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ABSTRACT

Do central banks rebalance their currency shares? The answer matters because the dollar's predominant role in large official reserve holdings means that widespread rebalancing requires central banks to buy (sell) a depreciating (appreciating) dollar, stabilising its value against other major currencies. We hypothesise that larger reserve holdings have led central banks to approach their investment more systematically and to make rebalancing in the face of exchange rate changes the norm. We illustrate the choice with two polar case studies: the US clearly does not rebalance its small FX reserves; Switzerland does rebalance its very large reserves, so that changes in exchange rates do not move its currency allocation. Our hypothesis finds partial support in global aggregated data. They reject both no rebalancing and full rebalancing and point to emerging market economies as the source of the aggregate result. We also test for rebalancing with panel data and find that our sample economies on average again behave in intermediate fashion, partially but not fully rebalancing. However, when observations are weighted by the size of reserves, the panel analysis finds full rebalancing. A variety of control variables and splits of the panel sample do not alter the thrust of these findings. Central banks rebalance their FX reserves extensively but not uniformly.

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1. Introduction

Much recent research has focused on the dollar's dominance in the denomination of trade, of stocks of international bank debt and in foreign exchange (FX) reserves (Gopinath and Stein, 2018a,b). The dollar's dominance in FX reserves implies that the management of these reserves can have important effects on the dollar's exchange rate. If central banks seek to maintain a target share of dollar reserves, then they must sell dollars when it strengthens and buy dollars when it weakens. This trend-resisting behavior would tend to stabilise the dollar's exchange rates.

This possibility stands in contrast to a long-standing literature that analyses the possibly destabilising effects of official FX reserve managers shifting reserves between competing reserve currencies. Between the World Wars, Młynarski (1929) warned of instability in *official* currency allocations; Eichengreen and Flandreau (2007) demonstrated such instability in the 1930s. Triffin (1960) updated Młynarski's warning for Bretton Woods, pointing to the capacity of reserve shifts to break its dollar-gold link (Bordo and McCauley, 2019). Sterling's decline subsequently demonstrated such instability (Schenk, 2003). Proponents of a substitution account in 1979-80 sought to manage reserve managers' shift out of the dollar by replacing dollars with International Monetary Fund (IMF) Special Drawing Rights (SDRs; McCauley and Schenk, 2011). Blanchard et al (2005) revived portfolio balance theory to analyse the possible effect of China's reallocating its FX reserves from the dollar to the euro (see also Lu and Wang, 2019).

A back-of-the-envelope calculation underscores rebalancing's macroeconomic potential. Assume the dollar depreciates by 10% against the euro, the yen, sterling and the renminbi.[1] At end-2020, US dollar reserves stood at about $7.5 trillion and non-dollar reserves stood at about $5.2 trillion equivalent.[2] A 10% dollar depreciation against this basket of reserve currencies would

[1] A 10% depreciation in a year is big, but peak-to-trough dollar downswings can entail multiple such moves.
[2] We use identified (i.e., "allocated") FX reserves in the COFER data to allocate the unidentified ("unallocated") ones between dollar and non-dollar. That is, claims in USD equal identified claims in USD ($7.0 trillion) plus unidentified

thus add over $0.5 trillion to reserves. For the dollar to retain its 59% share, over $300 billion would need to be shifted into the dollar.[3,4] Is this a big number? It is almost half the 2020 US current account deficit of $647 billion, which is 3.1% of GDP. It approaches in size the massive Japanese intervention of 2003-04 (Gerlach-Kirsten et al., 2016).

Carrying forward the back-of the envelope calculation suggests that the investment of such official dollar purchases could significantly add to the demand for US Treasury bonds. Once they have bought dollars, central bank reserve managers' modal investment is US Treasury notes, especially at intermediate maturities ("the belly of the curve", Gerlach-Kirsten et al., 2016; McCauley, 2020). The importance of official buying and selling to US bond yields is the subject of many studies (eg Bernanke et al., 2004; Backus and Wright, 2007; Warnock and Warnock, 2009; Gerlach-Kristin, et al., 2016; McCauley, 2017). These studies tend to find that $1 billion of official inflow into US Treasury bonds was associated with a one basis point decline in their yields. Who knows how persistent such an effect might be? Still, the strong suggestion is that rebalancing of official FX portfolios in the context of dollar depreciation could support a Treasury bond market challenged by heavy supply and recurrent strains in market-making, breadth, depth, and liquidity (Liang and Parkinson, 2020).

Do central banks rebalance their currency shares in response to exchange rate changes between the dollar and other reserve currencies? This is an unstudied question that deserves attention for three reasons.

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claims in USD, the latter of which is the total unidentified claims ($0.83 trillion) times the USD share in the identified reserves ($0.83 trillion *x* 59%). Hence, the dollar reserves can be calculated as $7.5 trillion. Similarly, the non-dollar reserves can be calculated as identified of $4.9 trillion plus an estimated $339 billion or $5.2 trillion.

[3] Without rebalancing, the dollar reserves would be 57% of total reserves. To take the dollar share back up to 59%, a rebalancing act worth $305 billion, or 2.3% of $13.2 trillion (= total reserves after the 10% depreciation), would be needed.

[4] In practice, dollar reserve accumulation quickens during a dollar downswing (Bordo and McCauley, 2019, Table 1), so the rebalancing could be done by simply not shifting freshly bought dollars into other key currencies.

First, FX reserves now stand at $12.7 trillion; the management of such a large portfolio should interest policymakers, academics and financial market participants. The implications for FX rates of equity rebalancing by private portfolio managers has received some attention. Hau and Rey (2006), Cappiello and De Santis (2005, 2007) and Camanho et al. (2020) posit that global investors rebalance symmetrically in response to own-currency equity gains and currency gains. However, Curcuru, et al. (2014) find that US investors do not stabilise FX rates by rebalancing after FX movements. Recognizing widespread currency hedging of cross-border equity holdings (Borio et al., 2017), Melvin and Prins (2015) show that equity gains lead index-tracking investors to maintain their hedge ratios by simultaneously selling the currency forward at the 4pm "London fix" at end-month, depreciating it. To our knowledge, this is the first study of reserve managers' currency rebalancing.

Secondly, as suggested above, rebalancing can stabilize key FX rates. If, when the dollar rises, central banks sell it, and when it falls, they buy it, they counter the widespread momentum-following FX strategy of leveraged commodity ("CTA") funds and others (Neely et al. 2009; Menkhoff et al., 2012: Moskowitz et al., 2012; Ivanova, et al. 2021). The issue of whether central bank reserve managers damp FX market swings is important.[5]

Third, as noted, rebalancing can affect official demand for US bonds. In particular, a depreciating dollar can provide support to the US Treasury market, where issuance is heavy and at

[5] In a related literature, Pihlman and van der Hoorn (2010) argued that central banks' instrument choice (not currency choice) was procyclical around the 2008 Great Financial Crisis, as central banks withdrew deposits from banks in a flight to quality to US Treasury securities. McCauley and Rigaudy (2011), using BIS international banking data, find that reserve managers' retreat from risky banks started with Swiss banks in 2007 and was spread over quarters, in sharp contrast to US money market funds' run on non-US banks in the days and weeks after the Lehman Brothers failure, as described by Baba, et al., (2009). See McCauley and McGuire (2009) for the flight to quality in US Treasury bills in late 2008.

writing the Fed is currently buying $80 billion a month partly in response to recurring strains.[6] If the dollar experiences a long downswing (Engle and Hamilton, 1990; Chinn, 2015), then rebalancing toward the dollar could provide a sustained bid for US bonds.

