, valuation changes arising from both exchange rate and asset price movements can be expressed as:

$$RES\_Val = \sum_c \frac{dS^c}{S^c} w^c + \sum_c \sum_a \frac{dP_a^c}{P_a^c} w^c w_a$$

In order to estimate these components, currency weights of the five major currencies (USD, Euro, Yen, Pound) as well as the SDR are considered as the account for the vast majority of reserves. Country-specific currency weights ( $w^c$ ) are taken from the Reserve Template, when data are reported. Otherwise, group averages from COFER are used. As mentioned, individual country information is confidential for all COFER reporting economies.

Asset type weights are based on the country-specific information available in the IRFCLT. The key categories included there are: (i) Currency and Deposits; (ii) Securities; (iii) Position at the IMF; (iv) SDR holdings; (v) Gold; (vi) Other foreign currency assets. As shown in Online Appendix 1 Figure 1, the bulk of foreign assets is held in the form of Securities and Currency & Deposits, which have relatively stable shares over time, although there is considerable cross-sectional heterogeneity. Other forms of reserves, like claims on the IMF, SDRs, Gold and Other Assets represent a small fraction of total reserves for most countries.

**Online Appendix 1 Table 1. Coverage of Central Banks' Foreign Currency Positions Data**

IFS code	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		
128	Denmark																							
142	Norway																							
144	Sweden																							
146	Switzerland																							
156	Canada																							
174	Greece																							
176	Iceland																							
181	Malta																							
186	Turkey																							
199	Australia																							
196	New Zealand																							
199	South Africa																							
213	Argentina																							
218	Bolivia																							
223	Brazil																							
228	Chile																							
233	Colombia																							
238	Costa Rica																							
243	Dominican Republic																							
248	Ecuador																							
253	El Salvador																							
258	Guatemala																							
268	Honduras																							
273	Mexico																							
278	Nicaragua																							
283	Panama																							
288	Paraguay																							
293	Peru																							
298	Uruguay																							
299	Venezuela																							
313	Bahamas, The																							
336	Guyana																							
343	Jamaica																							
369	Trinidad and Tobago																							
419	Bahrain																							
423	Cyprus																							
433	Iraq																							
436	Israel																							
439	Jordan																							
443	Kuwait																							
446	Lebanon																							
449	Oman																							
453	Qatar																							
456	Saudi Arabia																							
466	United Arab Emirates																							
469	Egypt																							
474	Yemen																							
487	West Bank and Gaza																							
512	Afghanistan																							
513	Bangladesh																							
516	Brunei Darussalam																							
518	Myanmar																							
522	Cambodia																							
524	Sri Lanka																							
528	Taiwan Province of China																							
532	Hong Kong SAR																							
534	India																							
536	Indonesia																							
542	Korea																							
544	Lao P.D.R.																							
546	Macao SAR																							

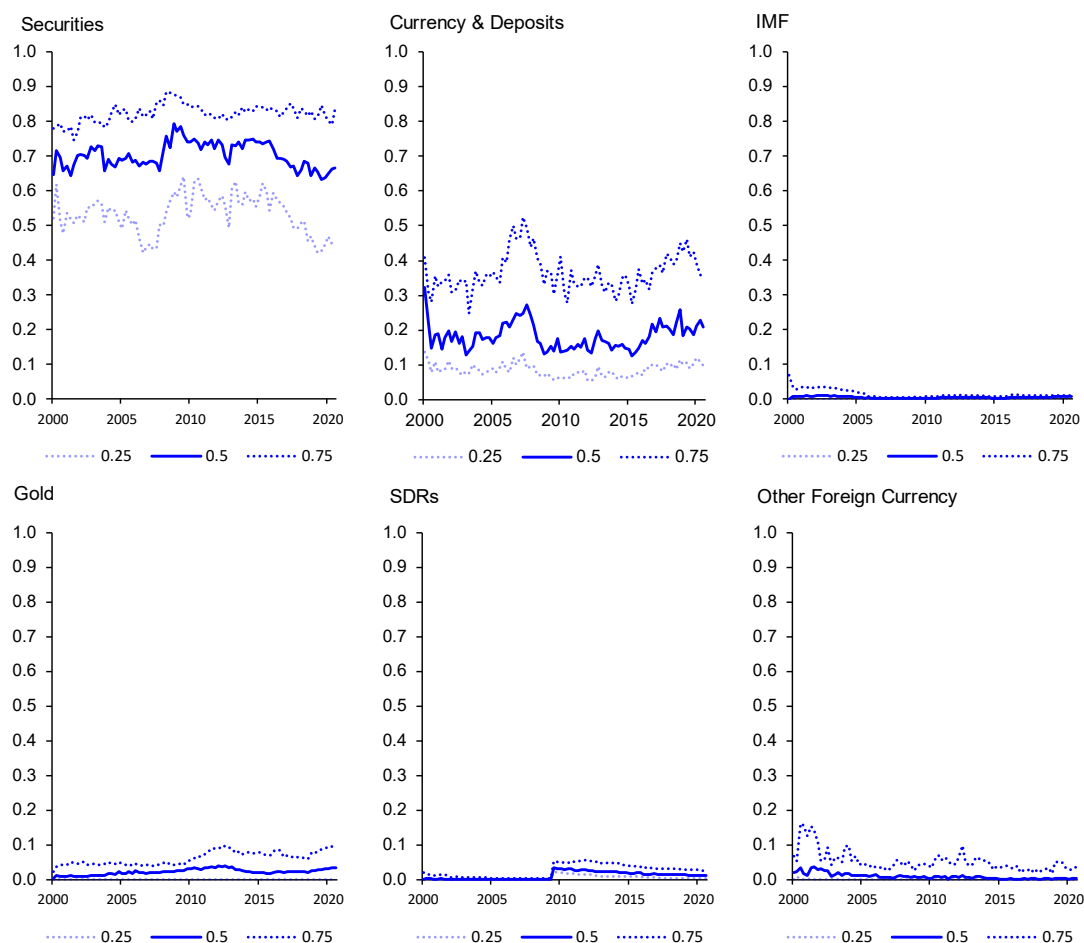
Source: Monetary and Financial Statistics Dataset

