The impact of capital flow volatility on exchange rate volatility: from mitigating factors to the FX resilience measure[1]

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Abstract

We investigate the impact of capital flow (CF) volatility on exchange rate (FX) volatility across advanced economies and emerging market economics. We find that CF volatility has a significant impact on FX volatility after controlling for FX regimes. We further identify the economic factors that can mitigate the adverse impact of CF volatility on FX volatility, as well as the thresholds above which significant mitigating effects exist. Finally, we construct an intuitive FX resilience index based on these mitigating factors and show that countries with lower ranking in the index generally experienced greater FX volatility during the 2018 emerging market currency crisis and the 2020 Covid-19 pandemic.

Keywords: Capital flow volatility, Exchange rate volatility, cluster analysis, threshold regression models, Exchange rate resilience index

JEL classification: F21, F31, F32, F37

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1. Introduction

Cross-border capital flows have increased dramatically since 2000. For example, according to the IMF Coordinated Portfolio Investment Survey (2020)[5], cross-border portfolio investment (including equities and debts) in advanced and emerging economies increased from $11tn in 2001 to $57tn in 2019. Increased capital flows and interconnectedness between countries' financial sectors can provide substantial benefits. Meanwhile, however, the growth in cross-border capital flows was also accompanied by an increase in the volatility of capital flows (Forbes, 2012). Extreme movements in capital flows – whether in the form of sharp increases or decreases – can lead to excessive exchange rate volatility (Lane and Milesi-Ferretti, 2007; and Gabaix and Maggiori, 2015), and hence have a negative impact on economic growth and the stability of the financial sector (Obstfeld and Rogoff, 1998; Bacchetta and Wincoop, 2000; Giannellis and Papadopoulos, 2011).

In this paper, we investigate the impact of capital flow (CF) volatility on exchange rate (FX) volatility, and the economic factors that may mitigate or aggravate such impact (mitigating factors).[6] Based on these economic factors, we introduce an FX resilience index to measure a country's exchange rate resilience during times of heightened capital flow volatility. Our analysis focuses on portfolio investment flow, which is the main contributory factor to short-term FX movement, rather than other types of capital flows such as FDI or bank flows (see, for example, Froot and Ramadorai, 2005; and Hau and Rey, 2006)[7,8].

This study contains three steps: First, we conduct a cluster analysis on the impulse response of FX volatility to CF volatility shocks between countries with sound economic conditions and those with less-sound economic conditions, where economic conditions are measured by key economic factors documented in the literature. Second, we we apply Pedroni's (2013) panel structure VARs model (PSVARs, hereafter) to estimate the effects of structural CF volatility shocks on FX volatility for the two clusters. Our hypothesis is that CF volatility shocks cause a smaller increase in FX volatility for the cluster of countries with sound economic conditions. Third, we construct an FX resilience index based on the estimated elasticity of mitigating factors to FX volatility, and conduct two case studies using real market events to assess the robustness of the FX resilience index.

Our main findings are as follows: First, we find that FX volatility responds to composite CF volatility shocks in a smaller scale for countries with sound economic conditions, regardless of FX regimes.

[5] See https://data.imf.org/?sk=B981B4E3-4E58-467E-9B90-9DE0C3367363.

[6] In the rest of the paper, mitigating factors refer to economic factors that have mitigating or aggravating effects on FX volatility.

[7] Related literature includes Brooks et al. (2004), Siourounis (2004), Lane and Milesi-Ferretti (2004), Caporale et al. (2017), Rafi and Ramachandran (2018) and Cesa-Bianchi et al. (2019).

[8] In the rest of the paper, capital flow refers to portfolio investment flows (equities and debt).

Second, we identify the economic factors that can significantly mitigate the adverse impact of CF volatility on FX volatility during times of heightened CF volatility, which include trade openness, FX reserve, total foreign investment, credit to private sectors, short-term interest rate, fiscal surplus and financial development. We also identify the thresholds above which these economic factors will have significant mitigating effects. Finally, consistent with our expectations, the case studies of the 2018 emerging market currency crisis and the 2020 Covid-19 pandemic show that countries with lower ranking in the FX resilience index generally experienced greater FX volatility during these episodes.

Our paper has important contributions to the literature in the following ways. First, to our best knowledge, this is the first paper that directly quantifies the impact of CF volatility on FX volatility across the major AEs and EMEs using high frequency weekly data. Second and more importantly, we identify the economic factors that can significantly mitigate the adverse impact of CF volatility on FX volatility and relevant thresholds, as well as an FX resilience index, both of which can be used by policymakers to assess the vulnerabilities of exchange rates in the presence of volatile capital flows.

There have been limited empirical studies on the linkages between exchange rate and capital flows, in particular with a focus on developing and emerging countries. For example, Caporale el al. (2017) examine the relationship between equity and bond portfolio inflows and exchange rate volatility in a set of emerging markets in both linear and nonlinear frameworks, and find that high (low) exchange rate volatility is associated with equity (bond) inflows from the Asian countries toward the US; Ibarra (2011) and Kodongo and Ojah (2012) examine Mexico and four African countries (Egypt, Morocco, Nigeria, and South Africa) vis-à-vis the US, and Combes et al. (2012) focus on a panel of 42 emerging and developing economies. These studies find a dynamic relationship between capital flows and exchange rates, where capital flows are associated with a real exchange rate appreciation. However, none of these studies look at the impact of CF volatility on FX volatility and the relevant mitigating factors, which is the focus of our paper.

The remaining part of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the sample data and summary statistics. Sections 4 and 5 present the cluster analysis and the threshold analysis, respectively. Section 6 describes the two case studies, and Section 7 briefly concludes the findings.

2. Literature review

Our paper is related to the vast literature on the determinants of exchange rates, with an emphasis on the impact of capital flows on exchange rate movement. The very early Keynesian monetary approach

to exchange rate determination and exchange rate movements[9] focused on the elasticities of demand and supply of imports, exports and foreign currencies. In the early 1960s, Mundell (1963) and Fleming (1962) introduced capital flows into the exchange rate analysis, pointing out the important implications of capital mobility for the conduct of stabilization policy. While Mundell's framework initially adopted a fixed-price assumption, the opposite assumption of perfectly flexible prices and later the assumption of sticky prices (Dornbusch, 1976) were introduced in the 1970s, after the breakdown of the Bretton Woods system of pegged exchange rates, known as the flexible-price monetary model (FPMM). In these models, exchange rates are determined by macroeconomic fundamentals, including price level, nominal interest rate, real output, import and export (see, for example, Mundell, 1963; Meese and Rogoff, 1983; Baxter and Stockman, 1989[10]).

Meanwhile, other researchers explored exchange rate movements within a general portfolio balance model (PBM).[11] The PBM explores linkages between exchange dynamics, capital flows and asset prices, where the exchange rate is the main determinant of the current account balance: a surplus (deficit) in the current account balance is associated with a rise (fall) in net domestic holdings of foreign assets, which influences the level of wealth, and in turn the level of demand for (foreign) assets, which ultimately affects the exchange rate. For example, Gourinchas and Rey (2007) find that a country's external imbalance (net foreign assets and net export) predict the exchange rate at one quarter and beyond.[12] Several studies also find that real exchange rate is influenced by exogenous shifts in the terms of trade, trade openness, restrictions on the external payments system, fiscal policy and financial market depth and liquidity (see, for example, Athukorala and Rajapatirana, 2003; Lane and Milesi-Ferretti, 2004; Eichengreen and Gupta, 2015).

However, most of the literature described above focuses on the determinants of exchange rate levels, and relatively few studies focus on drivers of exchange rate volatility. Grossmann et al (2004) show that real GDP growth, foreign reserves, short-term nominal interest rate and domestic stock market return can explain FX volatility. More recently, the increase in cross-border capital flows, boosted by the deregulation of financial markets, is widely believed to be an important factor behind the excess volatility of some major currencies. At the time of the collapse of Lehman Brothers in September 2008, global capital flows declined sharply, before rising again in 2009 (Milesi-Ferretti and Tille, 2011). Following the Mexican peso crisis of 1994 and the Asian financial crisis of 1997-1998, capital inflows quickly turned into outflows. Guichard (2017) documents a growing literature on the global banking channel of exchange rate determination, where capital flows, generated by banks' foreign currency

[9] For example, Lerner (1936).
[10] Related literature also includes Mundell (1961, 1962); Fleming (1962); Dornbusch (1976); Flood and Rose (1995); MacDonald and Taylor (1993, 1994); Van den Berg and Jayanetti (1993); McNown and Wallace (1994).
[11] See Dornbusch and Fischer (1980), Isard (1980), Branson (1983, 1984).
[12] Related studies include Branson (1984), Hviding et al. (2004), Gourinchas and Rey (2007), Lane and Milesi-Ferretti (2010) and Hau and Rey (2006).

credit creation and institutional investors' cross border portfolio investment, are a key determinant of exchange rates.

The impact of cross-border capital flows on the volatility of exchange rates could be driven by a range of underlying factors. For example, Flood and Rose (1995) find increased volatility of exchange rates under a floating exchange rate regime. Similarly, Jeanne and Rose (2002) show that exchange rate volatility may differ between countries with a floating regime, even if their macroeconomic fundamentals are similar, possibly reflecting speculations in the foreign exchange market which are disconnected from macroeconomic fundamentals. Chen (2006) finds that higher interest rates move exchange rates to the high volatility regime.[13] Lovcha and Perez-Laborda (2013) argue that investors react differently in different states of the market. Leung and Wan (2019) find that countries with well-developed financial systems may have lower FX volatility. IMF (2021) shows that while a surprise monetary tightening of the US Federal Reserve tends to curb global investor risk appetite and trigger outflows from emerging market economies, economies with lower fiscal vulnerability are more insulated from these external financial shocks than others.

The types of capital flows could also matter. Brooks and others (2004) show that net portfolio flows between the Euro Area and the US track movements of their exchange rates well, while FDI is less significant in explain the exchange rate volatility. Caporale et al. (2017), Lane and Milesi-Ferretti (2004) both find a larger impact of equity flows, rather than bond flows, on the magnitude of exchange rate movement.[14] Other factors at play in this channel include the leverage of public and private sectors and equity market development (see, for example, Froot and Ramadorai, 2005; Gabaix and Gagggiori, 2015; Bruno and Shin, 2015 and Cesa-Bianchi et al., 2019[15]).

Foreign exchange rates, on the other hand, could also influence investors' decisions and thus cross-border capital flows. Extensive evidence shows that equity and bond portfolio flows change with the degree of uncertainty in the foreign exchange market. For example, Fidora et al. (2007) find that the exchange rate volatility is a key factor leading to bilateral portfolio home bias in a number of industrialized and emerging economies. Bacchetta and van Wincoop (2000) show, in a two-period general equilibrium model, that exchange rate uncertainty dampens net international capital flows. In addition, a flexible exchange rate regime could offer at least partial insulation from the external financial shocks (Obstfeld, Ostry, and Qureshi 2019), and also reduce the impact of these shocks on capital flows (Cerutti, Claessens, and Rose 2019).

[13] Chen (2006) uses data from Indonesia, South Korea, the Philippines, Thailand, Mexico and Turkey

[14] The former study is based on a sample of Asian countries over 1993-2015, while the latter is based on a sample of both developed and developing countries).

[15] Related literature also includes Adrian, Etula, and Shin (2009); Adrian, Etula, and Groen (2011); Borio and Zhu (2012); Aoki et al. (2015, 2018); Banerjee et al. (2015); Banerjee et all. (2015); Eichengreen and Gupta (2015); Guichard (2017); Georgiadis and Zhu (2019); Cesa-Bianchi et al. (2019).

Following the literature described above, we select a number of economic factors that can potentially mitigate the impact of CF volatility on FX volatility (mitigating factors), as listed below. These economic factors will form the basis of our analyses in the following sections.

- *Output*: real GDP growth
- *Trade*: trade openness (total import and export)
- *Foreign assets holdings*: FX reserve, total foreign investment (the sum of net FDI, net portfolio equities and net portfolio bonds)
- *Monetary policy stance*: short-term interest rate
- *Leverage*: total credit to private sectors
- *Fiscal policy*: fiscal surplus
- *Financial development*: financial development index
- *Exchange rate regime*: floating or non-floating exchange rate regimes

3. Data

3.1 Sample countries and data period

The original fund flow dataset provided by EPFR contains weekly data on equity fund flow and bond fund flow of 57 countries for the period of December 1999 to September 2020. The start date of data points and the continuity of the time series vary across the 57 countries within the original dataset. While half of the countries have equity fund flow data from 2002, most of the countries show bond fund flow data from 2011. To strike a balance between sample size and time span, we choose a sample period from January 2002 to December 2019 that consists of 27 countries with full data on equity fund flow and/or bond fund flows.