There are reasons to expect that today's large reserve holdings have led to a norm of rebalancing. Where reserves have grown, central banks have tended to come to the view that they represent a portfolio to be managed as such in a professional manner (Streit and Muhl, 2020. Means-variance optimization and eclectic methods guide the currency allocation (Frankel, 1985; Ramaswamy, 2008). Depending on central bank transparency and governance, reserve managers report and defend their currency allocations to senior management, the central bank board, the legislature or the public (Johnson-Calari and Strauss-Kahn, 2020). FX moves typically do not change whatever reasoning produced an allocation deemed optimal. Chinn and Frankel (2005) argue that rebalancing goes naturally along with means-variance optimisation and should be taken as the norm.[7] However, some central banks split reserves into liquidity and investment tranches (Borio et al., 2008; Schanz, 2019), with the former held in the intervention currency—typically the dollar--and this might limit rebalancing to the investment tranche.

Thus, we hypothesise that, as reserves have grown and their management has evolved, currency rebalancing has become the norm. We examine two case studies, perform time series analysis of aggregate IMF data and perform panel analysis on individual country data that we have collected. We examine several factors that may shape reserve managers' response to FX changes:

- **Size of FX reserve changes**: When reserves rise rapidly, reinvestment from the intervention

[6] Just as dollar depreciation lightens the burden of net US external liabilities (Tille, 2005), it may draw official foreign investment into US bonds.

[7] The exception would be elastic expectations, which extrapolate from a strengthening dollar that it is likely to strengthen more. Given long dollar swings (Engel and Hamilton, 1990), such expectations cannot be dismissed out of hand. A reserve manager judged on annual results might not safely assume a random walk.

currency (usually the dollar) into other key currencies may lag, boosting the intervention currency's share.[8] On the downside, use of reserves followed by rebalancing requires buying the intervention currency with other key currencies, and this too may lag, reducing the intervention currency's share.

- **Market volatility:** If reserve managers seek to rebalance without the order flow's disturbing key FX rates (eg dollar/euro), then strained markets may inhibit or at least slow the rebalancing (Fischer et al., 2021).[9] Think 2008Q4 or 2020Q1.
- **Scale of FX reserves**: Larger reserves are likely to be managed as an endowment rather than as a liquid pool (even if there are matching interest-bearing liabilities). Optimization and rebalancing become more likely with larger size (Beck and Weber, 2011).

The main findings of this paper are five.

First, our two case studies are polar opposites: the currency composition of US reserves follows exchange rates while that of Swiss reserves is subject to regular rebalancing.

Second, we find partial rebalancing at the aggregate level. While an appreciating dollar does significantly raise the USD share in FX reserves, the rise is also significantly less than what would find if no central bank were rebalancing. Perhaps, some central banks reporting in the IMF currency composition of official FX reserves (COFER) database rebalance and some do not. When we look at the aggregates for advanced and emerging economies, it appears that the evidence for rebalancing arises from the emerging market economies, which hold the bulk of global reserves.

Third, panel analysis of more than 70 economies also finds that in aggregate central banks partially rebalance. When advanced and emerging markets are separately analysed, their behavior

[8] See Gerlach-Kristen et al. (2016) on the similar lag between the Japanese Ministry of Finance (MoF) buying dollars and its investing them in US Treasury securities.

[9] Or central banks may follow the advice of Harvey et al. (2021) and not rebalance in volatile markets if exchange rate changes are perceived to have momentum, so that delaying rebalancing is profitable.

does not differ substantially. The difference between the aggregate result and the panel result may arise from Japan, the largest reserve holder among advanced economies, which is present in the COFER data but absent from the panel data.

Fourth, when we weight the observations by the scale of reserves, full rebalancing is the result. On this showing the Swiss approach is more typical of big reserve holders than the US approach. This finding is consistent with large reserves making reserve management more like private portfolio management. Again, Japan may partially explain the difference between this finding and the finding for the IMF aggregate data.

Fifth, rapidly growing reserves are associated with a higher dollar share. We interpret this as reflecting the dollar as dominant ("vehicle") currency in the FX market: most central banks buy dollars and then diversify into their target currencies with a lag. We find that rapid growth of Swiss reserves lowers the dollar share, which is consistent with the central bank acquiring euros in the first instance. By contrast, there is little evidence that financial market volatility affects rebalancing.

Taking them altogether, we find that there is strong evidence for rebalancing, especially among large reserve holders. That said, clearly the rebalancing is not universal. The implication is that the dollar does derive stability from this source.

The rest of this paper is in four parts. Section 2 profiles two well-reported FX reserve managers, the US Treasury and Fed and the Swiss National Bank (SNB; Streit and Muhl, 2020), the former not at all rebalancing, the latter rebalancing. Section 3 analyzes aggregate rebalancing, using the IMF COFER database. Section 4 reports a panel analysis of 70 countries using the dataset of Ito and McCauley (2020). Section 5 concludes.

2. Case studies with rich data – US and Swiss reserve management

We start our analysis on whether or not central banks rebalance by focusing on two country case studies. Both the US and Swiss central banks disclose detailed information on their FX reserve portfolios on a quarterly basis. The United States serves as a usefully pure case of no rebalancing, Switzerland, although more complicated, serves no less certainly as a case of rebalancing.

2.1 US reserve management

Federal Reserve Bank of New York (FRBNY) reports the composition of US FX reserves every three months in USD. Since 2000, the US intervened in the FX market only once after the Tohuku Earthquake in Japan, selling $1 billion equivalent of yen in a concerted action with the Japanese Ministry of Finance, the ECB, the Bank of Canada, and the Bank of England. Thus, apart from a vanishing trickle of interest receipts, the quarterly variation in the dollar value of US FX reserves held in euro and yen arises from valuation effects.[10] US reserves rise when the dollar depreciates against the euro and yen, and fall when the dollar rises against them.

Such translation effects, however, are not restricted to the USD value of the foreign currencies. There are also important shifts in this US case in the value of the euro against the yen. Without a response by the US authorities, changes in this cross-rate shift the euro and yen shares of US FX reserves. For instance, if the yen rises against the euro, absent any response, the yen gains weight in US reserves. It is this valuation effect that this paper addresses.

If one uses end-quarter rates for the close in New York (admittedly these Datastream data do not exactly match the FRBNY's use of noon New York rates to value its portfolio), to convert the dollar amounts reported by the Fed into euro and yen, it is clear that the US authorities do not rebalance. The lines in Figure 1(a) gently slope in reflection of interest receipts (costs), with the

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[10] In its most recent report for Q4 2020, FRBNY (2021, p 15) ascribes the changes in euro holdings of $1.1 billion and yen holdings of $0.4 billion, as usual, to FX rate changes: "These changes are largely driven by foreign exchange translation effects" in the context of a depreciating dollar. Below we exclude FX holdings arising from FX swaps, which is easy to do using the quarterly reports' regular table, "Breakdown of foreign reserve assets held", since these remain in the reciprocal nostro accounts and are not invested in government securities, BIS deposits or the like (Potter et al., 2020).

exception of the aforementioned drawdown in yen in March 2011. The evolving euro/yen exchange rate, not the managers in New York and Washington, set the pace for the change in shares.

The point that the US authorities do not rebalance is already well demonstrated, but another graph helps to set up our subsequent analysis. Figure 1(b) shows the euro share of US reserves from end-2000 to end-2020 (excluding holdings of various currencies that result from FX swaps, which remain as correspondent bank deposits in the counterparty central bank).