**Online Appendix 1 Table 1 (continued). Coverage of Central Banks' Foreign Currency Positions Data**

IFS code	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
548	Malaysia																						
558	Nepal																						
564	Pakistan																						
566	Philippines																						
576	Singapore																						
578	Thailand																						
582	Vietnam																						
612	Algeria																						
614	Angola																						
616	Botswana																						
622	Cameroon																						
628	Chad																						
634	Congo, Republic of																						
636	Congo, Democratic Republic of the																						
642	Equatorial Guinea																						
644	Ethiopia																						
646	Gabon																						
652	Ghana																						
656	Guinea																						
664	Kenya																						
672	Libya																						
674	Madagascar																						
684	Mauritius																						
686	Morocco																						
688	Mozambique																						
694	Nigeria																						
698	Zimbabwe																						
714	Rwanda																						
728	Namibia																						
732	Sudan																						
738	Tanzania																						
744	Tunisia																						
746	Uganda																						
754	Zambia																						
853	Papua New Guinea																						
911	Armenia																						
912	Azerbaijan																						
913	Belarus																						
914	Albania																						
915	Georgia																						
916	Kazakhstan																						
918	Bulgaria																						
921	Moldova																						
922	Russia																						
924	China																						
926	Ukraine																						
927	Uzbekistan																						
935	Czech Republic																						
936	Slovak Republic																						
939	Estonia																						
941	Latvia																						
942	Serbia																						
944	Hungary																						
946	Lithuania																						
948	Mongolia																						
960	Croatia																						
961	Slovenia																						
962	North Macedonia																						
963	Bosnia and Herzegovina																						
964	Poland																						
968	Romania																						

Source: Monetary and Financial Statistics Dataset

**Online Appendix 1 Figure 1. Weights by asset type**  
(share of total foreign currency assets)



Sources: International Reserves and Foreign Currency Liquidity Template (IRFCLT), and authors' calculations.  
Notes: Cross-section percentiles 25, 50 and 75 among economies reporting to IRFCLT (and with GDP larger than US\$10 billion in 2019) are depicted.

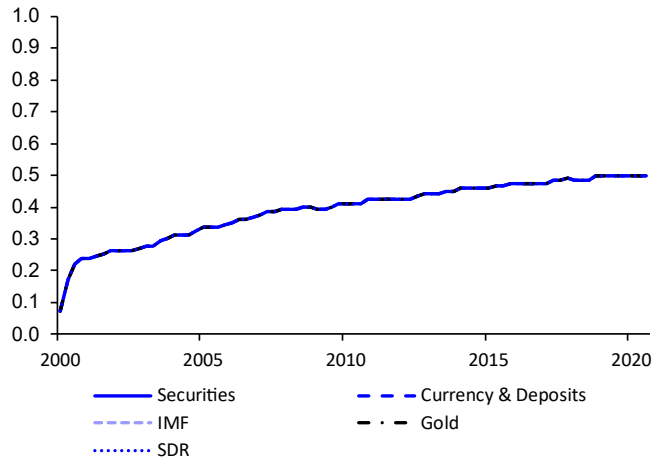
Data on the asset structure of reserves is available for about 50 percent of the countries in the sample from the IRFCLT (see Online Appendix 1 Figure 2). We complement that information with partial information available in MFS. Concretely, MFS reports gold and SDR holdings of central banks, which we use to calculate the weight of those two items in countries' reserves.

Using this information, asset weights are constructed as follows: (i) based on country-specific shares reported in the IRFCLT, when available; (ii) when country-specific information is only available for some (most recent) periods, shares are spliced backwards using median weights observed for other countries to account for broad trends in the asset structure, while maintaining heterogeneity in levels; (iii) when no country-specific information is available in IRFCLT, we use MFS based data for the weights on gold and SDR assets and use the median breakdown of foreign currency assets from IRFCLT for the rest of the assets; and (iv) finally, if no information is available from either MFS or IRFCLT the median of the weights observed for all countries in IRFCLT are used.

Online Appendix 1 Figure 2 illustrates the coverage of available country-specific asset-type weights, which has grown over time but remains only slightly above half of the sample of countries of analysis.

For most AEs and some EMDEs, there is ample information since the early 2000s, while data for smaller EMDEs and LICs remains limited.

**Online Appendix 1 Figure 2. Coverage of data on asset structure**

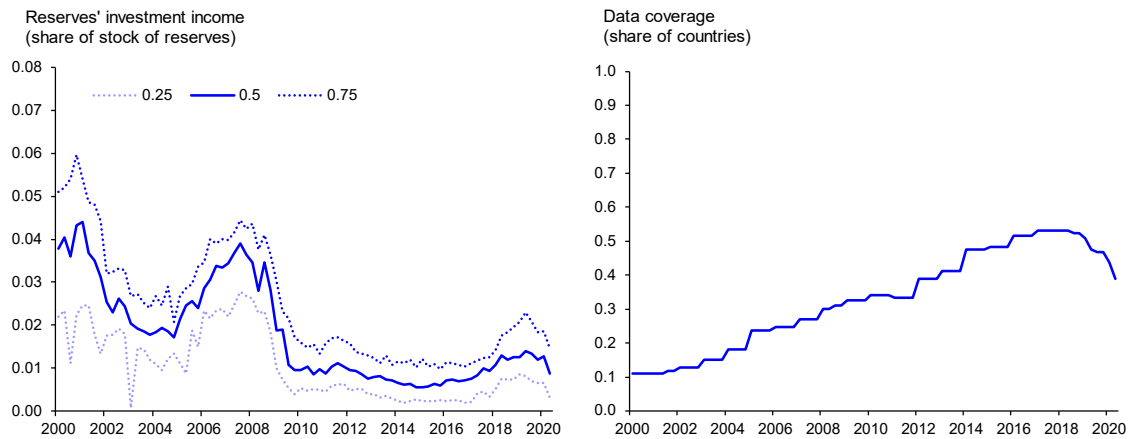


Sources: International Reserves and Foreign Currency Liquidity Template (IRFCL), and authors' calculations.

**Investment income**

Some countries report investment income on reserves as part of the income balance in their balance-of-payments statistics, although in many cases providing short time series (Online Appendix 1 Figure 3). This provides an exact measure of the investment income on reserves that needs to be netted out. When available, such series are used as a measure of income on reserves.

**Online Appendix 1 Figure 3. Investment Income on Reserves**



Sources: *International Reserves of Foreign Currency Liquidity, Balance of Payments Statistics*, author's calculations.  
 Notes: Left panel depicts cross-section percentiles 25, 50 and 75 among economies (with GDP larger than US\$ 10 billion in 2019) reporting to IRFCL and BOP. Right panel shows the share of countries in the sample with reported BOP data on investment income on reserves.