We further exclude Eurozone countries, because the fund flows data of Eurozone countries involves intra-Eurozone fund flows that is unsuitable for our research question – a substantial proportion of the capital flow volatility of Eurozone countries may be attributed to intra-Eurozone fund flows which does not influence the volatility of the Euro. The final sample consists of 20 countries for the period 2002 – 2020, including 9 Advanced Economies (AEs) and 11 Emerging Market Economies (EMEs), categorised using the MSCI ACWI Index (see Table 1 for the list of countries).[16]

Regarding each country's FX regimes, we broadly categorize them as floating and non-floating FX regimes based on the IMF Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), where the value of the FX regime index ranges from 1 (i.e. the least flexible FX regime)

[16] MSCI ACWI Index is an internationally recognized benchmark for emerging and developed markets by practitioners and researchers. As of December 2019, the index covers more than 3,000 constituents across 11 sectors and approximately 85% of the free-float-adjusted market capitalization in each market.

to 6 (i.e. floating FX regimes). Table 1 presents the categorization of the sample countries during the sample period, including whether or not the country's currency had non-floating FX regimes (i.e. FX regimes with an index value below 6) periods and when.

[Insert Table 1 here]

3.2 Economic data

The main variables in our study are capital flow (CF) volatility and foreign exchange rate (FX) volatility, where capital flow refers to equity plus bond portfolio flows. As mentioned above, we use EPFR portfolio flows (equities and bonds) to construct the measure of capital flow volatility. Following the literature, we calculate capital flow volatility as the standard deviation of portfolio flows at weekly frequency (estimated in a 4-week rolling window) and quarterly frequency (estimated in a non-overlap quarterly window), where portfolio flows are defined as the percentage change in asset under management subtracted by portfolio performance and foreign exchange rate change. [17, 18] We label this measure as Vol_CF. We calculate the volatility of nominal foreign exchange rate (against the US dollars) in the same manner, and label them as Vol_FX. Figure 1 plots the weekly VOL_CF and VOL_FX of all-country average (Panel A), individual EMEs (Panel B) and individual AEs (Panel C).

Panel A of Figure 1 shows that VOL_CF closely tracks VOL_FX at the aggregate level, where both picked up during the global finance crisis in 2008, Euro debt crisis in 2011, economic slowdown in China and Brexit in 2016 and the pandemic in 2020. The co-movement of VOL_CF and VOL_FX (could we add a correlation value here?) is consistent with finding in the literature that CF and FX levels tend to move together. For example, Brooks et al (2004) find that net portfolio flows between the Euro area and the US can closely track movements of their exchange rate. Rafi and Ramachandran (2018) have similar finding for EMEs.

For EMEs, as shown in Panel B of Figure 1, India, Russia and Czech Republic exhibit high FX volatility and CF volatility from 2002 to 2020, whereas Malaysia and Thailand have subdued FX volatility alongside despite relatively high CF volatility. For AEs, Panel C of Figure 1 shows that FX volatility

[17] We follow the methods used in Pagliari and Hanna (2017) and Broto et al (2011).
[18] We also calculate another measure of capital flow volatility - the residual of ARIMA(1,1,0) process of portfolio flows at weekly frequency and quarterly frequency (weekly average within the quarter). Since the average value and standard deviation of this measure are much smaller than those measured by standard deviation of capital flows, we adopt the latter in our analysis as more variation can effectively capture the co-movement of FX volatility and CF volatility.

surpasses CF volatility in most of the sample period for Canada, Japan, United Kingdom and Unite States, and for Australia, Sweden and Switzerland in the post-2008 crisis period.

At first glance, different observations among countries may reflect the existing FX exchange rate regime: countries with floating exchange rate regime may experience larger FX volatility. Indeed, for Hong Kong where the currency board arrangement was present, the FX volatility is substantially lower. However, exchange rate regime is not the only explanation. For example, for Singapore where a managed floating regime is adopted and for Sweden which runs a floating exchange rate regime, the volatility of FX has been broadly lower than or close to that of the capital flows. Other economic factors could have played a role in mitigating the impact of CF volatility on FX volatility. In the following sections, we will use statistical analyses to test this hypothesis and identify the economic factors that may have such mitigating effects.

[Insert Figure 1 here]

As discussed in Section 2, in addition to capital flows, there are other factors that may affect exchange rate movement, such as output, trade, foreign assets holdings, monetary policy tightening, leverage, fiscal policy, financial development and exchange rate regime. In order to control for these effects, we collect and construct these economic variables for each country. Table 2 presents the definitions and data sources of these variables, and Tables 3 and 4 present the summary statistics and correlation matrix of these variables. In Table 4, VOL_FX shows a high positive correlation with Vol_CF and short-term interest rate, and a high negative correlation with real GDP growth, trade openness, FX reserve, total foreign investment, fiscal surplus. These simple correlations are preliminary evidences that high CF volatility is associated with high FX volatility, and sound economic conditions (i.e., high levels of real output, international trade, net foreign asset holdings, financial market depth; and tight fiscal policy and monetary policy) is associated with low FX volatility. This gives an initial list of the potential FX volatility mitigating factors. Table 4 also shows that financial development is highly correlated with credit to private sector. To avoid multicollinearity in regression analysis, we keep only one of them in the regression each time.

[Insert Table 2 here]

[Insert Table 3 here]

[Insert Table 4 here]

4. Cluster analysis

In this section, we conduct a cluster analysis of potential FX volatility mitigating factors – estimating the impulse response of FX volatility to structural CF volatility shocks between two clusters of countries with sound and less-sound economic conditions. The hypothesis is that countries with sound-economic conditions have a smaller response of FX volatility to CF volatility shocks. We use weekly data and Pedroni's (2013) Panel Structure VARs model (PSVARs) to estimate the impulse response function. The analytical approach proceeds in two steps.

In step 1, we divide countries into two groups based on the soundness of their economic conditions using a K-means clustering algorithm. Specifically, we first normalize the quarterly economic factors for each country by calculating their z-scores, and then use the K-means clustering algorithm to categorize these countries into two clusters.[19] Countries in the same cluster have similar distances to the cluster centroid. In economic terms, this means that countries in the same cluster should have similar economic conditions. Then, based on the quarterly average values of the economic factors of each cluster, we identify the cluster with sound economic conditions and the cluster with less-sound economic conditions. In order to control for the influence of FX regime on FX volatility, we cluster countries with free-float and managed FX regimes separately (see Table 1 for details).

Table 5 shows the clustering of sample countries. For countries adopting a free-float FX regime (Panel A), Cluster 1 are EMEs (i.e., Brazil, Chile, India and Thailand) and Cluster 2 are mainly AEs (except Korea). For countries with managed FX regimes (Panel B), Cluster 1 are EMEs and Cluster 2 are AEs (Hong Kong and Singapore).

Table 6 shows that, for both FX regimes, countries in Cluster 2 tend to have better economic conditions than Cluster 1. For countries with a free-float FX regime (Panel A), Cluster 2 has better economic conditions than Cluster 1, except that Cluster 2 has lower levels of trade openness and FX reserve. For countries with managed FX regime (Panel B), Cluster 2 outperforms Cluster 1 in terms of all economic factors except for the real GDP growth. As expected, AEs by and large have better economic conditions than EMEs, except for real GDP growth (Panel C). Therefore, we label Cluster 2 and AEs as clusters with sound economic conditions, and Cluster 1 and EMEs as clusters with less-sound economic conditions.

[Insert Table 5 here]

[Insert Table 6 here]

[19] The Matlab codes of the K-means clustering algorithm is provided by Alex Pienkowski at the IMF, of which the kmean function in Matlab toolkit is used. The K-means clustering is a simple yet powerful centroid-based algorithm commonly used in data science. In the algorithm, each cluster is associated with a centroid. The main objective of the K-means algorithm is to minimize the sum of distances between the points and their respective cluster centroid. Points are split into different clusters based on the minimized sum of distance.

In step 2, we use PSVARs to estimate the impulse response of FX volatility to structural shocks of CF volatility for the two comparative clusters. The hypothesis is that clusters with sound economic conditions have smaller FX volatility responses to CF volatility shocks than other clusters, after controlling for the FX exchange regimes. The PSVARs estimation is at weekly frequency, where equity index return of local countries is included as a control variable.[20] The PSVARs are suitable to our data because of the cross-sectional dependencies and dynamic heterogeneities in the multi-country panels. Furthermore, this method allows us to decompose the structural shock into *common* and *idiosyncratic* components. That said, we can estimate the impulse responses of individual country variables to common international shocks that capture global events (e.g. changes in global financial cycles driven by monetary policies in core countries), as well as the responses of individual country variables to their own events (e.g. independent monetary policies) while controlling for the common global shocks.

The endogenous variables and their order in the PSVARs are described as the following,

$$\{\text{Vol\_CF, Vol\_FX, EquityReturn}\}, \quad (1)$$

where Vol_CF is the standard deviation of weekly portfolio flows (equities and bonds), Vol_FX is the standard deviation of the weekly J.P.Morgan nominal effective exchange rate index, and EquityReturn is the logarithm return of domestic equity indices. Detailed definitions of the variables can be found in Section 3. We specify a 4-lag PSVARs with short-run restrictions. The short-run restrictions are based on ordering endogenous variables in the VAR according to their speed of reaction to different shocks. Specifically, a structural shock of Vol_CF can have an immediate effect (i.e. at period=1) on Vol_CF, Vol_FX and EquityReturn; a structural shock of Vol_FX can only have an immediate effect on Vol_FX, and EquityReturn, but no immediate effect on Vol_CF; and a structural shock of EquityReturn can only have an immediate effect on EquityReturn, but no effect on Vol_CF and Vol_FX.

Figure 2 presents the impulse response of FX volatility to the structural CF volatility shocks estimated by equation (1),[21] where the composite CF volatility shock (column 1) is further decomposed into the common shocks (column 2) and idiosyncratic shocks (column 3). For countries adopting free-float FX regimes, Cluster 1 countries (with less-sound economic conditions) has relatively high and bumpy FX volatility responses to composite CF volatility shocks than Cluster 2 countries (with sound economic

[20] For weekly FX volatility, we assume that the quarterly macroeconomic factors used are less relevant. Hence, we only include weekly domestic equity index return as a control variable in the PSVARs. Grossmann et al. (2014) show that a negative shock to the stock market increases exchange rate volatility.

[21] All the three variables do not contain unit roots up to lag 5 in the Levin-Lin-Chu (2002) panel unit root tests.

conditions), especially in the first eight weeks after the shock (Figure A.1), and this is mainly ascribed to the component of common shocks (Figure A.2) rather than the component of idiosyncratic shocks (Figure A.3). This pattern is more obvious for countries with managed FX regimes (Figure B.1) and for the group of AEs and EMEs: clusters with less-sound economic conditions have higher FX volatility reaction to CF shocks relative to other clusters (Figures B.1 and C.1) over the 20-week post-shock period, except that this was mainly driven by the component of idiosyncratic shocks (Figures B.3 and C.3) rather than the component of common shocks (Figures B.2 and C.2). We discuss the results in detail below.

Figure (A.1) shows that, for countries with a free-float FX regime, Cluster 1 exhibits a sharp increase in FX volatility to the composite CF shocks in the first three weeks followed by a sharp fall in week 5, and then rises again and stays at around 0.01 in the rest of the response period. In the 20-week response period, the weekly FX volatility of Cluster 1 increases by an average of 0.01, equivalent to an FX volatility of 1.10 for Brazil based on data as of the last week of September 2020. On the contrary, the responses of FX volatility of Cluster 2 (with sound economic conditions) is relatively mild in the 20-week response period, where the weekly FX volatility increases by an average of 0.01, equivalent to an FX volatility of 0.55 for the U.K. based on data as of the last week of September 2020.