It is evident that the euro share moves around quite a bit, as a consequence of basically static holdings of euros and yen and an evolving cross-rate between them. In the 20 years, the euro peaked against the yen at 168 yen per euro in June 2008, and troughed at 99 yen per euro just four years later in June 2012, in the wake of the European sovereign debt crisis. In June 2008 the US reserve portfolio comprised 63.8% euro and 36.2% yen. In June 2012, it comprised 53.9% euro and 46.1% yen. To repeat, the US authorities do not rebalance despite big swings in the euro/yen.

Figure 1(c) plots the observed euro share again and now also the change in the share based on the previous quarter's quanta of euros and yen and the actual exchange rate change (described in detail in equation 1 below). The dashed line cumulates these changes. This tracks the observed ratio very well except in March 2011. If the US authorities had religiously rebalanced, however, we would observe the flat dotted line.

The upshot is that US reserve management is well characterized by the dashed line and not at all by the dotted line. The US practice of not rebalancing in response to changes in the euro/yen exchange rate allows changing exchange rates full play to alter shares; by contrast, rebalancing them would offset euro/yen rate changes fully.

When we move to other non-G3 cases, such as next up Switzerland, the main currencies are not euro and yen but rather dollar and euro, which together make up about four-fifths of all FX reserves. A complication is that central banks that do rebalance may also irregularly shift their strategic asset allocations to raise or to lower the dollar share. The SNB is so transparent that we can insert dummies to capture these re-weightings, so that the degree of rebalancing in other, more normal quarters can be assessed econometrically. However, this is possible for neither the aggregates nor the panel analysis. The danger, for instance, is that there is a positive relationship between the dollar's appreciation and reweighting in favor of the dollar (the elastic expectations case). In this case, we might misinterpret a re-weighting as a lack of rebalancing.

3.2 Swiss reserve management

Turning now to Switzerland, Figure 2 illustrates the development of the major currency shares in SNB's FX reserves from 2005Q1 through 2020Q4.[11]

Interestingly, the share of the USD appears to be roughly stable from 2005Q1 through 2015Q1, hovering 26-28%, though there are two spikes down, one in 2010Q1-Q2 when the Greek debt crisis broke out and the other in 2012Q2 before ECB President Mario Draghi promised to do "whatever it takes" on 26 July 2012. In the beginning of 2015, after the SNB ended the exchange rate cap of the Swiss franc against the euro in an environment of dollar appreciation, the SNB boosted the USD share gradually, getting closer to 40%. For the last five years, it is stabilized around 35-37%.[12]

In the analysis below we dummy out four quarters when the SNB changed its strategic asset

[11] From the SNB's website, we use the data "Foreign currency investments, including derivatives, excluding foreign exchange swaps for monetary policy purposes." There is another data series called "Foreign currency investments, excluding foreign exchange derivatives" and its time series starts in 1997Q1. However, the latter include spot positions in the dollar and euro that result from swaps done for monetary policy purposes. In particular, faced with a small domestic money market but a large FX market, the SNB often swaps CHF against USD to provide domestic bank reserves. This increases its holdings of USD, but not its USD exposure. Thus, of more interest from a reserve management perspective are the SNB's FX holdings excluding swaps.

[12] The EUR share presents a mirror image. It peaks at 70% in 2010Q1 and again at 60% in 2012Q1, after which, however, the EUR share consistently falls. For the last few years of the sample, it marks around 40%. SNB reports the shares of JPY, GBP, and CAD, but as was in the case of the aggregate picture based on the COFER dataset, none of these currencies appear to be a third dominant currency.

allocation by currency:

1. 2010:1 "new investment currencies were added: the Australian dollar (AUD), Singapore dollar (SGD), and Swedish krona (SEK) in 2010" (Streit & Muhl, 2020, p 237)
2. 2010:3: "The share of the main investment currencies, the US dollar and the euro, fell slightly [from 30% and 58% in Table on p 66] to 25% and 55% respectively, while the shares of the Canadian dollar and Japanese yen rose". (SNB, 2011, p 68)
3. 2015:1: "in 2015 the Chinese renminbi (CNY)" was added (Streit & Muhl, 2020, p 237)
4. 2017:1: "The euro share declined slightly in favour of the US dollar; the shares of the other currencies remained unchanged" (SNB, 2018, p 84).

How do the SNB reserve managers respond to movements in the key currency exchange rates? We examine the impact of the exchange rate movements on the share of the USD

For the analysis, we construct a variable called Val_Eff_{USD}, which represents the pure valuation effect of the dollar. The USD share in FX reserves changes depends on both the movements of the dollar's exchange rates against other currencies and the change in the quantity of reserves in different currencies. The valuation effect on the dollar share captures the former and can be expressed as follows:

$$Val\_Eff_{USD}^{SNB} = \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_{C}^{C}\frac{\mathrm{R}_{C}(\mathrm{t}-1)}{FX_{C}(t)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_{C}^{C}\frac{\mathrm{R}_{C}(\mathrm{t}-1)}{FX_{C}(t-1)}} \qquad (1).[13]$$

[13] More generally, the valuation effect of major currency c is: $Val\_Eff_{c}^{SNB} = \frac{\frac{R_{C}(\mathrm{t}-1)}{FX_{C}(t)}}{\sum_{C}^{C}\frac{\mathrm{R}_{C}(\mathrm{t}-1)}{FX_{C}(t)}} - \frac{\frac{\mathrm{R}_{C}(\mathrm{t}-1)}{FX_{C}(t-1)}}{\sum_{C}^{C}\frac{\mathrm{R}_{C}(\mathrm{t}-1)}{FX_{C}(t-1)}}$. Note that other authors use the term valuation effect differently, incorporating interest rate effects, as in Arslanap and Tsuda (2015).

R_c is foreign exchange reserves in major currency c, which we obtain from the SNB's database. That is, R_{USD} is FX reserves in USD, R_{JPY} is FX reserves in the Japanese yen, and so forth. Non-USD reserves, $R_{c,c\neq USD}$, need to be converted to USD by using the exchange rate of currency c per dollar. Hence, $\frac{\mathrm{R}_c(t)}{FX_c(t)}$ is the holding of FX reserves that is denominated in c, as expressed in USD at the current exchange rate. In equation (1), while the first term values last period's holdings $R_{USD}(t\text{-}1)$ and $R_c(t\text{-}1)$ at the current exchange rate ($FX_c(t)$))), the second term values the same holdings at the previous period's exchange rate ($FX_c(t-1)$). We are only interested in the valuation effect that results from exchange rate moves, so we keep the quantum of reserves in each major currency c in its local currency constant (as $R_c(t\text{-}1)$). By subtracting the previously observed USD share (the second term in equation (1)) from the calculated USD share that only incorporates the exchange rate change (not any change in the quantum of the reserve currencies), we obtain $Val\_Eff_{USD}^{SNB}$.