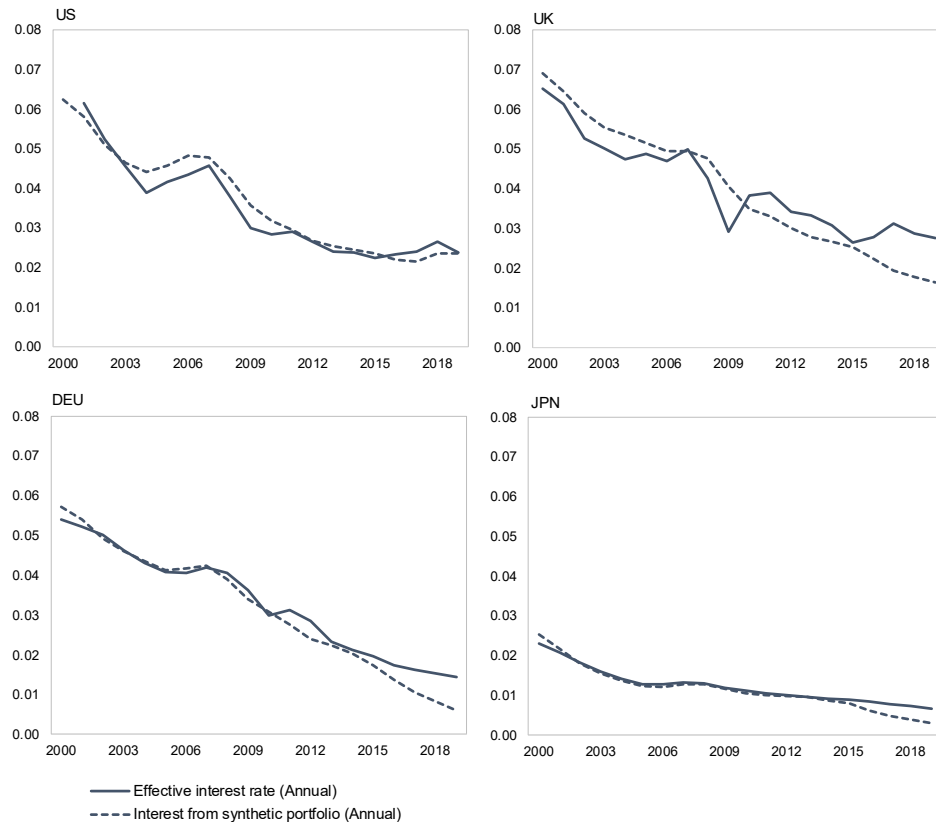
Otherwise, the interest on reserves is estimated using available information on currencies and asset types combined with estimates of the coupon rate on the different instruments as follows:

**Online Appendix 1 Table 2. Interest rates ( $i_a^c$ )**

	USD	Euro	Yen	Pound	SDR
Currency & Deposits	3-month US interbank rate	3-month Euro interbank rate	3-month Yen interbank rate	3-month Pound interbank rate	--
Securities	Effective rate <sup>1</sup>	Effective rate <sup>1</sup>	Effective rate <sup>1</sup>	Effective rate <sup>1</sup>	--
SDR	--	--	--	--	SDR rate
IMF Position	--	--	--	--	SDR rate
Gold	--	--	--	--	--
Other	Same as securities				--

As shown in Online Appendix 1 Table 2, the interest rate on short-term assets like currency and deposits can be estimated fairly accurately with the prevailing market rate. Estimating the coupon rate on longer-term securities, however, is more challenging as the holdings of this type of securities may encompass a portfolio of different maturities with coupon rates that may be different from the prevailing market rates. To overcome this obstacle, the effective rate paid by reserve currency-issuing countries, available from their public accounts, is used. A synthetic portfolio combining 2-year and 10-year bonds purchased over the last 2 and 10 years, respectively, which are shown to track the effective interest rate paid closely over the sample period (Online Appendix 1 Figure 4).

$$\bar{i}_t^c = (0.7) * \sum_{l=1}^{10} \left(\frac{1}{10}\right) i_{t-l}^{c,10y} + (0.3) * \sum_{l=1}^2 \left(\frac{1}{2}\right) i_{t-l}^{c,2y}$$

**Online Appendix 1 Figure 4. Effective interest rate and 10-Year Treasury Bond Yield**

Sources: *World Economic Outlook*, *Haver Analytics*, and authors' calculations.  
 Note: Effective interest rate is imputed by dividing general government interest expense by general government gross debt. Synthetic portfolio composed of 70 percent of 10-year maturity bonds purchased over the last 10 years and 30 percent of 2-year maturity bonds purchased over the last 2 years.

Valuation changes are estimated with the following assumptions for asset prices:

**Online Appendix 1 Table 3. Asset Prices ( $P_a^c$ )**

	USD	Euro	Yen	Pound	SDR
Currency & Deposits	1	1	1	1	--
Securities	Weighted average of 2- and 10-Govt Bond	Weighted average of 2- and 10-year Bund	Weighted average of 2- and 10-year Govt Bond	Weighted average of 2- and 10-year Govt Bond	--
SDR	--	--	--	--	1
IMF Position	--				1
Gold	Price in US dollars	--	--	--	--
Other	Same as securities				--

Currency and Deposits, the SDR and IMF position are taken at nominal value, implying that only exchange rate changes lead to valuation changes for this component. Consistent with the estimation of interest income, security holdings are assumed to combine 2- and 10-year bonds purchase in previous 2 and 10 years respectively. The market price of the basket of securities in currency  $c$  can, thus, be estimated as:

$$P_t^c = (0.7) * \sum_{RM=1}^{10} \left(\frac{1}{10}\right) P^{c,,10,RMY} + (0.3) * \sum_{RM=1}^2 \left(\frac{1}{2}\right) P^{c,,10,RMY}$$

where  $P_t^{c,,M,RMY}$  is the price of a bond of original maturity  $M$  and residual maturity in years  $RMY$  that pays out interest  $\alpha^{c,M}$  on a quarterly basis, is given by:

$$P_t^{c,,M,RM} = \alpha^{c,M} \frac{\left[1 - \left(1 + \frac{i^{RM}}{4}\right)^{-RM}\right]}{i^{RM}/4}$$

where  $i^{RM}$  is the observed  $M$ -quarter maturity (residual) market yield and  $RM$  is the number of quarters of residual maturity. Information on the yield curve at each point in time is used to estimate changes in these prices. This entail a refinement with respect to previous estimations (e.g., Dominguez, 2012) which assumed a 10-year residual maturity bond was systematically held.

Gold holdings are valued at end of period market rates. Exchange rates are end-of period nominal rates vis-à-vis the US dollar (e.g., USD/Euro), as reported in *International Financial Statistics*.

## VIII. ADJUSTMENTS AT DIFFERENT FREQUENCIES

The requirements for the computation of the FXI proxy depend on the frequency of interest.

**Quarterly frequency.** The computation of FXI proxies at quarterly frequency makes use of the data from balance-of-payments statistics, which report changes in reserves on a transaction basis and,



thus, are not polluted by valuation changes. Thus, quarterly proxies based on BOP flows only require adjusting for investment income flows.

**Monthly frequency.** Monthly proxies present additional challenges as transaction-based data (akin to those provided by balance-of-payment statistics) are rarely available. Thus, proxies rely on changes in stocks, which not only contain investment income flows but also exchange rate and asset prices changes. Thus, monthly proxies need to be adjusted for valuation changes as well.