By decomposing the response to composite shocks into common shocks (i.e. global events) and idiosyncratic shocks (i.e. individual country events), Cluster 1's average weekly increase in FX volatility due to the common shocks is 0.0024, higher than Cluster 2 (0.0017); Cluster 1's average weekly increase in FX volatility due to the idiosyncratic shocks is 0.0063, lower than Cluster 2 (0.0092). Since Cluster 1 consists of EMEs and Cluster 2 consists of mainly AEs, this implies that EMEs' FX volatility is more sensitive to global events and less sensitive to individual country events relative to AEs. This is consistent with recent cases. For example, when U.S. interest rates went up and global financial conditions tightened in 2018, many emerging markets around the world experienced an outflow of foreign investment and currency devaluation, and countries with floating FX regimes were hit particularly hard (e.g., India, Argentina, Turkey, South Africa and Indonesia).

For countries with managed FX regimes, the composite CF shocks (Figure B.1) lead to increases in Cluster 1's FX volatility by a weekly average of 0.005, equivalent to an FX volatility of 0.21 for Malaysia based on data as of the last week of September 2020. The FX volatility of Cluster 2 decreases by a weekly average of 0.001, equivalent to an FX volatility of 0.19 for Singapore based on data as of the last week of September 2020. The attribution to the common shocks (Figure B.2) and idiosyncratic shocks (Figure B.3) is 0.001 and 0.005 respectively for Cluster 1, and is -0.001 and -0.001 respectively for Cluster 2.

In terms of AEs and EMEs, following the composite CF shocks (Figure C.1), EMEs' FX volatility increases by a weekly average of 0.006, while the FX volatility of AEs rises by a weekly average of

0.003. The attribution to the common shocks (Figure C.2) and idiosyncratic shocks (Figure C.3) is 0.0014 and 0.006 respectively for EMEs, and is 0.001 and 0.003 respectively for AEs.

In summary, the clustering analysis supports our hypothesis that countries with heathy economic conditions can better absorb CF volatility shocks and stabilize FX volatility than countries with less heathy economic conditions.

5. Threshold analyses

5.1. Panel data regression

In this section, we use panel data regression analysis to identify the economic factors that can mitigate the impact of CF volatility on FX volatility. We consider the economic variables used in the cluster analysis as potential mitigating factors. We further measure the thresholds above which the mitigating factors can significantly reduce FX volatility when CF volatility rises. Finally, we use the estimated thresholds to construct an FX resilience index for individual countries.

We identify the significant mitigating factors through the quarterly panel data regression:

$$Vol\_FX_{it} = \partial + \gamma_1 Vol\_CF_{it} + \gamma_2 Vol\_CF_{it} * MF_{it} + \gamma_3 MF_{it} + \gamma_4 X_{it} + \varepsilon_{it} \quad (2)$$

where MF_{it} is a vector of economic factors used in the previous Section, $Vol\_CF_{it} * MF_{it}$ is an interaction term, and X_{it} is a vector of control variable such as FX regime index, local equity return, capital flow, VIX and global commodity index return. As described in Section 3, some economic factors are highly correlated with each other, we therefore include these factors in the regression separately. We use feasible generalized least squares for the panel data regression. This estimation also adjusts for the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels.

We identify an economic variable as a significant FX volatility mitigating (aggravating) factor if γ_2 is significantly negative (positive). Our hypothesis is that, for the mitigating factor *MF* (e.g. FX reserve), $\gamma_1 > 0$ and γ_2<0, so that the total impact of CF volatility ($\gamma_1 + \gamma_2 * MF_{it}$) is more negative when CF volatility increases, keeping others constant. *Vice versa*, for the aggravating factor *MF*, $\gamma_1 > 0$ and γ_2>0, so that the total impact of CF volatility ($\gamma_1 + \gamma_2 * MF_{it}$) is more positive (e.g. credit growth) when CF volatility increases, keeping others constant.

Moreover, when γ_1 and γ_2 are estimated, a threshold of *MF* (i.e. $\widetilde{MF}$) above which the mitigating effect takes place can be computed as:

$$\frac{\partial(Vol\_FX_{it})}{\partial(Vol\_CF_{it})} = \gamma_1 + \gamma_2 MF_{it} < 0 \Leftrightarrow MF_{it} > \widetilde{MF} := -\frac{\gamma_1}{\gamma_2},\ for\ mitigating\ factors$$

$$\frac{\partial(Vol\_FX_{it})}{\partial(Vol\_CF_{it})} = \gamma_1 + \gamma_2 MF_{it} > 0 \Leftrightarrow MF_{it} < \widetilde{MF} := \frac{\gamma_1}{\gamma_2},\ for\ aggravating\ factors \quad (3)$$

Regressions (1) – (8) of Table 7 present the estimation results of equation (2). *Vol_CF* has a significantly positive impact on FX volatility in all regressions, and most of them are significant at the 1% level. Some mitigating factors are significant on a standalone basis, while other mitigating factors are only significant with the interaction term ($Vol\_CF_{it} * MF_{it}$). As demonstrated by the estimated coefficients of the interaction term $Vol\_CF_{it} * MF_{it}$, the significant mitigating factors for FX volatility include trade openness, FX reserve, total foreign investment, credit to private sectors, short-term interest rate, fiscal surplus and financial development, while real GDP growth does not show a significant mitigating effect. This finding is consistent with the cluster analysis in the previous section, where countries with sound economic conditions are more resilient to CF shocks than other countries, except countries with lower real GDP growth.

Two aspects regarding the seven significant mitigating factors are worth highlighting. First, only two factors, namely credit to private sector and short-term interest rate, are also significant without the presence of CF volatility changes (i.e. without the interaction term). While credit to private sector mitigates FX volatility during times with heightened CF volatility (i.e., the coefficient of the interaction term *Vol_CF*CreditToPrivate* is -0.001 at the 1% significance level), it aggravates FX volatility at normal times when CF volatility is stable (i.e., the coefficient of *CreditToPrivate* is 0.001 at the 10% significance level). This implies that during stress times credit growth can inject liquidity to the real economy and alleviate market stress. However, during normal times, excessive leverage leads to excessive FX volatility through the global banking channel. Meanwhile, the coefficient of short-term interest rate is positive at the 1% significance level with or without the presence of CF volatility changes, implying that tightened monetary policy can lower FX volatility, which is consistent with our intuition.

Second, trade openness (import and export) can capture the impact of both import and export on FX volatility, via the portfolio balance channel of FX determination. In the classic exchange rate modelling, trade openness automatically stabilizes volatile foreign exchange rates as imports would reduce and exports would increase when the currency depreciates, and *vice versa*. Recent studies further find that this so-called expenditure switching effect on exchange rates are mostly coming through imports within a 12-month period, because most countries' export volumes tend to have little response to exchange rates in the short run because most exports are invoiced in US dollars (see Adler et al., 2019).

The above findings show that, similar to the level of exchange rates, exchange rate volatility can also be determined through both the portfolio balance channel and the global banking channel. The mitigating factors that are related to the portfolio balance channel include trade openness, net foreign assets holdings, fiscal policy and financial development, and those that are related to the global banking channel include leverage of private sectors, fiscal policy, monetary policy and floating FX regime (i.e. the coefficient of FX_regime is positive at the 1% significance level across the eight regressions in Table 7).

The estimates in equation (2) can also be used to derive the thresholds above which significant mitigating effects exist using equation (3). The lower part of Table 7 presents the results. The point estimates show that, when a country experiences heightened CF volatility, its FX volatility can be effectively reduced if the country's trade openness is above 25.6% of GDP, FX reserve is above 1.6% of GDP, total foreign investment is above 4.6% of GDP, credit to private sector is above 144.3% of GDP, short-term interest rate is below 5.1%, fiscal surplus is above 0.3% of GDP and financial development index is above 0.7 (as a reference, the financial development index for the U.S. is 0.9). The point estimates of the thresholds are close to the mean of the economic factors (see Table 3).

To take into account estimation errors, we also calculate the 90% confidence interval of the threshold estimates and adopt the lower bound of the 90% confidence interval as a minimum threshold requirement. The bottom line of Table 7 shows that the minimum thresholds of the mitigating factors are 8% for trade openness, 0.2% for FX reserve, 1.6% for total foreign investment, 38.5% for credit to private sector, 1.6% for short-term interest rate, 0% for fiscal surplus and 0.2 for financial development index.

[Insert Table 7 here]

5.2. FX resilience index

The estimated coefficients of the interaction term $CF\_SD_{it} * MF_{it}$ further allow us to construct an FX resilience index, which measures countries' ability to mitigate the impact of CF volatility on FX volatility. In equation (4), we calculate the index for country *i* using the panel estimated coefficients of the interaction terms of the seven significant mitigating factors and the quarterly averages of the mitigating factors of individual country through the sample period (i.e., 2002Q1 – 2019Q4).

$$FX\_Resillience_i = \sum_{m=1}^{m} \widehat{\gamma_2}\, MF_i \quad (4)$$

where MF_i is the significant mitigating factors identified in Eq.(2), calculated as the quarterly average over the period in interest for country i, and m is the total number of the significant MFs. Obviously, more negative values of $FX\_Resillence_i$ would indicate stronger FX resilience.

Table 8 presents the resilience index of individual countries ranked from the lowest (the most resilient) to the highest (the least resilient). A negative index value indicates a country's capacity to reduce FX volatility through the mitigating factors: a more negative value reflects a stronger capacity to mitigate impact of CF volatility on FX volatility. Panel A.1 shows the index ranking for countries with free-float FX regime, where Thailand, Chile, Brazil and India (i.e. the cluster with less-sound economic conditions) have lower rankings. Panel A.2 shows the index ranking for countries with managed FX regime, where Hong Kong and Singapore (i.e. the cluster with sound economic conditions) are on the top of the index ranking. This is consistent with the cluster analysis in the previous section, which showed that countries with sound economic conditions have smaller FX volatility response to CF shocks and hence stronger FX resilience. Panels B.1 and B.2 show the resilience index for EMEs and AEs respectively. In general, the ranking is consistent with our expectation.

[Insert Table 8 here]

Figure 3 illustrates the individual component of the FX resilience index (i.e., the contributions of the seven mitigating factors to the index) for each country. Visually, credit to private sector, financial development and fiscal surplus are the three largest contributors to the resilience index across the 20 sample countries. This implies that countries with an aim to improve FX resilience may focus on these measures, including expanding lending to private sector in the short term, and lowering fiscal deficit and improving financial market depth and efficiency in the longer term.

[Insert Figure 3 here]

6. Case studies

In this section, we apply the thresholds of the mitigating factors and FX resilience index in two market events – the emerging market currency crisis in 2018 and the 2020 Covid-19 pandemic – when global financial markets experienced large capital outflows. We find that our results based on the mitigating factors and FX resilience index are consistent with the outcomes of the two market events.

6.1 Case study: the 2018 emerging market currency crisis

In 2018, amid tightening US monetary policy and rising crude oil price, many emerging markets around the world experienced plummeting currencies and capital outflows, e.g. in India, Brazil, Argentina, Turkey, South Africa, and Indonesia. For example, the Indian rupee witnessed high volatility, falling by nearly 14% between April to October in 2018, and the Brazilian real depreciated by nearly 20% from January to September in 2018. Meanwhile, some countries (including AEs) weathered the storm well and maintained relatively stable exchange rates (e.g., Korean, Malaysia, Hong Kong and Switzerland). As described below, such differences in FX volatility can be largely explained by the FX resilience index.

We first calculate the percentage change in FX volatility per unit of CF volatility between 2017 and 2018 for each sample country, and rank them from the lowest to the highest.[22] Then we calculate each country's average quarterly mitigating factors in 2018, and report the number of the mitigating factors that have attained the point estimate thresholds – we label them as supporting factors. Table 9 presents the results for individual countries ranked by change in FX volatility per unit of CF volatility (from low to high). Panel A of Table 9 shows that countries had smaller (more negative) FX volatility change (per unit of CF volatility) in 2018, in general, had higher number of supporting factors. In particular, India, Brazil and Morocco that suffered from heightened FX volatility failed to meet all the point estimate thresholds. Furthermore, the chart in Panel C of Table 9 illustrates the correlation between the number of supporting factors and the FX volatility change, which shows an inverse relationship between the number of supporting factors achieved by a country and its FX resilience.

As a robustness check, we also calculated the number of mitigating factors exceeding the minimum thresholds as well as the point estimate thresholds for sample countries, and compared their rankings with the actual change in FX volatility. The results remain largely similar.