We regress the observed change in the USD share on the calculated valuation effect $Val\_Eff_{USD}^{SNB}$ as below, and report the results in Table 1.

$$\Delta \boldsymbol{y}_{\boldsymbol{t}}^{\boldsymbol{USD}} = \alpha + \boldsymbol{\beta Val\_Eff_{USD,t}^{SNB}} + X'_t\Gamma + \varepsilon_t \qquad (2)$$

The estimation results suggest that rebalancing is very much the norm at the SNB. The coefficient on the constructed valuation change is consistently insignificant. Rapid growth of the

SNB's reserves is associated with a lower dollar share (second row).[14,15] This finding is consistent with the SNB's intervening in the spot FX market to buy euro and then rebalancing by buying dollars only with a lag. In particular, if the SNB sought to minimize the effect on the euro/dollar rate of such rebalancing, it could have adopted the latest trading technology of using algorithmic trading to dribble orders into the automated interbank brokerage platform, EBS. But this would introduce lags, especially if euro-buying were heavy at end-quarter. The upshot would have been a positive association of very rapid growth of Swiss reserves and the euro share, and a corresponding negative association between growth and the dollar share.[16]

Stepping back, the contrast between the management of the modest US reserves and the very large Swiss reserves in the face of exchange rate changes presents a stark contrast. The US Treasury and Fed hold a certain number of euros and yen and, scant interest earnings aside, hold them from quarter to quarter. This means that the share of euro and yen in the US reserve portfolio drifts with the euro/yen exchange rate. By contrast, the SNB has (varying) targets for the dollar and euro portions of its FX reserves. Exceptional growth in those reserves apart, the SNB sells dollars after dollar appreciation and buys dollars after dollar depreciation. Such rebalancing tends to stabilise the dollar's exchange rate.

How does the aggregate of FX reserve management fit in between these two polar cases? Section 3 attempts to answer this question using much the same approach as we have used with the Swiss data.

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[14] "FX assets" in the estimation model are total reserve assets with the valuation effects removed in an analogous way to equation (1). Here, instead of maintaining the volumes (i.e., the quantum) of local currency reserves constant, we hold the exchange rate constant over the consecutive quarters and let the quantum of local currency reserves vary (See Appendix 1).

[15] The negative effect of the growth rate of the SNB's reserves is greater when the valuation effect is greater (third row).

[16] When we repeat the regression exercise for the euro share, the estimated coefficient of the growth rate of FX assets is found to be positive.

3. The big picture of global reserve management –rebalancing or not?

We now focus on an overview of the use of major international currencies as reserve currencies, based on aggregate IMF composition of foreign exchange reserves (COFER) data. Figure 3 shows that the dollar remains the dominant reserve currency, followed at a distance by the euro. From 1999 through 2011, the USD share showed a moderately declining trend, falling from 72% to about 60%. The share rose in 2014 and fell again from 2017.[17] The development of the EUR share has not quite mirrored that of the USD share. The EUR share showed a moderately rising trend from the beginning of the sample period, rising from less than 20% to 28% up to 2010. Then the sovereign and bank crisis erupted in the euro area, driving down the share. It then bottomed out in 2015 at about 20%. The JPY and GBP come in a distant third and fourth, with shares hovering below 5%.

Passing this view of broad trends to quarter-by-quarter changes, we examine how the valuation effect, $Val\_Eff_{USD}^{COFER}$, affects the observed USD share from the COFER database by regressing the latter on the former as follows:

$$\Delta \boldsymbol{y_t^{USD}} = \alpha + \boldsymbol{\beta Val\_Eff_{USD,t}^{COFER}} + X'_t\Gamma + \varepsilon_t \qquad (3)$$

Some reserve managers might tolerate currency shares moving within a broad band, and regard rebalancing as a decision that might have to be defended if an exchange rate trend were to prove persistent. Others might take rebalancing as the norm "[b]ased on the theoretical and empirical findings of modern portfolio theory (MPT) and a reflection on the principles and practices of

[17] Observations starting in 2015 Q2 contain a growing proportion of Chinese reserves, but the order of entry of these data may have favoured some reserve currencies over others, making the aggregates for a number of years noisy. See Hauck and Truman (2015). We reran the aggregate analysis leaving out these later years and the results did not change.

professional portfolio management techniques" (Streit and Muhl, 2020, p 227).

If the estimated coefficient on $Val\_Eff_{USD}^{COFER}$ is found to be one, then reserve managers eschew rebalancing and let the USD reserve share follow exchange rate movements one-to-one. In contrast, if the estimated coefficient is found to be zero, as for the Swiss reserves, reserve managers actively rebalance to maintain the USD reserve share constant.

We test the estimate of $Val\_Eff_{USD}^{COFER}$ and report the estimation results for the full sample in Table 2 (a). According to the estimation results, the coefficient of $Val\_Eff_{USD}^{COFER}$ is significantly positive across different models, but less than one. When the null hypothesis of $\beta(VE)$=1 is tested, it is rejected at statistically significant levels in all cases, indicating that the estimate of the valuation effect variable is less than one.[18] That means that overall, reserve managers partially rebalance. This aggregate finding may reflect the diverse behavior across reserve managers, some of which rebalance and others which do not.

In model 2, we find the estimate of the growth rates of total reserve assets, net of the exchange rate effects, to be significantly positive.[19] That means, when the reserve portfolio grows rapidly, the USD share rises. This may result from the fact that, for most countries, the USD is the intervention currency, the vehicle currency in the spot market in which the authorities can operate. If, in addition to this vehicle currency role of the dollar, rebalancing into other key currencies takes time, then reserve growth can lead to a perhaps temporarily higher dollar share. Symmetrically, a rapid drawdown of reserves may lower the dollar share as sales of reserves take place against the dollar and lags intervene between such sales and rebalancing from other key currencies into the dollar.

[18] The p-value is reported at the bottom row of the table.
[19] "Total reserve assets" are "allocated reserves in dollars" in the COFER database. As was in the case of the SNB regression, we hold the exchange rate constant over the consecutive quarters and let the quantum of local currency reserves vary.

In model 3, we test whether rapid growth of the portfolio affects the dollar share's response to valuation effects. We find the estimated interaction between the value effect variable and the growth rate of the reserve portfolio is negative, but insignificant. Moreover, the estimate of the valuation effect variable remains unchanged despite the inclusion of the interaction term.

When the economy of concern faces economic uncertainty, the respective central banks' reserve managers may decide to make reserves more immediately useful for intervention (or to lend to banks) and thus to hold more USD-denominated assets. If that is the case, financial instability can lead to a higher USD share. The correlation between the USD and our proxy for financial instability, the VIX index, is then predicted to be positive.

In model 4, we include the first-difference of VIX in the estimation. Its estimate is found to be positive, but not statistically significant while the estimate on $Val\_Eff_{USD}^{COFER}$ still lies between zero and one. In model 5, we test if there is any interaction between the VIX and the response to the value effect variable. The estimated coefficient is insignificant.

The IMF COFER also reports the share of major currencies for the subsamples of advanced economies (AEs) and emerging market and developing economies (henceforward EMEs), though the data series is available only up to 2015Q1.[20] We run the same estimation for these subsamples and report the results in Table 2(b) for AEs and Table 2(c) for EMEs, respectively.

For the advanced economies, the valuation effect on the USD share is found to be statistically positive, and the estimate of the valuation effect is not statistically different from the value of unity (Table 2(b)). That suggests that the SNB rebalancing act is unusual among AEs. On average, AEs' central banker let the share of USD rise when its value rises against other major currencies, possibly on a one to one basis.

[20] Related to Chinese renminbi's entry to the SDR basket, China started to report bit by bit its currency composition after this date (Hauck and Truman, 2015).

For the subsample of EMEs, reserve managers offset about half of the valuation effect. That is the coefficient on the calculated valuation effect is found to be significantly greater than zero, but significantly below the value of one. That is, on average, EME central banks rebalance partially, suggesting that some rebalance while others do not.

Table 2(c), model 5, also reports that the higher level the measure of financial instability is, the *lower* the USD share would be among EMEs. This might be explained by the tendency of EMEs to use dollar reserves to intervene to support their currencies in volatile markets.