Online Appendix 1 Tables 4 and 5 provide details on how different country-specific information is used to estimate valuation changes and investment income for specific countries and periods of time, at quarterly and monthly frequency, respectively.

**Online Appendix 1 Table 4. Basis for Valuation and Income Adjustments. Quarterly Frequency**



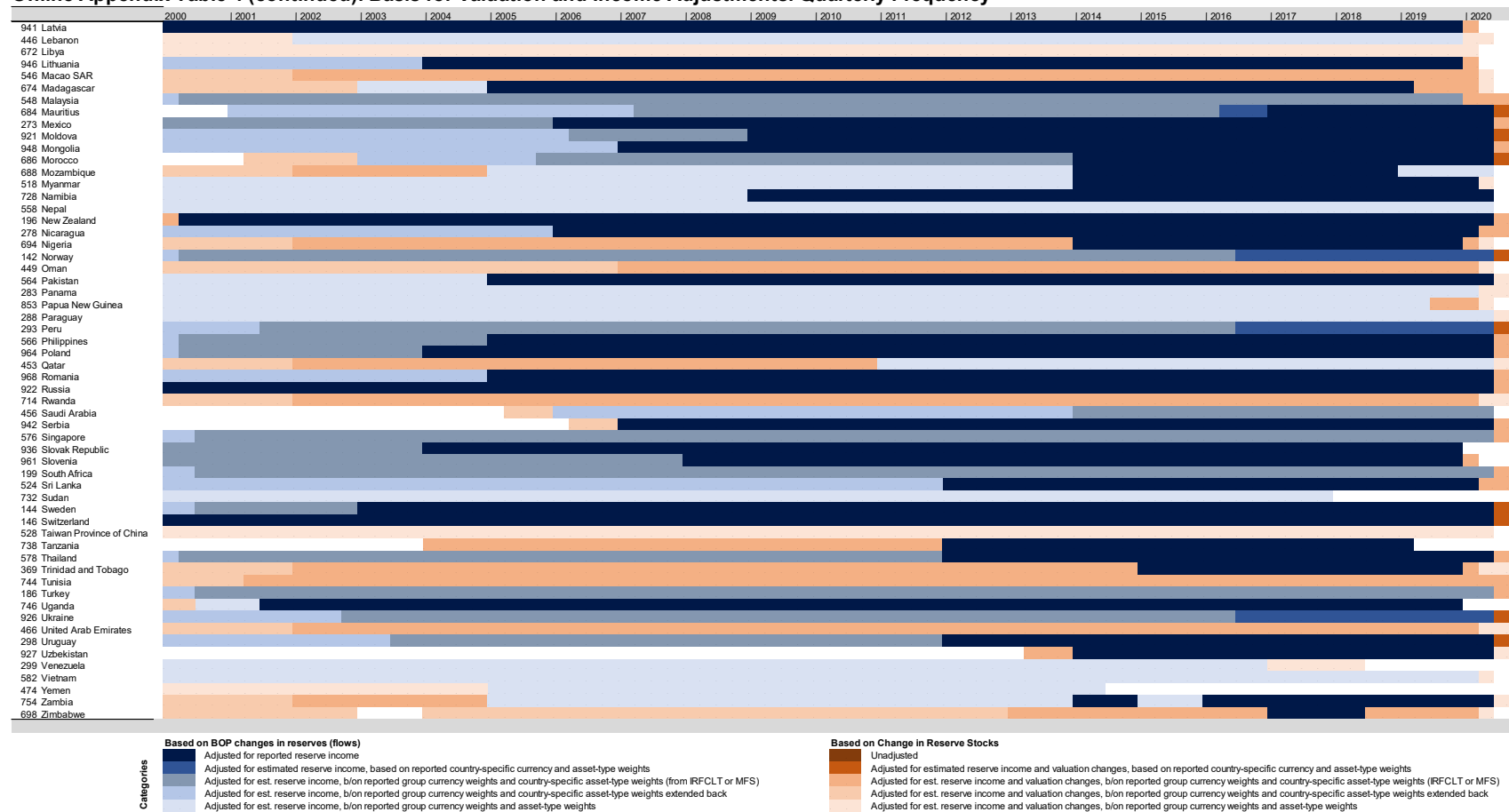
**Based on BOP changes in reserves (flows)**

- Adjusted for reported reserve income
- Adjusted for estimated reserve income, based on reported country-specific currency and asset-type weights
- Adjusted for est. reserve income, b/on reported group currency weights and country-specific asset-type weights (from RFCLT or MFS)
- Adjusted for est. reserve income, b/on reported group currency weights and country-specific asset-type weights extended back
- Adjusted for est. reserve income, b/on reported group currency weights and asset-type weights

**Based on Change in Reserve Stocks**

- Unadjusted
- Adjusted for estimated reserve income and valuation changes, based on reported country-specific currency and asset-type weights
- Adjusted for est. reserve income and valuation changes, b/on reported group currency weights and country-specific asset-type weights (RFCLT or MFS)
- Adjusted for est. reserve income and valuation changes, b/on reported group currency weights and country-specific asset-type weights extended back
- Adjusted for est. reserve income and valuation changes, b/on reported group currency weights and asset-type weights