[Insert Table 9 here]

6.2 Case study: the 2020 Covid-19 pandemic

The 2020 Covid-19 pandemic caused large disruptions to the world economy. The Bank of England Financial Stability Paper (Martin et al. 2020) indicates that "The spread of the Covid-19 virus was associated with a sharp deterioration in near-term growth prospects and an increase in economic

[22] We exclude Egypt from this case study due to the FX regime change in Egypt in 2018.

uncertainty. The resulting pressures on capital flows were amplified by a marked tightening in financial conditions, including strains in US dollar funding markets. The growing importance of more volatile flows from non-bank financial intermediaries, and in particular investment funds, was a further contributory factor to the scale of the outflows seen… The pressure on EME capital flows started to ease in May, but only after unprecedented policy interventions...Without these actions, the sudden stop in capital flows faced by EMEs would have been even more severe."

We calculate the FX resilience index for each of the 20 sample countries based on quarterly averages of mitigating factors in 2019 (i.e., the most recent data in our sample), and then compute the percentage change of FX volatility per unit of CF volatility between 2020 and 2015-2019 average. We rank the countries by the FX risilience index as well as changes in FX volatility from the lowest (i.e. the most negative/resilient) to the highest (i.e. the least negative/resilient). Table 10 presents the results. Panel A of Table 10 shows that, for EMEs, the ranking of the FX resilience index is by and large consistent with the ranking of change in FX volatility, except Czech Republic and India (shaded in grey). Similarly, Panel C of Table 10 shows that, for AEs, both rankings are also by and large in line with each other, except Canada and United Kingdom (shaded in grey). Overall, the FX resilience index appears to be a relatively reliable measure of a country's FX resilience to capital flow shocks.

[Insert Table 10 here]

7. Conclusion

The rapid growth of cross-border capital flows has been an important feature in the global economic landscape since 1990s. Foreign capital flows can support growth through greater allocative efficiency, better risk sharing and increased technology transfer, however, the volatility of the flows and the resulting heightened exchange rate volatilities can undermine the desired growth (Carney, 2019).

We find that capital flow volatility is positively related to exchange rate volatility. We identify the economic factors that can mitigate the adverse impact of CF volatility on FX volatility, and the thresholds above which significant mitigating effects exist. These factors include trade openness, FX reserve, total foreign investment (excluding FX reserve), credit to private sector, short-term interest rate, fiscal surplus and financial development. These factors have been documented in the literature of determinants of exchange rate levels, particularly how trade (i.e. current account), net foreign assets (i.e. capital account) and credit markets jointly influence exchange rates through the portfolio balance channel and the global banking channel.

We further construct an FX resilience index for individual countries using the estimated mitigating factors. Results from case studies show that the FX resilience index is a relatively reliable indicator of a country's FX resilience during times of heightened CF volatility. This may provide a useful tool for policymakers to assess and improve the resilience of their exchange rates to capital flow shocks. In particular, one imminent challenge amid the ongoing Covid-19 pandemic is how each country should prepare themselves for a sudden monetary tightening of the advanced economies (e.g. the US), given the prospect of a global multi-speed recovery (IMF, 2021) and a potential higher-than-expected inflation resulting from the substantial fiscal stimulus and the speedy distribution of vaccines.

Our paper can serve as a springboard for future studies. One possible extension is to include Eurozone countries if the relevant data on fund flows excluding intra-Eurozone flows can be obtained. Other extensions could be to better understand and analyse the channels through which capital flow volatility has an impact on other economic variables. Apart from mitigating capital flow risks, another key challenge for policymakers is preserving the key benefits that capital flows have to offer. Our methodology and results can help explore ways to balance these objectives.

References

Athukorala, P. and Rajapatirana, S. (2003). "Capital inflows and the real exchange Rate: A comparative study of Asia and Latin America," *The World Economy* 26: 613-637.

Bacchetta, P. and Wincoop, E.V. (2000). "Does exchange-rate stability increase trade and welfare?" *The American Economic Review* 90: 1093-1109.

Bacchetta, P. and Wincoop, E.V. (2000). "Trade in nominal assets and net international capital flows." *Journal of International Money Finance* 19, 55–72.

Branson, W.H. (1983). "A model of exchange-rate determination with policy reaction: evidence from monthly data." *NBER Working Paper* no. 1189, issued in August 1983.

Branson, W.H. (1984). "Exchange rate policy after a decade of 'floating'." *NBER Chapters*, in: Exchange rate theory and practice, pages 790118.

Brooks, R., Edison, H., Kumar, M.S. and Sløk, T. (2004). "Exchange Rates and Capital Flows," *European Financial Management* 10: 511-533.

Brooks, R., Edison, H., Kumar, M.S., Slok, T. (2004). "Exchange rates and capital flows." *European Financial Management* 10, 511–533.

Broto, C., Diaz-Cassou, J. and Erce, A. (2011). “Measuring and explaining the volatility of capital flows to emerging countries,” *Journal of Banking & Finance* 35: 1941–1953.

Caporale, G.M., Ali, F. M., Spagnolo, F., and Spagnolo, N. (2017). “International portfolio flows and exchange rate volatility in emerging Asian markets.” *Journal of International Money and Finance* 76 (2017) 1-15

Carney, M. (2019). “Pull, push, pipes: sustainable capital flows for a new world order,” *Speech* in the Institute of International Finance Spring Membership Meeting, Tokyo.

Cerutti, Eugenio, Stijn Claessens, and Andrew K. Rose. (2019). “How Important Is the Global Financial Cycle? Evidence from Capital Flows.” *IMF Economic Review 67: 24-60.*

Cesa-Bianchi, A., Kumhof, M., Sokol, A. and Thwaites, G. (2019). “Towards a new monetary theory of exchange rate determination,” *Bank of England Staff Working Paper* No. 817.

Chen, S.S. (2006). “Revisiting the interest rate–exchange rate nexus: a Markov-switching approach.” *Journal of Development Economics* 79, 208–224.

Combes, J-L., Kinda, T., and Plane, P. (2012). “Capital flows, exchange rate flexibility, and the real exchange rate.” *Journal of Macroeconomics* 34, 1034–1043.

Dornbusch, R. (1976). “Expectations and Exchange Rate Dynamics.” *Journal of Political Economy*, Vol. 84, No. 6, pp. 1161–1176.

Eichengreen, P. and Gupta, R. (2015). “Tapering talk: The impact of expectations of reduced Federal Reserve security purchases on emerging markets,” *Emerging Markets Review* 25: 1-15.

Filardo, A.J. (1994). “Business-cycle phases and their transitional dynamics.” *Journal of Business Economics and Statistics* 12 (3), 299–308.

Fleming, J. M. (1962). “Domestic financial policies under fixed and floating exchange rates.” *IMF Staff Papers* vol. 9, pp. 369–379.

Flood, Robert P. & Rose, Andrew K. (1995). "Fixing exchange rates A virtual quest for fundamentals," *Journal of Monetary Economics*, Elsevier, vol. 36(1), pages 3-37, August.

Forbes, K.J. (2012). “Capital flow volatility and contagion: a focus on Asia,” *MIT Sloan School Working Paper* No. 4979-12.

Gabaix, X. and Maggiori, M. (2015). “International liquidity and exchange rate dynamics,” *The Quarterly Journal of Economics* 130:1369-1420.

Giannellis, N. and Papadopoulos, A.P. (2011). “What causes exchange rate volatility? Evidence from selected EMU members and candidates for EMU membership countries,” *Journal of International Money and Finance* 30, 39-61.

Gopinath, G., (2015). “The International Price System”, *Jackson Hole Symposium,* Vol. 27, Federal Reserve Bank of Kansas City.

Gourinchas, P. and Rey, H. (2007). "International Financial Adjustment" *Journal of Political Economy* 115, 4 August 2007: 665-703.

Grossmann, A., Love, I. and Orlov, A.G. (2014). “The dynamics of exchange rate volatility: A panel VAR approach,” *Journal of International Financial Markets, Institutions & Money* 33: 1-27.

Guichard, S. (2017). “Findings of the recent literature on international capital flows,” *OECD Economics Department Working Paper* No. 1410.

Han, X. and Wei, S. (2016). “International transmission of monetary shocks: Between a trilemma and a dilemma,” *NBER Working Paper* No. 22812.

Hau and Rey (2006). ‘Exchange rates, equity prices, and capital flows’, *The Review of Financial Studies*19, 273-317.

*Hviding, K., Nowak, M. and Ricci, L.A. (2004). “*Can higher reserves help reduce exchange rate volatility?” *IMF Working Paper* No. WP/04/189.

Ibarra, C.A. (2011). “Capital flows and real exchange rate appreciation in Mexico,” *World Development* 39, 2080–2090.

International Monetary Fund (2021). “Managing Divergent Recovery”, *World Economic Outlook* Chapter 4, April 2021.

Isard, P. (1980). “Factors determining exchange rates: the roles of relative price levels, balances of payments, interest rates and risk,” *International Finance Discussion Papers* 171, Board of Governors of the Federal Research System (U.S.), revised 1980.

Kodongo, O. and Ojah, K. (2012). “The dynamic relation between foreign exchange rates and international portfolio flows: evidence from Africa’s capital markets.” *International Review of Economics and Finance* 24, 71–87.

Lane, P.R. and Milesi-Ferretti, G.M. (2004). “The transfer problem revisited: Net foreign assets and real exchange rates,” *The Review of Economics and Statistics* 86: 841-857.

Lane, P.R. and Milesi-Ferretti, G.M. (2007). “The external wealth of nations mask II: Revised and extended estimates of foreign assets and liabilities, 1997-2002,” *Journal of International Economics* 73: 223-250.

Lerner, A.P. (1936). ‘The symmetry between import and export taxes”. *Economica*, 1936, 3(11), 306-313.

Lovcha, Y. andPerez-Laborda, A. (2013). “Is exchange rate-customer order flow relationship linear? evidence from the Hungarian FX market.” *Journal of International Monetary Finance* 35, 20–35.

Martin, F.E., Joy, M., Maurini, C., Moro, A., Landi, V.N., Schiavone, A., and van Hombeeck, C. (2020). “Capital flows during the pandemic: lessons for a more resilient international financial architecture”, *Bank of England Financial Stability Paper* No. 45

Meese, R.A. and Rogoff, K. (1983). “Empirical exchange rate models of the seventies: Do they fit out of sample?” *Journal of International Economics* 14: 3-24.

Milesi-Ferretti, G-M. and Tille, C. (2011). “The great retrenchment: international capital flows during the global financial crisis.” *Economic Policy* 26, 289–346.

Montiel and Pedroni (2018), “Trilemma-Dilemma: Constraint or Choice? Some Empirical Evidence from a Structurally Identified Heterogeneous Panel VAR,” *Open Economies Review* 30:1–18.

Mundell, R. (1963). “Capital mobility and stabilization policy under fixed and flexible exchange rates,” *Canadian Journal of Economics and Political Science*, Vol. 29, pp. 475–85.

Obstfeld, M. and Rogoff, K. (1998). “Risk and exchange rate,” *NBER Working Paper* No.6694.

Obstfeld, M., Jonathan D. Ostry, and Mahvash S. Qureshi (2019). “A Tie That Binds: Revisiting the Trilemma in Emerging Market Economies.” *The Review of Economics and Statistics, MIT Press* 101 (2): 279-93.

Olivier Jeanne & Andrew K. Rose, 2002. "Noise Trading And Exchange Rate Regimes," *the Quarterly Journal of Economics*, MIT Press, vol. 117(2), pages 537-569, May

Pagliari, M.S. and Hannan, S.A. (2017). “The Volatility of Capital Flows in Emerging Markets: Measures and Determinants,” *IMF Working Paper* No. WP/17/41.

Pedroni, P. (1999). “Critical values for cointegration tests in heterogeneous panels with multiple regressors,” *Oxford Bulletin of Economics and Statistics* 61: 653-670.

Pedroni, P. (2001). “Purchasing power parity tests in cointegrated panels,” *Review of Economics and Statistics* 83: 727-731.

Pedroni, P. (2013). “Structural panel VARs,” *Econometrics* 1: 180-206.

Rey, H. (2016). “International Channels of Transmission of Monetary Policy and the Mundellian Trilemma,” *NBER Working Paper* No. 21852.

Shambaugh, J.C. (2004). “The Effect of Fixed Exchange Rates on Monetary Policy**,”** *The Quarterly Journal of Economics* 119:301-352.