4. Testing the valuation effects on the USD share in the panel context

We have found full rebalancing for Switzerland and partial rebalancing for the global aggregate and EME economies. We now analyse the relationship between valuation effects and dollar shares in annual data across individual countries.

We build upon Ito and McCauley (2020), who investigated the determinants of the shares of major currencies in FX reserves. This work added about 30 countries to previous work done on individual country data (Truman and Wong, 2006; McCauley and Chan, 2014; Ito et al., 2015; Gopinath and Stein, 2018a,b) and reduced the European bias in the earlier work. This work has been joined a paper by Iancu et al. (2020) which claims (p 19) "a novel database of individual economies' reserve currency by currency".[21] The COFER data are reported for aggregates, but not for individual countries except for some consenters.[22]

Here, we update the Ito-McCauley dataset and expand the country coverage. The original dataset included 58 economies in the 1999-2018 period. Now, the new dataset comprises of 74

[21] The May 2019 *JIMF* conference at which Ito and McCauley (2020) was presented, and the circulation of the December 2019 BIS Working Paper version precedes the November paper from the IMF Strategy, Policy and Review Department and the Statistics Department.
[22] Heller and Knight (1978), Dooley et al (1989), and Eichengreen and Mathieson (2000) have used individual countries' confidential data from the COFER database.

economies in the 1999-2020 period.[23]

With this dataset, we test the impacts of exchange rate fluctuations on the currency composition in a panel data setting. For that, we first construct the valuation effect variable, $Val\_Eff_{USD}^{IM}$, by using the Ito-McCauley dataset and estimate the impact of $Val\_Eff_{USD}^{IM}$ on the first-difference of the USD shares in FX reserves for 70 economies over the period of 2001 through 2020.[24]

To control for time invariant factors that may affect the response of currency composition to exchange rates, we include country fixed effects in the estimation model. Fixed effects also help control for factors that do not vary over the sample period such as institutional development. We report the estimation results in Table 3.

First of all, the estimate on the valuation effect ($\hat{\beta}(VE)$) is significantly positive across different models, with its coefficient ranging around 0.40 to 0.67. While the magnitude of $\hat{\beta}(VE)$ is significantly greater than zero, it is also statistically lower than the value of one in all models. As was in the case with the aggregate COFER data, we see evidence for partial rebalancing. That is, some economies rebalance while others do not, suggesting heterogeneity across economies in terms of central banks' reaction to USD-exchange rate movements.

The growth rate of the portfolio (net of the valuation effect) positively affects the USD share, again suggesting that when the portfolio expands, the volume of USD reserves disproportionally increases, making the USD share rise. This can be interpreted as reflecting the dollar's vehicle

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[23] The original dataset (Ito and McCauley, 2019) did not include the US or the euro area economies – Japan does not disclose the currency composition of FX reserves. The new dataset includes the US and 12 euro area economies: Belgium, Estonia, Finland, France, Germany, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Spain, and Slovenia. The US, however, is not included in the panel data analysis since the US dollar is not its foreign reserves.

[24] In the estimation exercise, the Euro area is included in the sample as an individual entity in addition to the area's member countries unless mentioned otherwise. The main focus of this exercise is to examine the behavior of central banks (i.e., ECB for the Euro area). However, in the weighted regression exercise, the Euro area is removed to avoid the redundancy in the weighting. In other regressions, when we conduct subsample analyses based on economic criteria, we remove the euro area as a group (i.e., individual euro member countries are retained in the sample).

currency role in the spot market *and* lags in the rebalancing.

We also test the point change (i.e., first-difference) in VIX and its interaction with the valuation effect.[25] However, neither of these variables enters the model significantly.

As suggested in the discussion, in column (2) of Table 4, we test for whether weighting the data by the size of the economy makes a difference. The results do not much change.

The way central banks respond to USD exchange rate movements may be affected by the size of holdings of FX reserves. Economies with more FX reserves in general have reason to devote more resources to their management and adopt modern portfolio optimization techniques (Streit and Muhl, 2020). To allow size to matter, we run a weighted regression, this time using FX reserves minus gold as shares of world total as the weight.

In column (3) of Table , the beta of VE is insignificant. That means, when the observations are weighted by FX reserves, full rebalancing is found to be the norm. As we expect, larger FX reserves lead to behavior more in line with private portfolio management.

To further test for possible heterogeneity across countries, we conduct several subsample analyses. First, we divide the full sample into the subsamples of AEs and EMEs.[26] Interestingly, the income level (whether AE or EME) does not matter. Columns (3) and (4) report that the estimates are quite similar between the subsamples of AEs and EMEs. The contrast to the result of the aggregate analysis above is stark. To some extent it could arise from the incompleteness of our country-level data set. In particular, this data set does not include Japan, the largest AE reserve holder.

The euro member economies may behave differently from the non-euro economies. Because

[25] For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX.

[26] Country grouping is based on the categorizations of the IMF.

they do not hold the euro as FX reserves, the euro member economies face one-less choice of major international currencies as FX reserves. Broadly, they hold mainly USD and JPY reserves with much more weight on the former.

On average, euro-member economies do not rebalance. For these economies, the impact of the exchange rate movements move the USD share 1:1. In contrast, the non-euro subsample is the familiar intermediate case. The beta estimate is significantly positive, but statistically lower than the value of one.

Does trade openness matter for reserve management? In Table 5, columns (1) and (2), the full sample is divided to the group of "more open to trade" and that of "less open to trade." We define an economy as "more open to trade" if its 1999-2020 average of trade openness (defined as (Exports+Imports)/GDP) is above the median. We find that less open economies, on average, rebalance while more open economies let exchange rates affect their USD share 1:1. More open economies experience larger volatility in their reserve holdings and tend not to put priority on stabilizing their currency composition.

Lastly, we divide the full sample between commodity exports and non-commodity exporters and examine whether there is any difference between the two subsamples. Policy-makers in commodity exporting countries have much experience in trying to stabilise their economies in the face of cycles in commodity prices. Whatever their success in that larger challenge, commodity exporters' central banks do succeed in preventing exchange rate movements from affecting their reserves' currency composition. By contrast, non-commodity exporters allow USD exchange rate movements to shift the USD shares in FX reserves.

5. Concluding remarks

How do reserve managers respond to exchange rate movements? It sounds like a simple question, but no one seems to have asked it, owing in part to the difficulty in assembling the data. By using different types of data, we explore the question of how central banks' reserve managers respond to exchange rate movements. Plainly, we focus on the question of whether central banks' reserve managers rebalance their currency shares or not. The main findings of this paper are five.

First, our two case studies are polar opposites: the currency composition of US reserves follows exchange rates while that of Swiss reserves is subject to regular rebalancing.

Second, we find partial rebalancing at the aggregate level. It appears that the evidence for rebalancing arises from the emerging market economies, which hold the bulk of global reserves.

Third, panel analysis of more than 70 economies also finds that in aggregate central banks partially rebalance. When advanced and emerging markets are separately analysed, their behavior does not differ substantially.

Fourth, when we weight the panel observations by the scale of reserves, full rebalancing is the result. From this perspective the Swiss approach is more typical of big reserve holders than the US approach. This finding is consistent with large reserve holders making reserve management more like private portfolio management.

Fifth, rapidly growing reserves are associated with a higher dollar share. We interpret this as reflecting the dollar as dominant ("vehicle") currency in the FX market: most central banks buy dollars and then diversify into their target currencies with a lag. By contrast, there is little evidence that financial market volatility affects rebalancing.