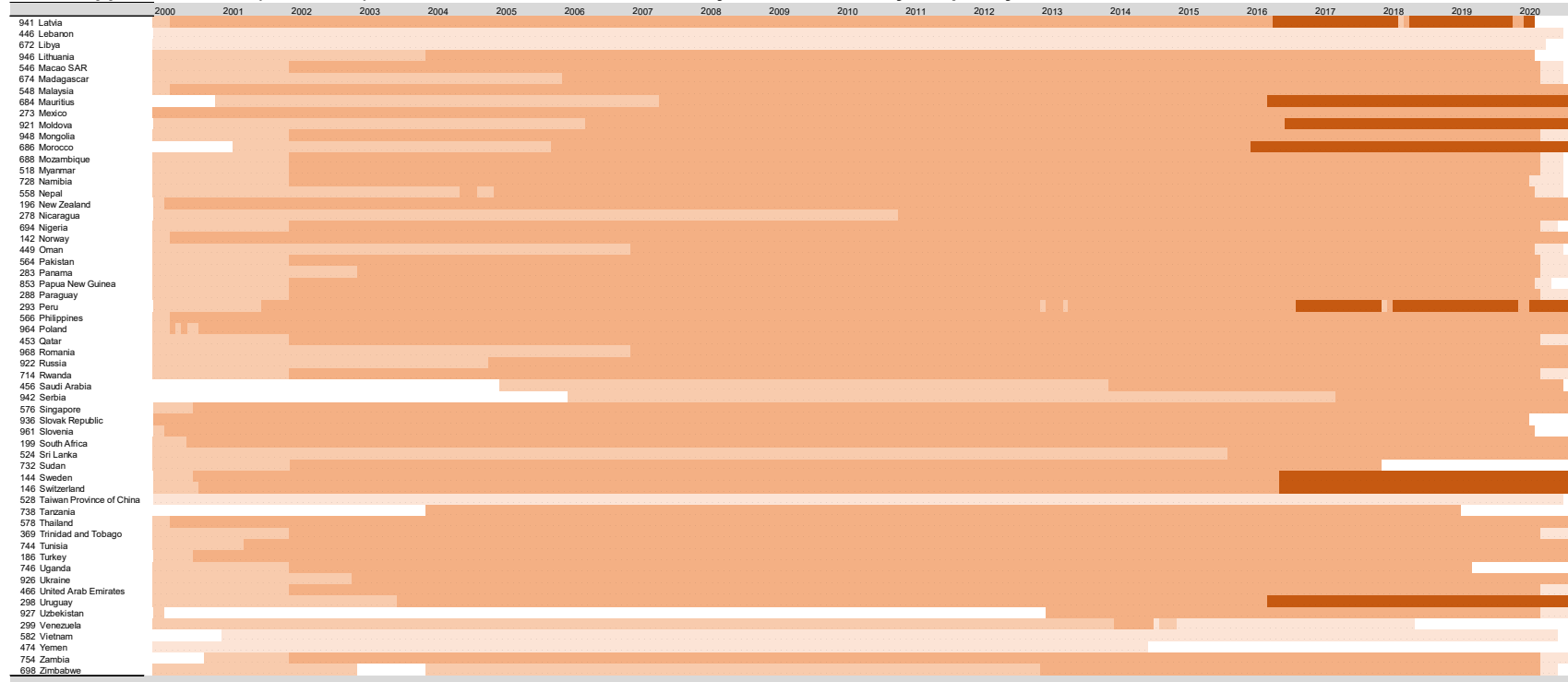
Online Appendix Table 4 (continued). Basis for Valuation and Income Adjustments. Quarterly Frequency



Online Appendix Table 5. Basis for Valuation and Income Adjustments. Monthly Frequency



Online Appendix Table 5 (continued). Basis for Valuation and Income Adjustments. Monthly Frequency



Categories	<b>Based on BOP changes in reserves (flows)</b>				<b>Based on Change in Reserve Stocks</b>			
		Adjusted for reported reserve income				Unadjusted		
		Adjusted for estimated reserve income, based on reported country-specific currency and asset-type weights				Adjusted for estimated reserve income and valuation changes, based on reported country-specific currency and asset-type weights		
		Adjusted for estimated reserve income, based on reported group currency weights and country-specific asset-type weights (from RFCLT or MFS)				Adjusted for estimated reserve income and valuation changes, based on reported group currency weights and country-specific asset-type weights (from RFCLT or MFS)		
		Adjusted for estimated reserve income, based on reported group currency weights and country-specific asset-type weights extended back				Adjusted for estimated reserve income and valuation changes, based on reported group currency weights and country-specific asset-type weights extended back		
	Adjusted for estimated reserve income, based on reported group currency weights and asset-type weights				Adjusted for estimated reserve income and valuation changes, based on reported group currency weights and asset-type weights			

## Foreign Exchange Derivatives

Operations using foreign exchange derivatives include changes in aggregate short and long positions in forwards and futures in foreign currencies vis-à-vis the domestic currency (including the forward leg of currency swaps), and financial instruments denominated in foreign currency but settled by other means (e.g., in domestic currency), as reported in the International Reserves and Foreign Currency Liquidity Template. Some clarifications are important:

- These notional amounts are not reported as part of the central bank's balance sheet, which only includes the market value of derivative positions (i.e., in- and out-of-the money positions) and, thus, may under or overestimate the actual FX derivative position.
- While changes in the notional amount properly capture new FXI operations through derivatives (e.g., a sale of FX forward), they would also capture the unwinding of derivative positions when they come due (in the previous example, this would result from the actual provision of FX as dictated by the previously sold forward FX contract). However, the unwinding of positions would normally be mirrored by other components of the central bank's balance sheet (drop in FX holdings in the example). Thus, a broad measure of FXI that encompasses spot and derivatives could adequately capture the initial FXI operation with derivatives while netting out their automatic unwinding.<sup>35</sup>
- Some central banks use FX swaps to manage liquidity and smooth market functioning. These FX swaps are combinations of spot and mirroring forward interventions and do not necessarily affect the central bank's FX position and, thus, do not represent FXI as defined in this paper. The spot and forward legs of these swaps are captured in our proxies for spot and derivative FXI, respectively. For countries using FX swaps frequently, a broad FXI measure that combines (adds) the spot and derivative FXI proxies provides a more accurate read of actual FXI operations
- Swap lines *among central banks* are also, in general, of different nature. While they provide foreign currency liquidity, they do not alter any of the central banks' net foreign currency positions. Specifically, when swap lines are first established, they entail only contingent credit lines with no impact on the balance sheet or derivative positions of either central bank. When the swap lines are activated or drawn, there is an increase in both central banks' foreign assets and liabilities. Despite the fact that a draw down entails a swap of currencies, there is no change in net foreign currency positions of either central bank as the exchange of currencies only serve the purpose of providing collateral. Any variation in the value of one currency relative to the other triggers an additional provision of the depreciated currency to maintain the parity in the value of currency holdings. Thus, there is no currency risk in the swap lines for any of the participating central banks.<sup>36</sup>

## Final Ad-hoc Adjustments

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<sup>35</sup> The use of non-deliverable forwards and currency swaps poses additional challenges as the unwinding of notional amounts when the contract comes due do not necessarily result in mirroring changes in other elements of the central bank's balance sheet.

<sup>36</sup> This description follows with the correct statistical treatment of central bank swaps but in practice certain central banks may follow different recording practices.

Online Appendix 1 Table 6 lists adjustments to series for issues that came up while reviewing the series.