Tables and Figures

Table 1. Breakdown of AEs and EMEs

This table shows the sample countries in our analysis, including nine advanced economies (AEs) and eleven emerging market economies (EMEs). Non-floating FX period is the year that the country implemented non-floating FX regime, of which the non-floating FX regime is classified as a value below 6 in the IMF Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER),

AEs			EMEs		
Country	Has non-floating FX periods? (Yes/No)	Non-floating FX periods	Country	Has non-floating FX periods? (Yes/No)	Non-floating FX periods
Australia	No		Brazil	No	
Canada	No		Egypt	Yes	2002-2019 excl. 2016
Japan	No		India	No	
Sweden	No		Morocco	Yes	2002-2019
United Kingdom	No		Russia	Yes	2002-2013
United States	No		Chile	No	
Hong Kong	Yes	2002-2019	China	Yes	2002-2019
Singapore	Yes	2002-2019	Czech Republic	Yes	2002-2006; 2013-2016
Switzerland	No		Korea	No	
			Malaysia	Yes	2002-2007; 2009-2015
			Thailand	No	

Table 2. Variables: definitions and data sources

Variables	Variables Symbols	Definitions and measures	Unit	Used of data	Original data frequency	Data sources
FX volatility	Vol_FX	FX_SD is the S.D. of nominal effective exchange rate at weekly frequency (estimated in a 4-week rolling window) and quarterly frequency (estimated in a non-overlap quarterly window).	Index	J.P.Morgan nominal effective exchange rate index. The index measures a currency's nominal exchange rate relative to a basket of other currencies using an trade-weighted calculation.	Daily	Bloomberg and author calculation
Capital flow	CapitalFlow	Funds flow (equities and bonds) is the % change of asset under management subtracted by portforlio performance and foreign exchange rate change.	%	Equity Funds, ETFs & Mutual Funds: Portfolio Change (%); Equity Funds,ETFs & Mutual Funds: Ending Assets (EOP,Mil.US$); Bond Funds: ETFs & Mut Funds: Port Change(AVG, %) and Bond Funds: ETFs/Mut Funds: End Assets(EOP, Mil.US$). Weekly	Weekly	EPFR and author calculation
Captital flow volatility	Vol_CF	CF_SD is the S.D. of funds flow (equity and bond) at weekly frequency (estimated in a 4-week rolling window) and quarterly frequency (estimated in a non-overlap quarterly window).	%	The same as above.	Weekly	EPFR and author calculation
Real GDP growth	RealGDP_Growth	Real GDP growth rate calcuated as quarterly % change.	%	Gross Domestic Product Based On Purchasing Power Parity, Standardized, Constant Prices, Seasonally Adjusted	Quarterly	Datastream and author calculation
GDP	GDP	Annual GDP	Millions, USD	GDP, PPP (current international $)	Annually	World Bank - WDI
Net export	NetExport	Net export of goods and services	% of annual GDP	Current Account, Goods and Services, Net, Millions USD	Quarterly	IFS and authors' calculatio
Trade openness	TradeOpenness	Total export and import divided by annual GDP	% of annual GDP	Export and Import, Current Account, Goods and Services, Credit, US Dollars	Quarterly	calculation
FX reserve	FXReserve	FX reserve	% of annual GDP	Supplementary Items, Reserves and Related items, US Dollars	Quarterly	IMF - IFS and author calculation
Net FDI	NetFDI	Net FDI	% of annual GDP	Financial Account, Net Lending (+) / Net Borrowing (-) (Balance from Financial Account), Direct Investment, Net Acquisition of Financial Assets, US Dollars	Quarterly	IMF - IFS and author calculation
Net portfolio equity	NetEquity	Net equities	% of annual GDP	Financial Account, Portfolio Investment, Net Acquisition of Financial Assets, Equity and Investment Fund Shares, US Dollars	Quarterly	IMF - IFS and author calculation
Net portfolio bond	NetBond	Net bonds	% of annual GDP	Financial Account, Portfolio Investment, Net Acquisition of Financial Assets, Debt Securities, US Dollars	Quarterly	IMF - IFS and author calculation
Total foreign investment	TFI	The summary of net FDI, net equtities and net bonds	% of annual GDP	See the definitions of Net FDI, Net portfolio equityes and Net portfolio bonds as described above.	Quarterly	IMF - IFS and author calculation
Credit to private	CreditPrivate	Total credit to private sector	% of annual GDP	Total credit to the private non-financial sector (core debt)	Quarterly	BIS
Fiscial surplus	FiscialSurplus	Net government borrowing, lending(-)/borrowing(+).	% of annual GDP	General government net lending/borrowing, percent of fiscal year GDP (Percent of annual GDP for quarterly data)	Quarterly	IMF
Short-term interest rate	ShortRate	3-month money market rate or Tbill rate	%	Australia, Singapore and U.S. use 3-month money market rate (code I60B.. in Datastream, has over 95% corelation with 3-month Tbill rate). The rest of the sample counties use 3-month Tbill rate from Bloomberg.	Quarterly	Datastream and Bloomberg
Finanical development ind	FinancialDevelopment	Finanical development index developed by IMF. See https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B	Index	A measure of the development of finanical markets and institutions of a country in terms of their depth (size and liquidity), access (ability of individuals and companies to access finanical services) and efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets)	Annually	IMF
FX regime	FX_Regime	IMF classification of FX regimes from No separate legal tender (1) to Free floating (6).	Index (1 -6)	The IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER)	Annually	IMF
Equity market index returr	EquityReturn	The logrithm return of domestic equity index	%	MSCI index	Daily	Datastream
U.S. eqtity volatility inde	VIX	CBOE VIX index	Index	CBOE VIX index	Daily	WRDS CRSP
Global commodity return	CommodityReturn	The logrithm return of Bloomberg Commodity Index	Index	Bloomberg Commodity Index (BCOM) is calculated on an excess return basis and reflects commodity futures price movements. The index rebalances annually weighted 2/3 by trading volume and 1/3 by world production and weight-caps are applied at the commodity, sector and group level for diversification.	Daily	Bloomberg

Table 3. Variables: summary statistics

	Obs	Mean	Std. Dev.	Min	Max
2002 - 2019: weekly					
Vol_FX (Index)	19580	0.56	0.50	0.04	17.28
Vol_CF (%)	19580	0.86	1.63	0.00	37.30
2002Q1 - 2019Q4					
Vol_FX (Index)	1440	1.13	0.98	0.08	17.86
Vol_CF (%)	1440	1.10	1.60	0.00	20.38
CapitalFlow (%)	1440	0.09	0.84	-4.57	8.03
RealGDP_Growth (%)	1440	0.91	1.51	-9.01	19.21
TradeOpenness (% of annual GDP)	1440	20.01	20.03	3.52	100.88
FXReserve (% of annual GDP)	1440	0.53	1.67	-7.52	20.42
TFI (% of annual GDP)	1440	1.72	3.20	-7.29	28.83
CreditPrivate (% of annual GDP)	1440	132.93	60.97	23.00	392.40
ShortRate (%)	1440	3.39	3.83	-0.84	26.24
FiscalSurplus (% of annual GDP)	1440	-0.52	1.05	-3.62	1.99
FinancialDevelopment (Index)	1440	0.66	0.20	0.27	1
FX_Regime (Index)	1440	4.95	1.40	2	6
EquityReturn (%)	1440	1.62	12.14	-72.02	46.58
VIX (Index)	1440	18.90	7.97	10.30	58.32
CommodityReturn (%)	1440	-0.13	9.16	-35.84	15.35

Table 4. Variables: correlation matrix

2002Q1 - 2019Q4	Vol_FX	Vol_CF	CapitalFlow	RealGDP_Growth	TradeOpenness	FXReserve	TFI	CreditPrivate	ShortRate	FiscalSurplus	FinancialDevelopment	FX_Regime	EquityReturn	VIX
Vol_CF	0.14													
CapitalFlow	0.12	0.29												
RealGDP_Growth	-0.16	0.04	0.11											
TradeOpenness	-0.24	0.07	0.01	0.08										
FXReserve	-0.08	0.02	0.08	0.15	0.26									
TFI	-0.14	0.02	0.06	0.02	0.60	0.15								
CreditPrivate	-0.05	-0.15	-0.02	-0.13	0.27	0.04	0.38							
ShortRate	0.23	0.26	0.04	0.01	-0.31	-0.13	-0.21	-0.61						
FiscalSurplus	-0.13	0.06	0.02	0.03	0.48	0.19	0.34	0.30	-0.29					
FinancialDevelopment	0.03	-0.19	-0.01	-0.17	0.10	0.02	0.23	**0.80**	-0.50	0.23				
FX_Regime	0.21	-0.12	-0.01	-0.17	-0.50	-0.13	-0.30	0.15	-0.03	-0.14	0.42			
EquityReturn	-0.24	-0.03	0.22	0.21	-0.01	0.10	0.07	-0.06	-0.01	-0.01	-0.04	0.00		
VIX	0.25	0.04	-0.08	-0.16	-0.01	-0.04	-0.05	-0.05	0.02	-0.10	-0.01	0.00	-0.31	
CommodityReturn	-0.18	0.00	0.14	0.18	-0.01	0.09	0.06	-0.04	-0.02	0.00	-0.03	0.00	0.51	-0.27

Table 5. K-means clusters

This table show the result of categorisation of countries using the K-means clustering algorithm. Panel A presents the two clusters for countries adopting free float FX regime. Panel B presents the two clusters for countries adopting managed FX regime, i.e. non-free-float FX regime. The annual FX regime is defined from the least flexible FX regime (i.e. No separate legal tender) with IMF FX regime index value of 1 to the most flexible FX regime (i.e. Free floating) with IMF regime index value of 6. In the current analysis, a country is defined as adopting free float FX regime if the average IMF FX regime index value equals 6 over the sample period, and defined as adopting managed FX regime otherwise.

Panel A. Free float FX regime		*Panel B. Managed FX regime*	
Country	K-means Cluster (1,2)	Country	K-means Cluster (1,2)
Brazil	1	Czech Republic	1
Chile	1	Egypt	1
India	1	Malaysia	1
Thailand	1	Morocco	1
Australia	2	Russia	1
Canada	2	China	1
Japan	2	Hong Kong	2
Korea	2	Singapore	2
Sweden	2		
Switzerland	2		
United Kingdom	2		
United States	2		

Table 6. The mean value of the economic factors of the K-means clusters, and EMEs vs AEs.

This table presents the average quarterly value of the economic factors across countries within the clusters. Sound economic conditions refer to countries with a high value of real GDP growth, trade openness, FX reserve, total financial investment (FDI, foreign portfolio equities and debts), credit to private sectors, fiscal surplus, financial development (financial markets and institutions), as well a low short-term interest rate. Less-sound economic conditions refer to countries with less well-performed economic factors relative to those with sound economic conditions. All variables are defined in Table 2.

Variables, panel mean, 2002Q1-2019Q4	RealGDP_Growth	TradeOpenness	FX_Reserve	TFI	CreditPrivate	ShortRate	FiscalSurplus	FinanicalDevelopment	FX_Regime
High/Low as to sound economic conditions	High	High	High	High	High	Low	High	High	-
Panel A. Countries with free float FX regime									
Cluster 1 (Less-sound economic conditions)	1.04	13.16	0.45	0.76	84.50	6.13	-0.74	0.53	6
Cluster 2 (Sound economic conditions)	**0.53**	**12.00**	**0.30**	1.58	179.74	1.68	-0.54	0.86	6
Panel B. Countries with managed FX regime									
Cluster 1 (Less-sound economic conditions)	1.27	17.38	0.56	0.62	87.58	4.65	-0.78	0.46	3.5
Cluster 2 (Sound economic conditions)	**1.08**	73.67	1.52	7.45	178.56	0.95	0.73	0.74	3
Panel C. EMEs vs. AEs									
Emerging Market Economies (EMEs)	1.15	15.82	0.51	0.70	93.55	5.03	-0.67	0.52	4.6
Advacnced Economies (AEs)	**0.61**	25.13	0.57	2.96	181.06	1.39	-0.35	0.84	5.3

Table 7. Estimates of the FX volatility mitigating factors and their thresholds

This table presents the estimates of equation (2), of which the interaction terms of the mitigating factor and Vol_CF are included separately from regression (1) to regression (8). Z-statistics are in brackets. ***, ** and * refer to the 1%, 5% and 10% significance level. The Wald test on the joint significance of all explanatory variables of the regression is reported by the p-value of the test statistic. The threshold point estimates are calculated by using equation (3), where both coefficients of Vol_CF and the interaction term are required to be, at least, at 10% significance level. The threshold range is the range between the 90% confidence interval lower bound of threshold to the point estimate of the threshold. Variables are defined in Table 2.