Taking these altogether, the strong suggestion is the association of reserve size and rebalancing. In the case studies, the Swiss have large reserves and rebalance; the US, modest reserves and do not rebalance. In the aggregate data, rebalancing seems more characteristic of EMEs, some of whom hold very large reserves. In the panel data, rebalancing is the norm when observations are weighted by reserve size in relation to GDP.

Thus, while our back of the envelope calculation must be qualified, there seems to be something to it. The dollar's dominance in reserve holdings and the widespread if not ubiquitous practice of stabilising its share of reserves provides a substantial bid for a depreciating dollar and an offer for an appreciating dollar. A 10% depreciation of the dollar could give rise to \$150-\$200 billion in dollar purchases. The implication for the foreign demand for US Treasury securities follows immediately.

Obviously, we need to know more about the management of this \$12.7 trillion portfolio. But this paper poses a macroeconomically important question and uses the available data to provide a first answer.

Appendix 1: Data definitions and sources

$Val\_Eff_{USD}^{COFER}$: The valuation effect of the USD, defined as:

$$\frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t-1)}}$$

where R_C is reserves, claimed in major currency *c*. FX_C is the value of major currency *c* per dollar. The reserve data are extracted from the IMF's COFER database. The exchange rate data is from the IMF *International Financial Statistics (IFS)*.

$Val\_Eff_{USD}^{SNB}$ is computed in the same way, but uses the data from SNB's database https://data.snb.ch/en/topics/snb#!/cube/snbcurrp.

$Val\_Eff_{USD}^{IM}$ is analogous to $Val\_Eff_{USD}^{SNB}$, but uses the data from Ito and McCauley (2020). Unlike the previous two valuation effects variables, this variable is not only time-variant but also variant across countries.

Total reserve assets net of the exchange rate effects are calculated using the following formula:

$$\frac{\mathrm{R}_{USD}(\mathrm{t})}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t})}{FX_c(t-1)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t-1)}}$$

VIX is the Chicago Board Options Exchange's (CBOE) Volatility Index, which is used as the measure of global financial instability. The index is available at: https://www.cboe.com/indices/ . "dVIX" is the first difference of VIX.

IR_G is the variable for FX reserves minus gold as a share of GDP. The data is extracted from the World Bank's *World Development Indicators*.

Appendix 2: Country list (73 economies including 27 AEs) for the panel analysis

Asia & Pacific (13): Australia[AE], Bangladesh[EME], Brunei, China[EME], Hong Kong, China[AE], India[EME], Korea, Rep.[AE], New Zealand[AE], Papua New Guinea, Philippines[EME], Sri Lanka, Taiwan, China[AE]

Western Europe (16): Belgium[AE], Estonia[AE], Euro Area[AE], Finland[AE], France[AE], Germany[AE], Iceland[AE], Italy[AE], Luxembourg[AE], Netherlands[AE], Norway[AE], Spain[AE], Sweden[AE], Switzerland[AE], United Kingdom[AE]

Eastern Europe and Central Asia (20): Azerbaijan, Bosnia and Herzegovina, Bulgaria[EME], Croatia, Czech Republic[AE], Georgia, Kazakhstan, Kyrgyz Republic, Latvia[AE], Lithuania[AE], Moldova, North Macedonia, Poland[EME], Romania[EME], Russian Federation[EME], Serbia, Slovenia[AE], Tajikistan, Turkey[EME], Ukraine[EME]

West Hemisphere (13): Argentina[EME], Bolivia, Brazil[EME], Canada[AE], Chile[EME], Colombia[EME], Costa Rica, Ecuador, Mexico[EME], Paraguay, Peru[EME], Uruguay, Venezuela, RB[EME]

Africa and Middle East (12): Ghana, Israel[AE], Kenya, Malawi, Mozambique, Namibia, Nigeria, South Africa[EME], Tanzania, Tunisia, Uganda, Zambia

Notes: "AE" stands for "advanced economies" whereas "EME" stands for emerging market economies. The definitions are based on the IMF categorization.

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Table 1: Regression of USD shares on valuation effects, using SNB data

	(1)	(2)	(3)	(4)	(5)
USD valuation effect (VE)	-0.147	-0.099	0.016	-0.119	-0.133
	(0.238)	(0.233)	(0.248)	(0.240)	(0.232)
Growth rate of FX assets		-0.024		-0.024	-0.029
		(0.012)**		(0.012)**	(0.012)**
VE x asset growth			-0.019		
			(0.010)*		
Change in VIX (dVIX)				0.114	
				(0.267)	
VE x dVIX					0.546
					(0.372)
N	63	63	63	63	63
Adj R2	0.42	0.45	0.44	0.44	0.46
H0: beta (VE) =1 (p-value)	0.00	0.00	0.00	0.00	0.00

Note: * p<0.1; ** p<0.05; *** p<0.01. "dVIX" is the first difference of VIX. For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX. "VE x dVIX" refers to the interaction between the USD valuation effect and dVIX.

Table 2 (a): Regression of USD shares on valuation effects, using COFER data

FULL sample, 1997Q1 to 2020Q1

	(1)	(2)	(3)	(4)	(5)
USD valuation effect (VE)	0.710 (0.062)***	0.724 (0.061)***	0.791 (0.096)***	0.725 (0.062)***	0.723 (0.061)***
Growth rate of FX assets		0.048 (0.020)**		0.048 (0.021)**	0.045 (0.021)**
VE x asset growth			-0.034 (0.030)		
Change in VIX (dVIX)				-0.001 (0.096)	
VE x dVIX					-0.122 (0.117)
N	87	87	87	87	87
Adj R2	0.60	0.62	0.60	0.62	0.62
H0: beta (VE) =1 (p-value)	0.00	0.00	0.03	0.00	0.00

Table 2 (b): Regression of USD shares on valuation effects, using COFER data

Advanced Economies sample, 1997Q1 to 2015Q1

	(1)	(2)	(3)	(4)	(5)
USD valuation effect (VE)	0.867 (0.088)***	0.865 (0.086)***	0.945 (0.133)***	0.861 (0.088)***	0.863 (0.087)***
Growth rate of FX assets		0.064 (0.032)*		0.063 (0.032)*	0.066 (0.032)**
VE x asset growth			-0.033 (0.042)		
Change in VIX (dVIX)				0.043 (0.138)	
VE x dVIX					-0.122 (0.160)
N	64	64	64	64	64
Adj R2	0.60	0.62	0.60	0.61	0.62
H0: beta (VE) =1 (p-value)	0.14	0.12	0.68	0.12	0.12

Notes: * p<0.1; ** p<0.05; *** p<0.01. For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX. "dVIX" is the first difference of VIX. "VE x dVIX" refers to the interaction between the USD valuation effect and dVIX.

Table 2 (c): Regression of USD shares on valuation effects, using COFER data, Emerging Market & Developing Economies sample, 1997Q1 to 2015Q1

	(1)	(2)	(3)	(4)	(5)
USD valuation effect (VE)	0.496 (0.124)***	0.547 (0.121)***	0.555 (0.187)***	0.585 (0.121)***	0.538 (0.120)***
Growth rate of FX assets		0.062 (0.025)**		0.057 (0.025)**	0.053 (0.026)**
VE x asset growth			-0.026 (0.061)		
Change in VIX (dVIX)				-0.354 (0.198)*	
VE x dVIX					-0.333 (0.236)
N	64	64	64	64	64
Adj R2	0.19	0.25	0.18	0.28	0.26
H0: beta (VE) =1 (p-value)	0.00	0.00	0.02	0.00	0.00

Notes: * p<0.1; ** p<0.05; *** p<0.01. "dVIX" is the first difference of VIX. For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX. "VE x dVIX" refers to the interaction between the USD valuation effect and dVIX.