**Online Appendix 1 Table 6. Ad-hoc Adjustments to Spot FXI Estimate**

Country	Period	Type of adjustment	Comments
Argentina	2017-2022	Manual adjustment	Large change in central bank holding of Government Securities due to change in accounting standards.
Bolivia	Jan, 2004	Proxy not reported	Decrease in central government foreign currency securities due to a reclassification to national currency.
Bosnia & Herzegovina	2000-2001	Proxy not reported	Outliers in the raw data (for the change in reserves)—pending verification
Dominican Republic	Aug, 2005	Proxy not reported	Outliers in the raw data —pending verification.
Egypt	Jun, 2008	Proxy not reported	Large decrease in foreign currency loans to non-residents—pending verification.
El Salvador	Jan, 2000	Proxy not reported	Outliers in the raw data (for the change in reserves)—pending verification
Euro Area	All	Proxy not reported	Major reserve currency economies are excluded
Guinea	May, 2011	Proxy not reported	Large one-time operation—pending verification.
Hungary	Jun, 2009	Proxy not reported	Some raw data on central bank balance sheet is based on estimations from the ECB data.
Jamaica	Mar, 2017	Proxy not reported	Break in the series due to introduction of the Standardized Report Form (SRF).
Japan	All	Proxy not reported	Major reserve currency economies are excluded
Macao SAR	Feb, 2012	Proxy not reported	Break in the series due to a new legislation on gross reserves.
Macao SAR	Jan 2013; Jan 2014; Jan 2015; Feb 2016	Proxy not reported	Transfer of funds to the fiscal reserve at the beginning of each year.
Madagascar	Jan 2006	Proxy not reported	Break in the series due to introduction of SRF.
Mauritius	Jan-Nov, 2000	Proxy not reported	Outliers in the raw data (for the change in reserves)—pending verification
Morocco	2000; Jan-Feb, 2001	Proxy not reported	Outliers in the raw data (for the change in reserves)—pending verification
Mozambique	Jul, 2004	Proxy not reported	Part of the medium- and long-term foreign liabilities of the central bank transferred to the treasury.
Nicaragua	Jan 2006; Dec 2011	Proxy not reported	Outliers in raw data—pending verification
North Macedonia	2000; Jan-Feb 2001	Proxy not reported	Outliers in the raw data (for the change in reserves)—pending verification
Pakistan	Jun 2015; Jul & Sep 2016	Proxy not reported	Data to be revised
Romania	Dec 2005; Jan & Jul 2007	Proxy not reported	Outliers in various series pending verification

Saudi Arabia	2000-2004; Jan-Feb, 2005	Proxy not reported	Outliers in the raw data (for the change in reserves)— pending verification
Singapore	May, 2019	Proxy not reported	Transfer of reserves to sovereign wealth fund.
Sri Lanka	All	Source replaced	Gross reserves from IFS includes government reserves. Central bank gross reserves from MFS used instead.
Tanzania	2000-2003	Proxy not reported	Large drop in gross reserves—pending verification.
Thailand	Jan, 2003	Proxy not reported	Break in the series due to introduction of SRF.
Tunisia	May, 2017	Manual adjustment	Reserve number interpolated to treat large one-time spike in the data.
United Kingdom	All	Proxy not reported	Major reserve currency economies are excluded
United States	All	Proxy not reported	Major reserve currency economies are excluded
Venezuela	Jun, 2014	Proxy not reported	MFS data reporting stopped.
Zambia	Nov-Dec, 2002	Proxy not reported	Break in the series due to introduction of SRF.



**ONLINE APPENDIX 2: SUMMARY METADATA FOR OFFICIALLY PUBLISHED FXI**

Country Name	<b>Albania</b>
Coverage	2004Q2 – 2019Q4; 2013M10 - 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly, Quarterly
Reported format	Euro
Link	<a href="https://www.bankofalbania.org/Markets/Operations_of_the_Bank_of_Albania/Interventions_in_the_foreign_exchange_market/">https://www.bankofalbania.org/Markets/Operations_of_the_Bank_of_Albania/Interventions_in_the_foreign_exchange_market/</a>
Note	Starting October 2013, daily data available.

Country Name	<b>Angola</b>
Coverage	2000M1 –2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars and Euros
Link	<a href="https://www.bna.ao/Conteudos/Artigos/lista_artigos_medias.aspx?idc=222&amp;idsc=14088&amp;id =1">https://www.bna.ao/Conteudos/Artigos/lista_artigos_medias.aspx?idc=222&amp;idsc=14088&amp;id =1</a>

Country Name	<b>Argentina</b>
Coverage	2003M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Daily, Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="http://www.bcra.gov.ar/PublicacionesEstadisticas/Informe_monetario_diario.asp">http://www.bcra.gov.ar/PublicacionesEstadisticas/Informe_monetario_diario.asp</a>

Country Name	<b>Australia</b>
Coverage	1989M1 – 2020M6
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of Local Currency
Link	<a href="http://www.rba.gov.au/statistics/tables/">http://www.rba.gov.au/statistics/tables/</a>

Country Name	<b>Bangladesh</b>
Coverage	2005Q1 – 2020Q2
Agency	Central Bank
Types of operations	Spot
Frequency	Quarterly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bb.org.bd/pub/publicitn.php">https://www.bb.org.bd/pub/publicitn.php</a>
Note	Partial data available through various reports on CB website

Country Name	<b>Bolivia</b>
Coverage	2008M12 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bcb.gob.bo/?q=estad-sticas-semanales">https://www.bcb.gob.bo/?q=estad-sticas-semanales</a>

Country Name	<b>Bosnia and Herzegovina</b>
Coverage	1998M1 – 2020M8
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of Local Currency
Link	<a href="http://statistics.cbbh.ba/Panorama/novaview/SimpleLogin_en.html.aspx">http://statistics.cbbh.ba/Panorama/novaview/SimpleLogin_en.html.aspx</a>
Note	2013M5 available only in the local language website

Country Name	<b>Brazil</b>
Coverage	2000M1 – 2020M9
Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap), and other derivatives (Options)
Frequency	Monthly, daily (from 2009)
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bcb.gov.br/en/financialstability/internationalreserves/Daily:Series:code:17843-spot%20net%20intervention%20&amp;code:24425-net%20forward%20interventions%20&amp;code:24427-net%20foreign%20currency%20loans%20and%20foreign%20currency%20repos%20&amp;code:24448-Banco%20Central%20net%20Repo%20lines%20of%20credit%20intervention">Monthly: https://www.bcb.gov.br/en/financialstability/internationalreserves/Daily: Series code: 17843 - spot net intervention &amp; code: 24425 - net forward interventions &amp; code: 24427 - net foreign currency loans and foreign currency repos &amp; code: 24448 - Banco Central net Repo lines of credit intervention</a>

Country Name	<b>Canada</b>
Coverage	2009M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of Local Currency
Link	<a href="https://www.canada.ca/en/department-finance/services/publications/monthly-official-international-reserves.html">https://www.canada.ca/en/department-finance/services/publications/monthly-official-international-reserves.html</a>

Country Name	<b>Colombia</b>
Coverage	1999M12 – 2020M9
Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap), and other derivatives (Options)
Frequency	Daily

Reported format	Millions of U.S. Dollars
Link	<a href="https://www.banrep.gov.co/es/estadisticas/intervencion-diaria-traves-diferentes-mecanismos">https://www.banrep.gov.co/es/estadisticas/intervencion-diaria-traves-diferentes-mecanismos</a>

Country Name	<b>Costa Rica</b>
Coverage	1999M12 – 2020M9
Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap), and other derivatives (Options)
Frequency	Daily
Reported format	Millions of U.S. Dollars
Link	<a href="https://gee.bccr.fi.cr/indicadoreseconomicos/Cuadros/fmVerCatCuadro.aspx?idioma=1&amp;CodCuadro=%201587">https://gee.bccr.fi.cr/indicadoreseconomicos/Cuadros/fmVerCatCuadro.aspx?idioma=1&amp;CodCuadro=%201587</a>