Dependent variable: Vol_FX	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Vol_CF	0.018	0.041	0.021	0.067	0.073	-0.039	0.019	0.091
	(1.6)*	(2.91)***	(2.01)**	(4.03)***	(2.84)***	(-3.04)***	(1.67)*	(2.61)***
Vol_CF*RealGDP_Growth	-0.001							
	(-0.19)							
RealGDP_Growth	-0.018	-0.020	-0.020	-0.026	-0.018	-0.021	-0.021	-0.019
	(-1.4)	(-2.14)**	(-2.25)**	(-1.7)*	(-2.01)**	(-2.33)**	(-1.95)**	(-2.1)**
Vol_CF*TradeOpenness		-0.002						
		(-4.15)***						
TradeOpenness	-0.001	0.002	-0.001	-0.001	-0.001	0.000	0.000	-0.001
	(-0.69)	(-0.97)	(-0.3)	(-0.27)	(-0.55)	(-0.2)	(-0.1)	(-0.47)
Vol_CF*FXReserve			-0.013					
			(-2.18)**					
FXReserve	0.001	0.003	0.012	-0.005	0.001	0.000	-0.001	-0.001
	-0.08	-0.34	-1.21	(-0.41)	(-0.03)	(-0.02)	(-0.16)	(-0.11)
Vol_CF*TotalForeignInvestment				-0.015				
				(-2.44)***				
TotalForeignInvestment	-0.010	-0.010	-0.011	0.006	-0.010	-0.010	-0.009	-0.011
	(-2.03)**	(-1.92)**	(-2.27)	-0.44	(-2.08)**	(-2.1)**	(-1.54)	(-2.31)**
Vol_CF*CreditToPrivate					-0.001			
					(-2.93)***			
CreditToPrivate	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
	(1.61)*	(-0.96)	-1.13	-1.05	(1.83)*	-0.99	-1.29	
Vol_CF*ShortRate						0.008		
						(3.62)***		
ShortRate	0.065	0.062	0.071	0.060	0.064	0.058	0.052	0.070
	(6.25)***	(-5.95)***	(6.9)***	(5.08)***	(6.86)***	(5.18)***	(4.25)***	(6.9)***
Vol_CF*FiscalSurplus							-0.061	
							(-5.11)***	
FiscalSurplus	-0.034	-0.050	-0.037	-0.055	-0.030	-0.042	0.042	-0.037
	(-1.46)	(-2.11)**	(-1.65)*	(-1.49)	(-1.41)	(-1.88)*	-1.42	(-1.66)*
Vol_CF*FinanicalDevelopment								-0.135
								(-2.6)***
FinanicalDevelopment								0.012
								(-0.03)
FX_Regime	0.333	0.376	0.347	0.314	0.340	0.358	0.409	0.370
	(4.45)***	(4.86)***	(4.75)***	(1.94)**	(4.63)***	(4.86)***	(4.77)***	(4.61)***
EquityReturn	-0.010	-0.010	-0.009	-0.014	-0.010	-0.009	-0.006	-0.010
	(-6.59)***	(-6.71)***	(-6.24)***	(-6.46)***	(-6.29)***	(-6.16)***	(-3.5)***	(-6.48)***
CapitalFlow	0.093	0.096	0.093	0.157	0.088	0.079	0.060	0.088
	(5.56)***	(5.77)***	(5.78)***	(5.97)***	(5.33)***	(4.95)***	(3.2)***	(5.44)***
VIX	0.016	0.016	0.016	0.021	0.016	0.016	0.015	0.016
	(5.68)***	(5.64)***	(5.69)***	(4.39)***	(5.81)***	(5.86)***	(4.61)***	(5.9)***
CommodityReturn	-0.006	-0.006	-0.006	-0.005	-0.006	-0.006	-0.006	-0.006
	(-3.14)***	(-3.1)***	(-3.34)***	(-1.64)*	(-3.37)***	(-3.38)***	(-2.77)***	(-3.37)***
Constant	-1.593	-1.827	-1.662	-1.637	-1.676	-1.658	-1.885	-1.627
	-3.80	(-4.16)***	(-4.07)***	(-1.70)*	(-4.02)***	(-4.02)***	(-3.90)***	(-3.79)***
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald tests (p-values)	0	0	0	0	0	0	0	0

Threshold	RealGDP_Growth	TradeOpenness	FXReserve	TotalForeignInvestment	CreditToPrivate	ShortRate	FiscalSurplus	FinanicalDevelopment
Point estimate	-	25.6	1.6	4.6	144.3	5.1	0.3	0.7
Threshold confidence interval bound: 90% confidence interval lower bound to the point estimate	-	[8, 25.6]	[0.2, 1.6]	[1.6, 4.6]	[38.5, 144.3]	[5.1, 1.6]	[0, 0.3]	[0.2, 0.7]

Table 8. FX resilience index ranking

This table presents the index value and index value ranking of countries. Panel A is categorized by the flexibility of FX regime, of which Panel A.1 is free float FX regime and Panel A.2 is managed FX regime. The categories of countries with free float and managed FX regimes are defined in Table (5). Panel B is categorized by EMEs and AEs, of which Panel B.1 is EMEs and Panel B.2 is AEs. The categories of EMEs and AEs are defined in Table (1). For both Panels A and B, a country's FX resilience index is calculated using equations (3), where the values of the mitigating factor are the quarterly average of the sample period of 2002 to 2019. The shaded areas refer to countries that are categorised in Cluster 2 (with sound economic conditions) as defined in Tables (5) and (6). The FX risilience index ranking is based on the index value, of which a lower value refers to a more resilient foreigh exchange rate to capital flow volatility for the country.

FX resilience index ranking			
Panel A.1 Free float FX regime		*Panel A.2 Managed FX regime*	
Switzerland	-0.45	Hong Kong	-0.69
Sweden	-0.37	Singapore	-0.50
Korea	-0.33	Malaysia	-0.24
Canada	-0.32	China	-0.23
Australia	-0.29	Czech Republic	-0.17
Thailand	-0.25	Russia	-0.13
United Kingdom	-0.24	Morocco	-0.06
Chile	-0.22	Egypt	0.12
Japan	-0.22		
United States	-0.18		
Brazil	0.01		
India	0.03		

Panel B.1 EMEs		*Panel B.2 AEs*	
Korea	-0.33	Hong Kong	-0.69
Thailand	-0.25	Singapore	-0.50
Malaysia	-0.24	Switzerland	-0.45
China	-0.23	Sweden	-0.37
Chile	-0.22	Canada	-0.32
Czech Republic	-0.17	Australia	-0.29
Russia	-0.13	United Kingdom	-0.24
Morocco	-0.06	Japan	-0.22
Brazil	0.01	United States	-0.18
India	0.03		
Egypt	0.12		

Table 9. Case study of mitigating factor thresholds: the U.S. Federal Reserve interest rate hike in 2018

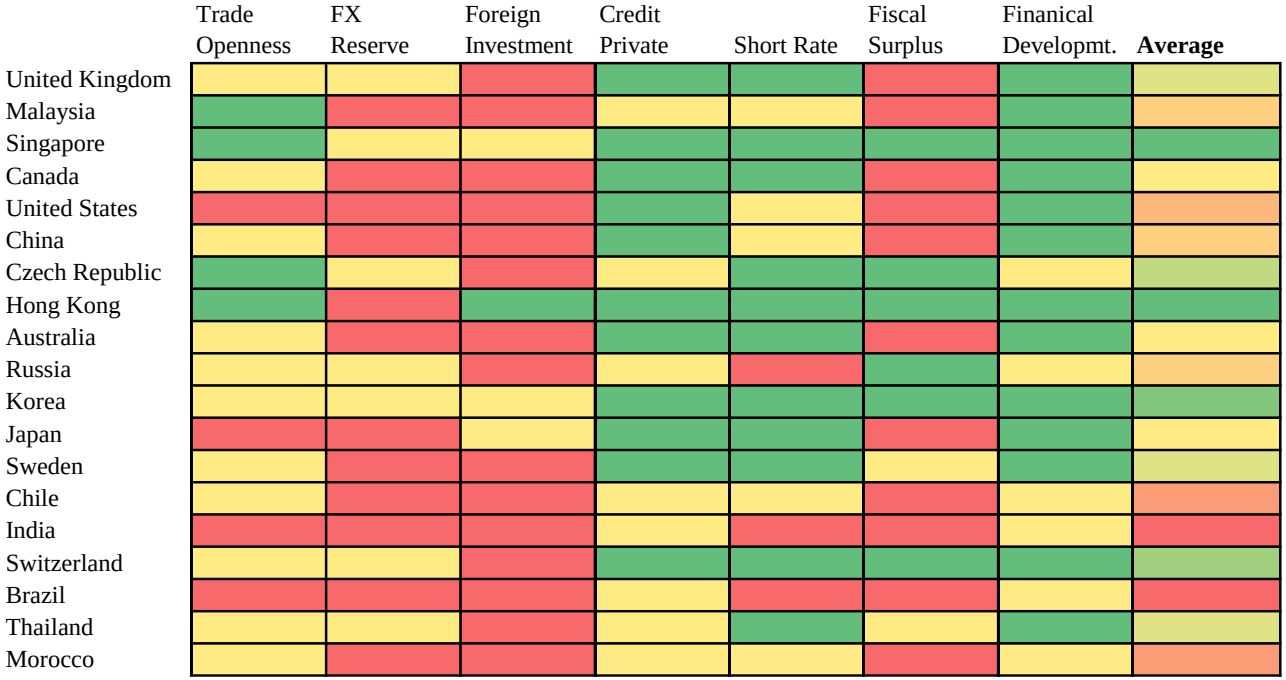
Panel A. FX volatility mitigating factors vs annual percentage change of FX volatility to per unit of CF volatility in 2018

This table presents the change in FX volatility per unit of CF volatility between 2018 and 2017 *vs* the average quarterly mitigating factors in 2018 for the sample countries (except Egypt). The former is ranked from the lowest to the highest. Values in bold refer to the mitigating factors attaining the point estimate thresholds (supporting factors). The total number of supporting factors of each country is reported in the far-right column. Variables are defined in Table (2).

		TradeOpenness	FXReserve	TotalForeignInvestment	CreditToPrivate	ShortRate	FiscalSurplus	FinanicalDevelopment		
Country code	Threshold range: 90% confidence interval lower bound to point estimate	[8, 25.6]	[0.2, 1.6]	[1.6, 4.6]	[38.5, 144.3]	[5.1, 1.6]	[0, 0.3]	[0.2, 0.7]	Change in Vol_FX per Vol_CF (%): 2018 vs 2017	No. of supporting factors (i.e. attaining the point estimate thresholds)
	Mean: 2018									
UK	United Kingdom	9.8	0.2	-1.1	**166.8**	**0.6**	-0.5	**0.9**	-65	3
MY	Malaysia	**26.7**	0.1	0.6	135.8	3.2	-0.8	**0.7**	-62	2
SG	Singapore	**54.7**	0.9	1.7	**166.1**	**1.3**	**0.9**	**0.8**	-46	5
CA	Canada	13.4	0.0	1.4	**211.0**	**1.4**	-0.1	**0.9**	-27	3
US	United States	5.1	0.0	0.3	**150.6**	1.8	-1.7	**0.9**	-26	2
CH	China	8.0	0.0	0.4	**203.1**	2.7	-1.2	**0.7**	-23	2
CZ	Czech Republic	**31.9**	0.2	0.6	89.0	**1.3**	**0.3**	0.5	-15	3
HK	Hong Kong	**80.8**	0.1	**11.9**	**298.8**	**1.4**	**0.6**	**0.8**	-9	6
AU	Australia	8.6	-0.2	1.1	**195.2**	**1.5**	-0.2	**0.9**	0	3
RU	Russia	10.4	0.6	0.4	63.0	7.1	**0.7**	0.5	4	1
KR	Korea	16.6	0.3	1.6	**185.4**	**1.5**	**0.6**	**0.8**	7	4
JP	Japan	7.4	0.1	1.7	**157.4**	**-0.1**	-0.6	**0.9**	7	3
SW	Sweden	15.7	0.0	0.4	**248.6**	**-0.7**	0.2	**0.8**	18	3
CL	Chile	12.3	0.1	0.5	139.8	2.5	-0.4	0.5	33	0
IN	India	7.8	0.0	0.0	56.1	6.2	-1.6	0.4	42	0
CH	Switzerland	21.7	0.5	0.9	**248.9**	**-0.7**	**0.4**	**1.0**	56	4
BR	Brazil	5.6	0.0	0.0	69.0	6.5	-1.7	0.6	57	0
TH	Thailand	23.7	0.4	1.1	116.0	**1.5**	0.0	**0.7**	79	2
MA	Morocco	14.7	-0.2	0.2	85.8	2.3	-0.9	0.4	103	0

Panel B. FX volatility mitigating factors in 2018

This heatmap illustrates the level of the FX volatility mitigating factors in 2018, as shown in Panel A above. The colour from light green, yellow to deep red refers to the mitigating factors attaining to their point estimate thresholds from the highest to the lowest.