Table 3: Determinants of Change in the USD Share in FX Reserves: 2001-2020, using the Ito-McCauley data

Estimation with economic-fixed effects

	(1)	(2)	(3)	(4)	(5)
USD Valuation Effect (VE)	0.404	0.594	0.524	0.614	0.622
	(0.205)**	(0.204)***	(0.211)**	(0.206)***	(0.205)***
Growth rate of FX assets		0.057	0.061	0.057	0.057
		(0.008)***	(0.009)***	(0.008)***	(0.008)***
Growth rate of FX assets x VE			0.433		
			(0.351)		
Change in VIX (dVIX)				-0.004	
				(0.005)	
dVIX x VE					-0.486
					(0.322)
N	1,070	1,051	1,051	1,051	1,051
# of countries	71	71	71	71	71
Overall R2	0.00	0.05	0.05	0.05	0.05
W/in R2	0.00	0.05	0.05	0.05	0.05
B/w R2	0.00	0.00	0.00	0.01	0.00
H0: beta (VE) =1 (p-value)	0.00	0.05	0.02	0.06	0.07

Notes: * p<0.1; ** p<0.05; *** p<0.01. "dVIX" is the first difference of VIX. For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX. "VE x dVIX" refers to the interaction between the USD valuation effect and dVIX.

Table 4: Determinants of Change in the USD Share in FX Reserves: 2001-2020

Various samples

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Fixed Effects, Full	Weighted with GDP world share, Full	Weighted with FX reserve world share, Full	Fixed Effects, Advanced Economies	Fixed Effects, EM-DEV economies	Fixed Effects, Euro member countries	Fixed Effects, Non-euro member countries
USD Valuation Effect (VE)	0.614	0.481	0.100	0.676	0.600	1.518	0.479
	(0.206)***	(0.151)***	(0.150)	(0.272)**	(0.286)**	(0.601)**	(0.220)**
Growth rate of FX assets	0.057	0.048	0.042	0.058	0.057	0.116	0.051
	(0.008)***	(0.006)***	(0.007)***	(0.012)***	(0.011)***	(0.025)***	(0.009)***
Change in VIX (dVIX)	-0.004	-0.003	-0.007	0.002	-0.007	-0.011	-0.003
	(0.005)	(0.004)	(0.004)**	(0.006)	(0.007)	(0.011)	(0.006)
N	1,051	1,037	1,037	383	666	174	877
# of countries	71	70	70	25	46	13	59
Overall R2	0.05	0.05	0.04	0.06	0.04	0.12	0.04
W/in R2	0.05	0.06	0.04	0.07	0.04	0.15	0.04
B/w R2	0.01	0.01	0.02	0.01	0.01	0.00	0.00
H0: beta (VE) =1 (p-value)	0.06	0.00	0.00	0.23	0.16	0.39	0.02

Notes: * p<0.1; ** p<0.05; *** p<0.01. The result reported in Column (1) is the same as that reported in Column (4) of Table 4. "dVIX" is the first difference of VIX. For easier comprehension, the unit of "VIX" is ten. Hence, the estimated coefficient of dVIX represents the impact of a 10-point increase in the change in VIX. The ECB as a group is removed from the sample in models 2 and 3 (the euro area economies are included). Country grouping is based on the definition by the IMF.

Table 5: Determinants of Change in the USD Share in FX Reserves: 2001-2020
Commodity Exporters vs. Non-Commodity Exporters

	More open to trade	Less open to trade	COMM. Exporters	Non-COMM Exporters
	(1)	(2)	(3)	(4)
USD Valuation Effect (VE)	1.034	0.146	0.394	0.752
	(0.311)***	(0.270)	(0.335)	(0.261)***
Growth rate of FX assets	0.061	0.064	0.053	0.063
	(0.012)***	(0.011)***	(0.011)***	(0.012)***
Change in VIX	-0.007	-0.002	-0.005	-0.003
	(0.008)	(0.006)	(0.008)	(0.006)
N	526	499	418	633
# of countries	35	34	27	44
Overall R2	0.06	0.06	0.05	0.05
W/in R2	0.06	0.06	0.05	0.05
B/w R2	0.01	0.04	0.00	0.03
H0: beta (VE) =1 (p-value)	0.91	0.00	0.07	0.34

Note: * p<0.1; ** p<0.05; *** p<0.01. An economy is defined as "more open to trade" if its 1999-2020 average of trade openness (defined as (Exports+Imports)/GDP) is above the median. "Commodity exporters" are the ones whose commodity exports account for 25% or greater of total exports. The Euro area as a group is removed from the sample, though individual euro area economies are included.