Country Name	<b>Croatia</b>
Coverage	2000M1 – 2020M9
Agency	Central Bank
Types of operations	Spot, other derivatives (Options)
Frequency	Daily
Reported format	Millions of Local Currency and Euros
Link	<a href="https://www.hnb.hr/en/statistics/statistical-data/financial-sector/central-bank-cnb/monetary-policy-instruments-and-liquidity">https://www.hnb.hr/en/statistics/statistical-data/financial-sector/central-bank-cnb/monetary-policy-instruments-and-liquidity</a>

Country Name	<b>Czech Republic</b>
Coverage	1997M5 – 2020M8
Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap)
Frequency	Monthly
Reported format	Millions of U.S. Dollars and Euros
Link	<a href="https://www.cnb.cz/en/financial-markets/foreign-exchange-market/cnb-foreign-exchange-trading/index.html">https://www.cnb.cz/en/financial-markets/foreign-exchange-market/cnb-foreign-exchange-trading/index.html</a>

Country Name	<b>Denmark</b>
Coverage	2011M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Billions of Local Currency
Link	<a href="https://www.nationalbanken.dk/en/pressroom/Pages/2020/09/DNN202009421.aspx">https://www.nationalbanken.dk/en/pressroom/Pages/2020/09/DNN202009421.aspx</a>

Country Name	<b>Ethiopia</b>
Coverage	2006Q2 – 2020Q1
Agency	Central Bank
Types of operations	Spot
Frequency	Quarterly
Reported format	Millions of U.S. Dollars
Link	<a href="https://nbebank.com/quarterly-bulletin/">https://nbebank.com/quarterly-bulletin/</a>
Note	CB shared 2006Q3-Q4 and 2009Q2 data, given these reports are not available online

Country Name	<b>Eurozone</b>
Coverage	2000Q3 – 2020Q2
Agency	Central Bank
Types of operations	Spot
Frequency	Quarterly publication of daily frequency
Reported format	Millions of Euro
Link	<a href="https://www.ecb.europa.eu/stats/balance_of_payments_and_external/international_reserves/fx_interventions/html/index.en.html">https://www.ecb.europa.eu/stats/balance_of_payments_and_external/international_reserves/fx_interventions/html/index.en.html</a>

Country Name	<b>Georgia</b>
Coverage	2009M3 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.nbg.gov.ge/index.php?m=306&amp;lng=eng">https://www.nbg.gov.ge/index.php?m=306&amp;lng=eng</a>

Country Name	<b>Guyana</b>
Coverage	2008M1 – 2020M8
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bankofguyana.org.gy/bog/images/research/Reports/abnov2019.pdf">https://www.bankofguyana.org.gy/bog/images/research/Reports/abnov2019.pdf</a>

Country Name	<b>Hong Kong SAR</b>
Coverage	1998M9 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of Local Currency
Link	<a href="https://www.hkma.gov.hk/media/eng/doc/market-data-and-statistics/monthly-statistical-bulletin/T070102.xls">https://www.hkma.gov.hk/media/eng/doc/market-data-and-statistics/monthly-statistical-bulletin/T070102.xls</a>

Country Name	<b>Iceland</b>
Coverage	1999M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of Local Currency
Link	<a href="https://si2.data.is/?sid=1wrq#">https://si2.data.is/?sid=1wrq#</a>

Country Name	<b>India</b>
Coverage	1995M6 - 2020M8
Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap)
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://dbie.rbi.org.in/DBIE/dbie.rbi?site=publications">https://dbie.rbi.org.in/DBIE/dbie.rbi?site=publications</a> <a href="http://www.rbi.org.in/scripts/BS_ViewBulletin.aspx">http://www.rbi.org.in/scripts/BS_ViewBulletin.aspx</a>

Country Name	<b>Israel</b>
Coverage	1989M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="http://www.boi.org.il/en/NewsAndPublications/PressReleases/Pages/Foreignexchange.aspx">http://www.boi.org.il/en/NewsAndPublications/PressReleases/Pages/Foreignexchange.aspx</a>
Note	Missing values treated as no intervention, as per Caspi et al, 2018

Country Name	<b>Japan</b>
Coverage	1991M5 - 2020M9
Agency	Ministry of Finance
Types of operations	Spot
Frequency	Monthly
Reported format	Billions of Local Currency
Link	<a href="https://www.mof.go.jp/english/international_policy/reference/feio/index.htm">https://www.mof.go.jp/english/international_policy/reference/feio/index.htm</a>

Country Name	<b>Jamaica</b>
Coverage	2003Q3 – 2017Q2; 2017M6 - 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Quarterly
Currency of intervention	U.S. Dollar
Units reported	Millions of U.S. Dollars

Link	<a href="http://boj.org.jm/publications/publications_show.php?publication_id=3">http://boj.org.jm/publications/publications_show.php?publication_id=3</a>
Note	Partial data available through various CB reports. Starting June 2017, Central Bank publishes announcements of each intervention.

Country Name	<b>Kazakhstan</b>
Coverage	1996M1 – 2020M6
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.nationalbank.kz/index.cfm?docid=3236&amp;switch=english">https://www.nationalbank.kz/index.cfm?docid=3236&amp;switch=english</a>

Country Name	<b>Korea</b>
Coverage	2018H2 - 2020Q2
Agency	Central Bank
Types of operations	Spot
Frequency	Half year in 2018H2 and 2019H1, quarterly starting 2019Q3
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bok.or.kr/eng/bbs/B0000298/list.do?menuNo=400374&amp;pageIndex=1">https://www.bok.or.kr/eng/bbs/B0000298/list.do?menuNo=400374&amp;pageIndex=1</a>
Note	Starting 2019Q3, intervention data is published on a quarterly basis.