Panel C. The correlation of the number of FX resilience supporting factors and annual percentage change of FX volatility to per unit of CF volatility in 2018.

This chart illustrates the estimated regression line between the number of supporting factors and annual percentage change of FX volatility to per unit of CF volatility in 2018 (i.e., the last two columns on the R.H.S. of Panel A)

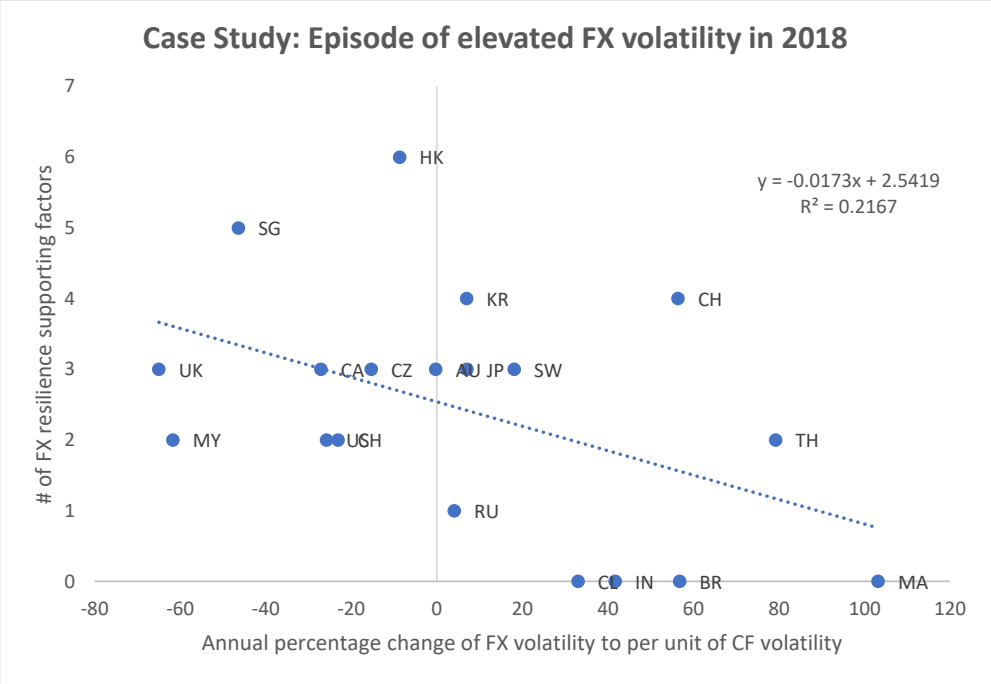


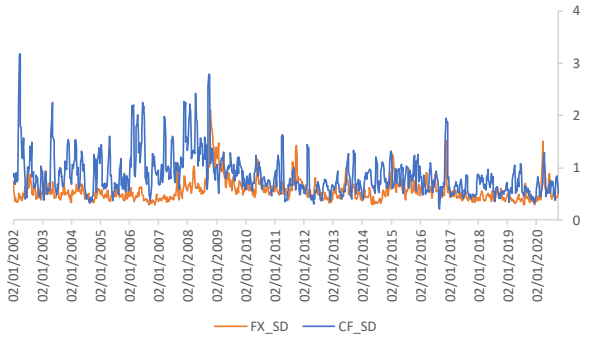
Table 10. Case study of FX resilience index: the 2020 pandemic

This table presents the FX resilience index ranking *vs* change in FX volatility ranking for the 20 sample countries during the 2020 pandemic. Panels A and B refer to EMEs and AEs, respectively. The FX resilience index is calculated by using equation (3), where the values of the mitigating factors are the quarterly average in 2019 (i.e. the most recent data in our sample). The change in FX volatility is calculated as the percentage change of FX volatility per unit of CF volatility between 2020 and the average of 2015 to 2019. Both the FX risilience index and the change in FX volatility are ranked from the lowest value (i.e. the most resilient) to the highest value (i.e. the least resilient). The shaded areas refer to countries with relatively big difference in ranking between the FX resilience index and change in FX volatility.

FX resilience index ranking		Change in FX volatility ranking	
FX resilience index: 2019		Change in Vol_FX per Vol_CF (%): 2020 *vs* mean of [2015, 2019	
		Panel A. EMEs	
Korea	-0.35	Korea	-37.49
Thailand	-0.29	China	-22.22
Malaysia	-0.28	Thailand	-19.74
Czech Republic	-0.22	India	-12.09
China	-0.20	Malaysia	-7.57
Chile	-0.20	Brazil	-4.92
Russia	-0.16	Russia	1.13
Morocco	-0.09	Chile	31.45
Brazil	-0.04	Czech Republic	64.44
India	0.02	Morocco	85.74
Egypt	0.16	Egypt	95.52
		Panel B. AEs	
Hong Kong	-0.56	Hong Kong	-54.26
Switzerland	-0.46	United Kingdom	-19.06
Singapore	-0.42	Sweden	-15.72
Sweden	-0.40	Australia	-7.73
Canada	-0.36	Switzerland	-2.50
Australia	-0.32	Singapore	-2.39
Japan	-0.27	United States	10.13
United Kingdom	-0.27	Japan	49.13
United States	-0.18	Canada	85.64

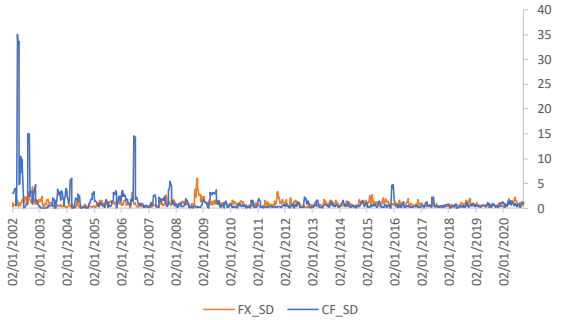
Figure 1. Weekly volatility of nominal effective FX rates (Vol_FX) and capital flows (Vol_CF)
This figure presents the volatility of nominal effective exchange rates alongside the volatility of capital flows of the average over all sample countries (Panel A), individual countries categorised as EMEs (Panel B) and individual countries categorised as AEs (Panel C). Both types of volatility are estimated as the standard deviation in a 4-week rolling window using weekly data.