Figure 1(a): US FX reserves in euro and yen

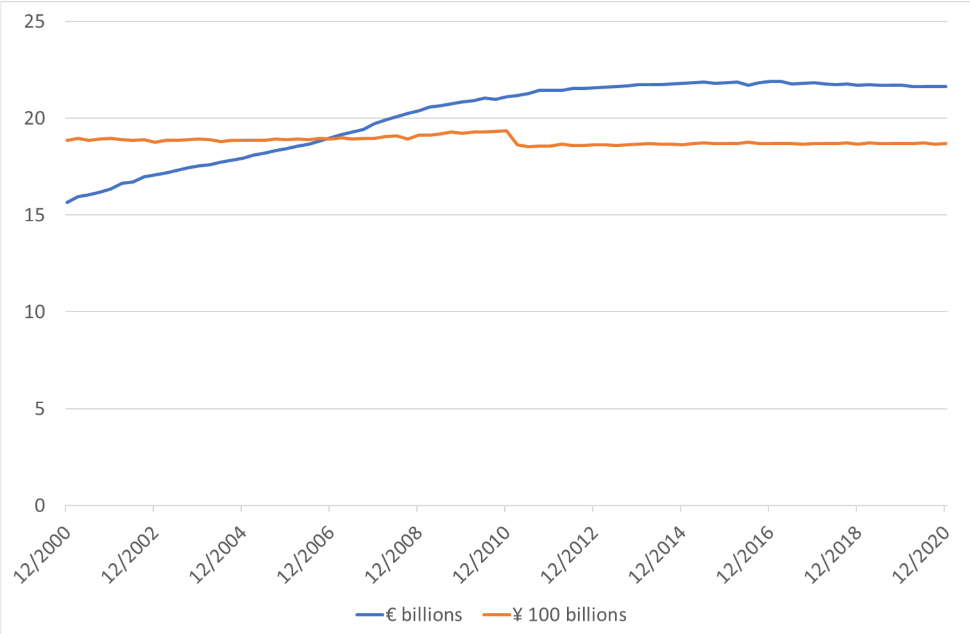


Figure 1(b): The euro share of US reserves

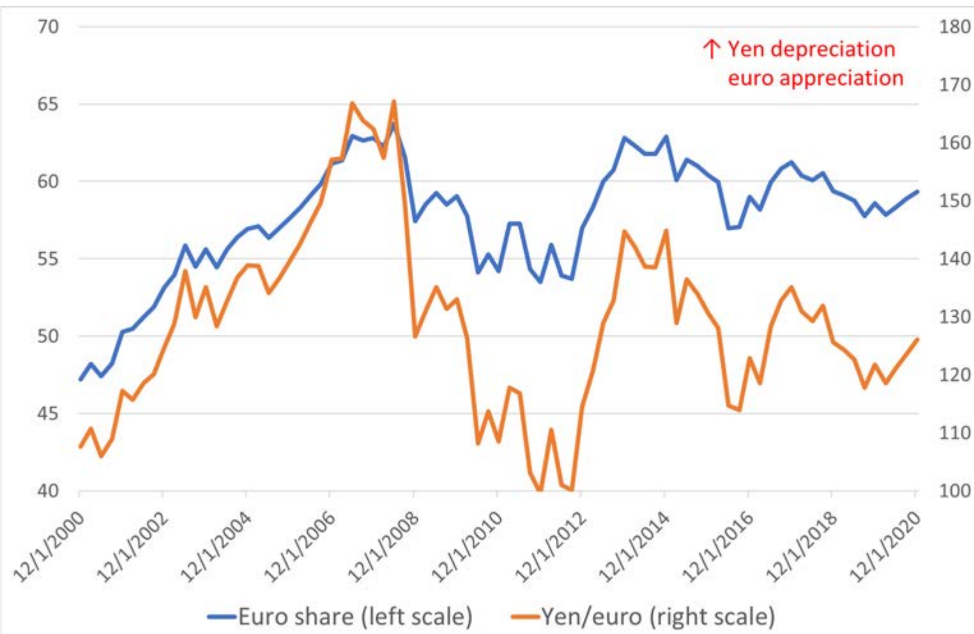


Figure 1(c): Euro share, valuation effect and rebalancing of US FX reserves, in percent

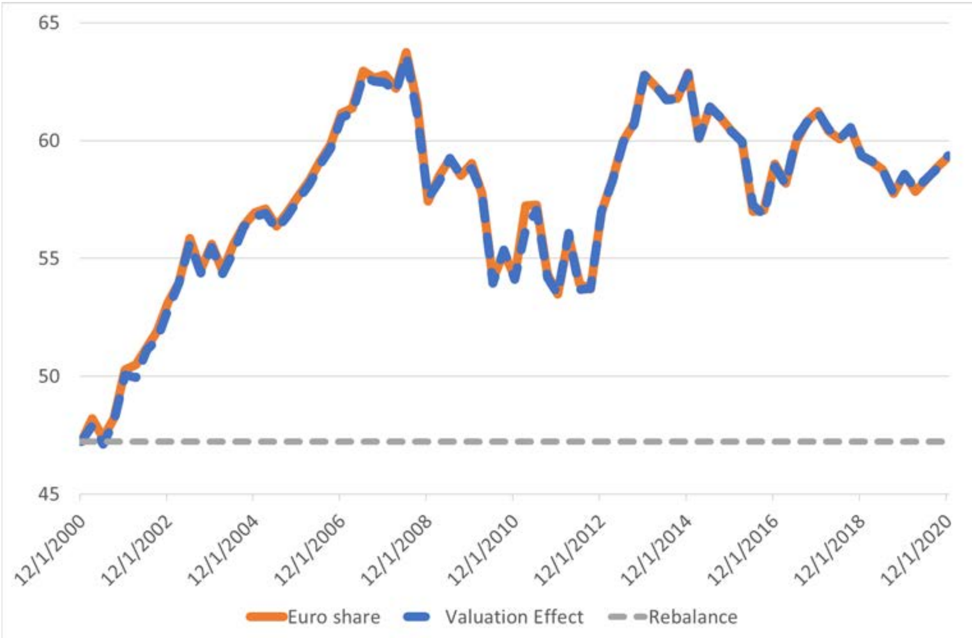
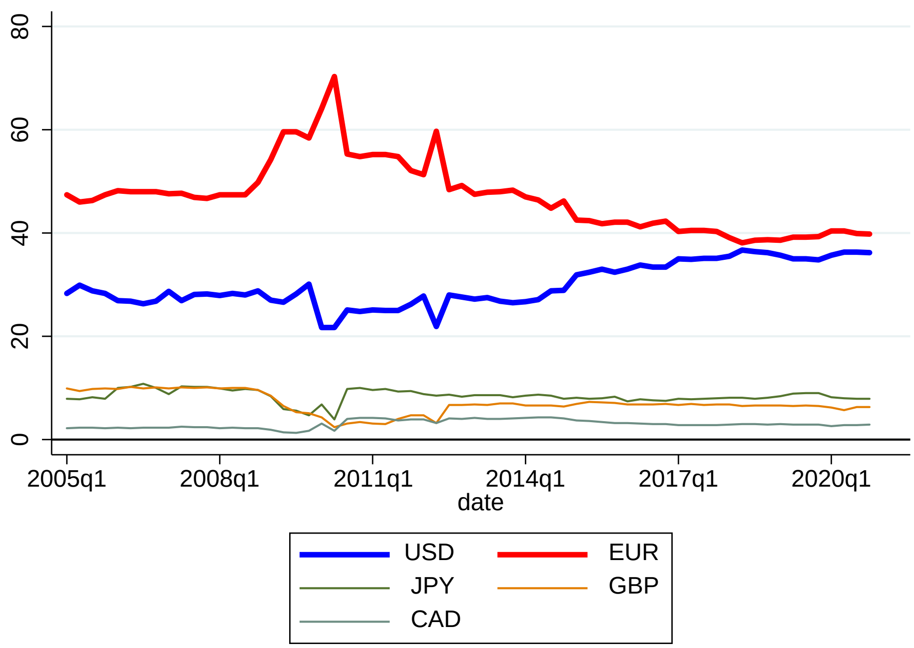
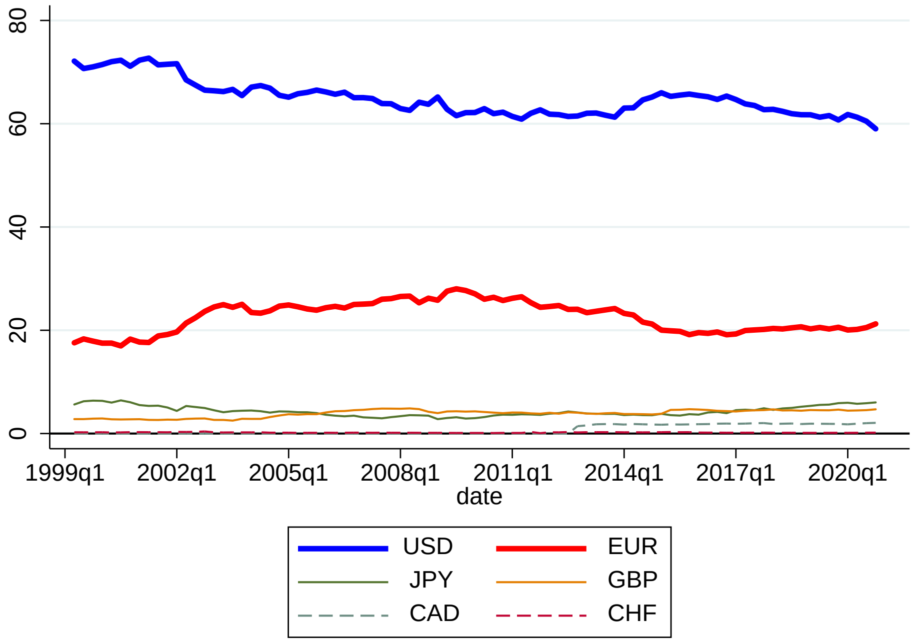


Figure 2: Currency composition of SNB's reserve assets, 2005Q1 – 2020Q4



Source: Swiss National Bank. https://data.snb.ch/en/topics/snb#!/cube/snbcurrp

Figure 3: Shares of major currencies – COFER dataset



Source: International Monetary Fund (IMF) COFER database