Country Name	<b>Mauritius</b>
Coverage	1999M4 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bom.mu/publications-statistics/monthly-statistical-bulletin">https://www.bom.mu/publications-statistics/monthly-statistical-bulletin</a>

Country Name	<b>Mexico</b>
Coverage	1996M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.banxico.org.mx/SielInternet/consultarDirectorioInternetAction.do?sector=4&amp;accion=consultarCuadro&amp;idCuadro=CF169&amp;locale=es">https://www.banxico.org.mx/SielInternet/consultarDirectorioInternetAction.do?sector=4&amp;accion=consultarCuadro&amp;idCuadro=CF169&amp;locale=es</a>

Country Name	<b>Moldova</b>
Coverage	2005M1 – 2020M9

Agency	Central Bank
Types of operations	Spot, forward and forward like (Swap)
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bnm.md/bdi/pages/reports/dovre/DOVRE2.xhtml">https://www.bnm.md/bdi/pages/reports/dovre/DOVRE2.xhtml</a>

Country Name	<b>Morocco</b>
Coverage	2018M1 – 2018M11
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of U.S. Dollars
Link	<a href="http://www.bkam.ma/Marches/Principaux-indicateurs/Marche-des-changes/Resultats-des-adijudications-en-devises?startDate=01%2F12%2F2013&amp;endDate=01%2F01%2F2020&amp;block=a966ed6a650b490e680b70f20886496d#address-e3688ae3555d6cf354a258340ff3609d-a966ed6a650b490e680b70f20886496d">http://www.bkam.ma/Marches/Principaux-indicateurs/Marche-des-changes/Resultats-des-adijudications-en-devises?startDate=01%2F12%2F2013&amp;endDate=01%2F01%2F2020&amp;block=a966ed6a650b490e680b70f20886496d#address-e3688ae3555d6cf354a258340ff3609d-a966ed6a650b490e680b70f20886496d</a>

Country Name	<b>New Zealand</b>
Coverage	2004M7 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of Local Currency
Link	<a href="https://www.rbnz.govt.nz/statistics/f5">https://www.rbnz.govt.nz/statistics/f5</a>

Country Name	<b>Nicaragua</b>
Coverage	2000M1 – 2019M11
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bcn.gob.ni/estadisticas/mercados_cambiaros/estadisticas_mensuales/1119/">https://www.bcn.gob.ni/estadisticas/mercados_cambiaros/estadisticas_mensuales/1119/</a>

Country Name	<b>Nigeria</b>
Coverage	2008M1 – 2017M6
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="http://statistics.cbn.gov.ng/cbnonlinestats/QueryResultWizard.aspx">http://statistics.cbn.gov.ng/cbnonlinestats/QueryResultWizard.aspx</a>

Country Name	<b>Paraguay</b>
Coverage	2013M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.bcp.gov.py/compras-y-ventas-de-divisas-del-bcp-i666">https://www.bcp.gov.py/compras-y-ventas-de-divisas-del-bcp-i666</a>

Country Name	<b>Peru</b>
Coverage	1995M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Daily
Reported format	Millions of U.S. Dollars
Link	<a href="https://estadisticas.bcrp.gob.pe/estadisticas/series/diarias/resultados/PD04658MD/html">https://estadisticas.bcrp.gob.pe/estadisticas/series/diarias/resultados/PD04658MD/html</a>

Country Name	<b>Russia</b>
Coverage	2008M8 – 2020M9
Agency	Central Bank & Ministry of Finance
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars and Euros
Link	<a href="http://www.cbr.ru/eng/archive/db/valint/">2008M8 – 2017M1: http://www.cbr.ru/eng/archive/db/valint/</a> ; <a href="https://www.minfin.ru/ru/statistics/fedbud/oil/?id_65=122094-svedeniya_o_formirovanii_i_ispolzovanii_dopolnitelnykh_neftegazovykh_dokhodov_federalno_go_byudzheta_v_2018-2020_godu">2018M1 - present: https://www.minfin.ru/ru/statistics/fedbud/oil/?id_65=122094-svedeniya_o_formirovanii_i_ispolzovanii_dopolnitelnykh_neftegazovykh_dokhodov_federalno_go_byudzheta_v_2018-2020_godu</a>
Note	Bank of Russia Annual report indicates there was no intervention in 2017: <a href="http://www.cbr.ru/Collection/Collection/File/9170/ar_2017_e.pdf">http://www.cbr.ru/Collection/Collection/File/9170/ar_2017_e.pdf</a>

Country Name	<b>Switzerland</b>
Coverage	2020Q1-Q2
Agency	Central Bank
Types of operations	Spot
Frequency	Quarterly
Reported format	Millions of Local Currency
Link	<a href="https://data.snb.ch/en/topics/snb#!cube/snbfxtr">https://data.snb.ch/en/topics/snb#!cube/snbfxtr</a>

Country Name	<b>Turkey</b>
Coverage	2013M6 – 2020M9
Agency	Central Bank
Types of operations	Spot and Other derivatives (Options)
Frequency	Monthly
Reported format	Millions of U.S. Dollars



Link	<a href="http://www.tcmb.gov.tr/wps/wcm/connect/a57592ac-61d2-406f-bd07-353a09962a80/Monthly+Buying+and+Selling+Amounts.pdf?MOD=AJPERES&amp;CV">http://www.tcmb.gov.tr/wps/wcm/connect/a57592ac-61d2-406f-bd07-353a09962a80/Monthly+Buying+and+Selling+Amounts.pdf?MOD=AJPERES&amp;CV</a>
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Country Name	<b>Ukraine</b>
Coverage	2018M1 – 2020M9
Agency	Central Bank
Types of operations	Spot
Frequency	Weekly
Reported format	Millions of U.S. Dollars
Link	<a href="https://bank.gov.ua/files/Finmarket/InterventionsResults_eng.xlsx">https://bank.gov.ua/files/Finmarket/InterventionsResults_eng.xlsx</a>

Country Name	<b>United Kingdom</b>
Coverage	2010M6 – 2020M9
Agency	Government
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of Local Currency
Link	<a href="https://www.gov.uk/government/collections/statistical-release-uk-official-holdings-of-international-reserves">https://www.gov.uk/government/collections/statistical-release-uk-official-holdings-of-international-reserves</a>

Country Name	<b>United States</b>
Coverage	1973M3 - 2020M6
Agency	Central Bank
Types of operations	Spot
Frequency	Daily from 1973M3 - 2011Q1, Quarterly from 2011Q2-2020Q2
Reported format	Millions of U.S. Dollars
Link	<a href="https://fred.stlouisfed.org/categories/32145?t=usa&amp;ob=pv&amp;od=desc;">https://fred.stlouisfed.org/categories/32145?t=usa&amp;ob=pv&amp;od=desc;</a> <a href="https://www.newyorkfed.org/markets/quar_reports.html">https://www.newyorkfed.org/markets/quar_reports.html</a>

Country Name	<b>Uzbekistan</b>
Coverage	2017M1 – 2020M6
Agency	Central Bank
Types of operations	Spot
Frequency	Monthly
Reported format	Millions of U.S. Dollars
Link	<a href="http://www.cbu.uz/en/publikacii/buleten/">http://www.cbu.uz/en/publikacii/buleten/</a>

Country Name	<b>Zambia</b>
Coverage	2013M1 – 2019M3
Agency	Central Bank

Types of operations	Spot
Frequency	Weekly
Reported format	Millions of U.S. Dollars
Link	<a href="https://www.boz.zm/monetary-and-financial-statistics-New.htm">https://www.boz.zm/monetary-and-financial-statistics-New.htm</a>



**PUBLICATIONS**