Panel A. Average over all countries

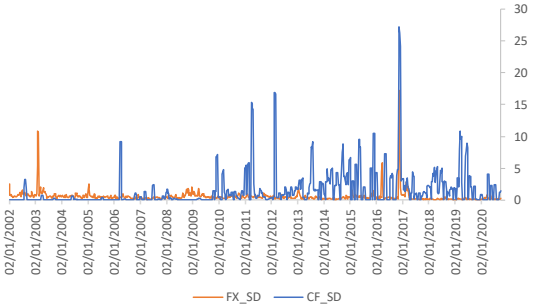


Panel B. EMEs

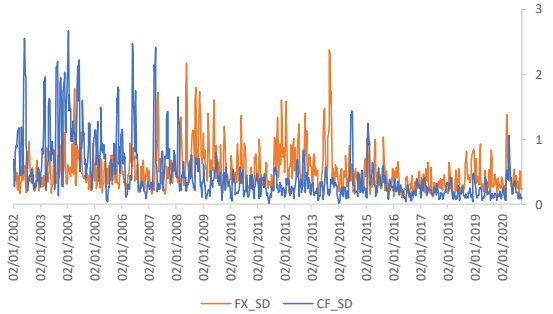
Brazil



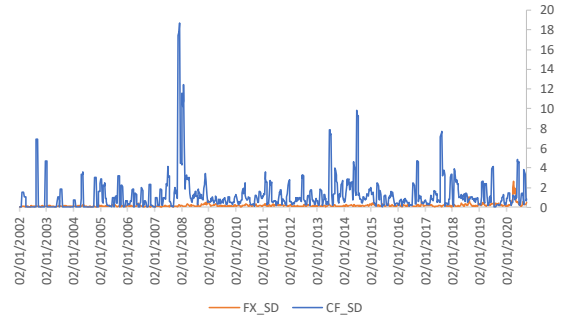
Egypt



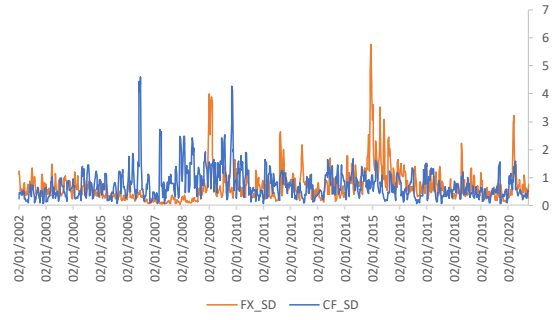
India



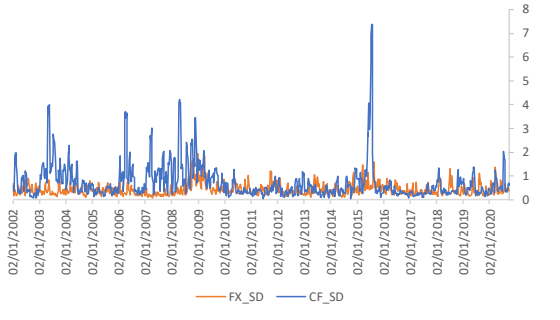
Morocco



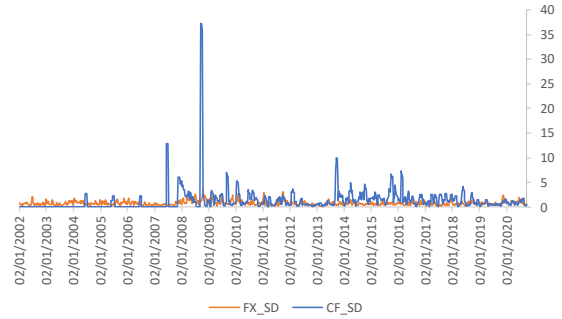
Russia



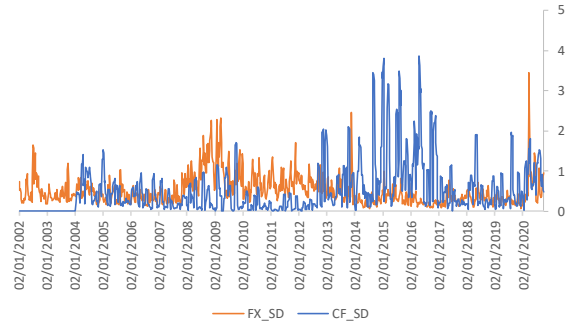
China



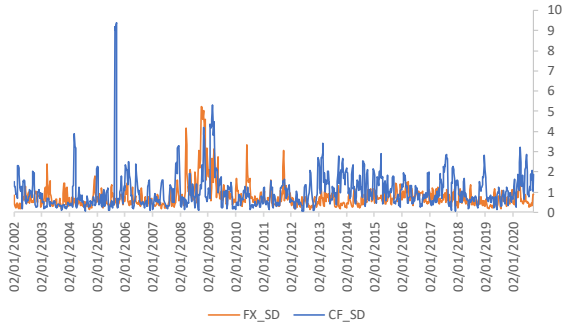
Chile



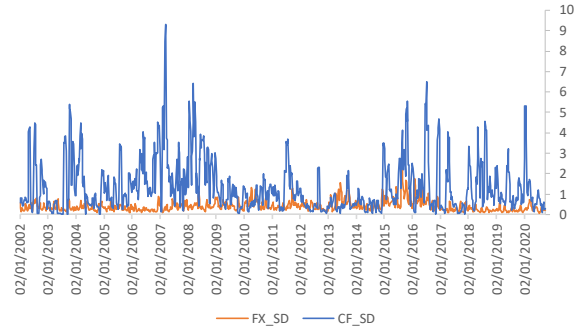
Czech Republic



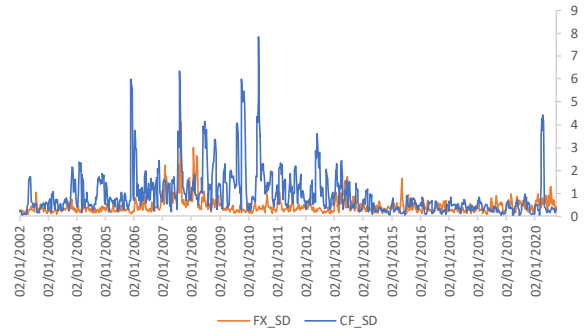
Korea



Malaysia

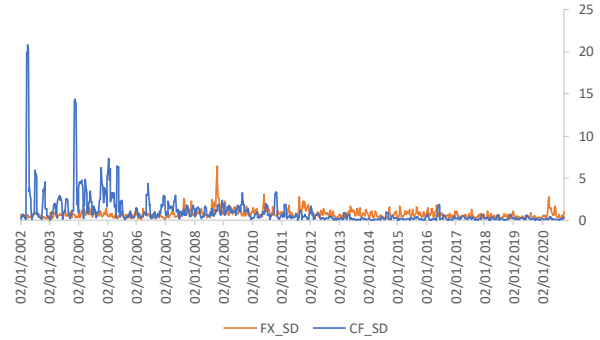


Thailand

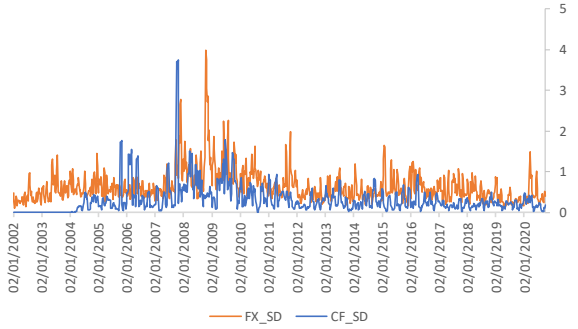


Panel B. AEs

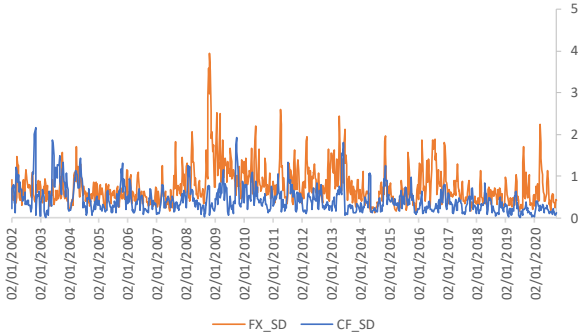
Australia



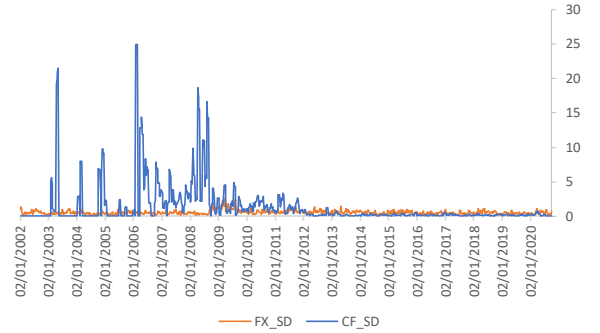
Canada



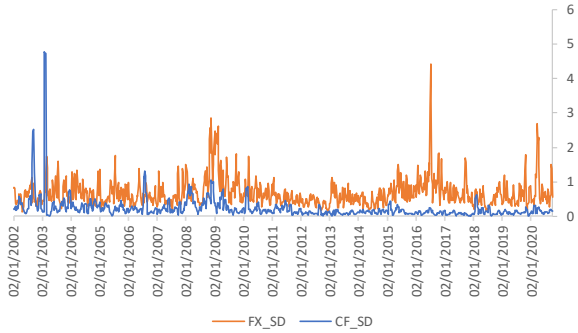
Japan



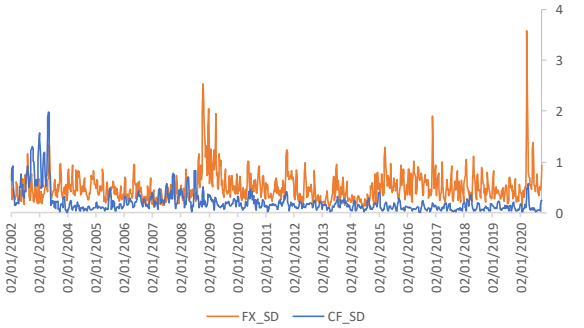
Sweden



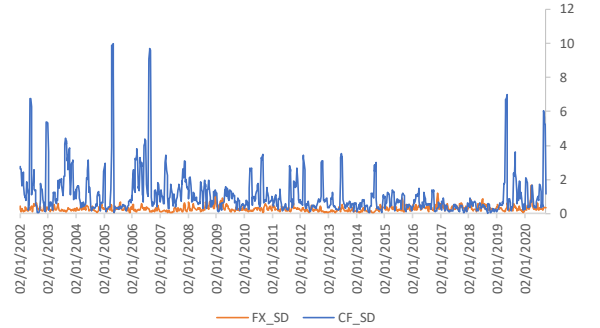
United Kingdom



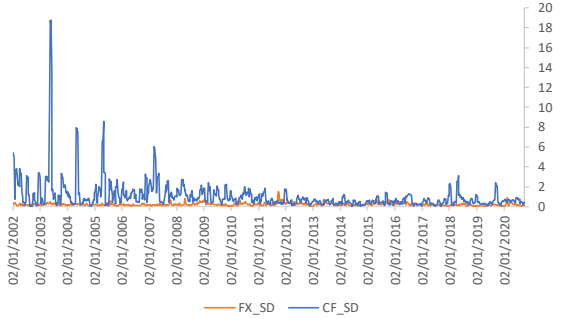
United States



Hong Kong



Singapore



Switzerland

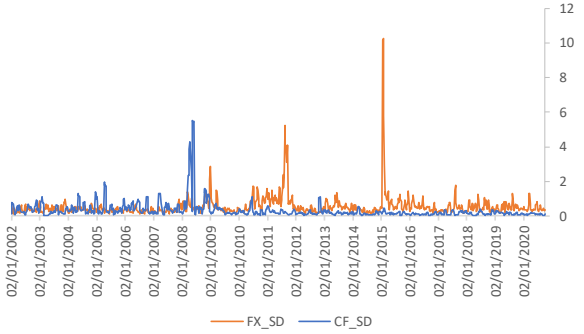
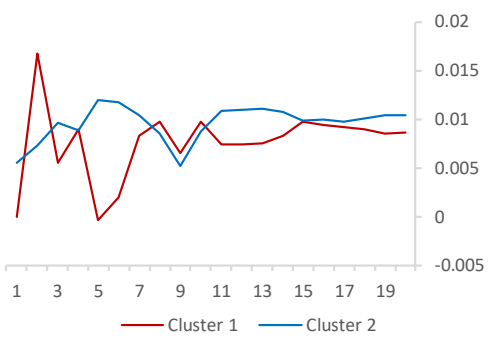


Figure 2. The impulse response function of FX volatility to capital flow volatility shocks

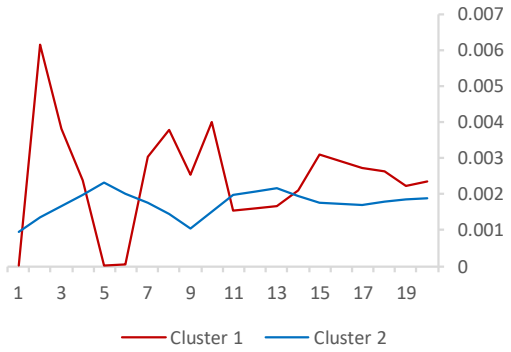
This figure shows the impulse response function of FX volatility to capital flow volatility shocks estimated by using equation (1). Figures (A.1 – A.3) in Panel A refers to the two cluster countries within the free float FX regime framework. Figures (B.1 – B.3) in Panel B refers to the two cluster countries within the managed FX regime framework, and Figures (C.1 – C.3) in Panel C refers to the two groups of countries, i.e. EMEs vs AEs. In addition, Figures (A.1), (B.1) and (C.1) refer to the impulse response function of FX volatility to the composite CF volatility shocks; Figures (A.2), (B.2) and (C.2) refer to the impulse response function of FX volatility to the decomposed composite CF volatility shocks – common shocks, and Figures (A.3), (B.3) and (C.3) refer to the impulse response function of FX volatility to the decomposed composite CF volatility shocks – idiosyncratic shocks.

1. Response to composite shocks
2. Response to common shocks
3. Response to idiosyncratic shocks

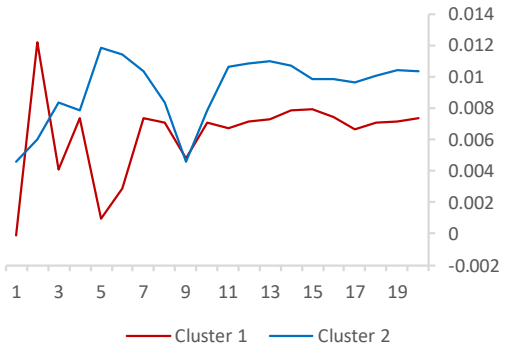
Panel A. Countries with free float FX regime: Cluster 1 (less sound economic condition) and Cluster 2 (sound economic condition)



(A.1)

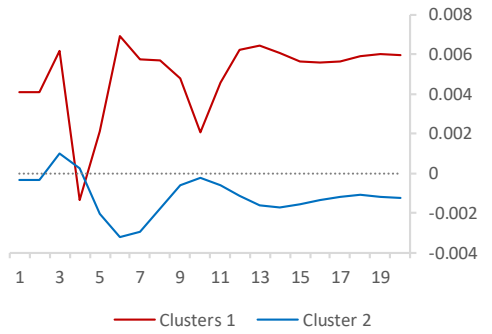


(A.2)

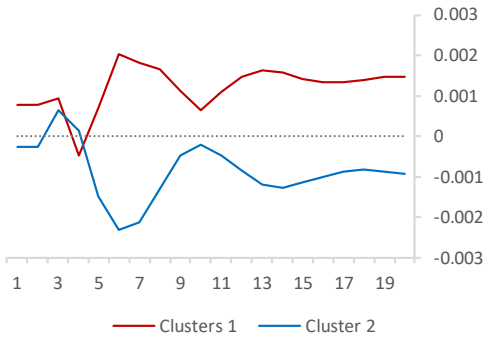


(A.3)

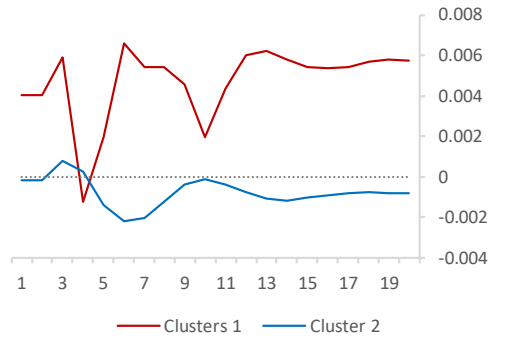
Panel B. Countries with managed FX regime: Cluster 1 (less sound economic condition) and Cluster 2 (sound economic condition)



(B.1)

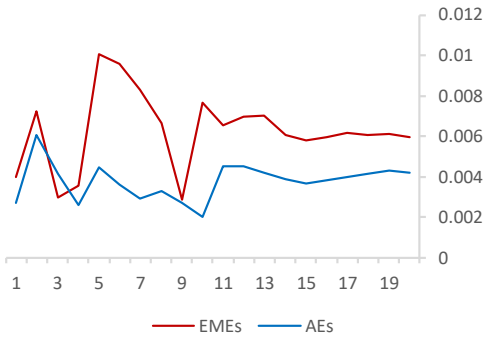


(B.2)

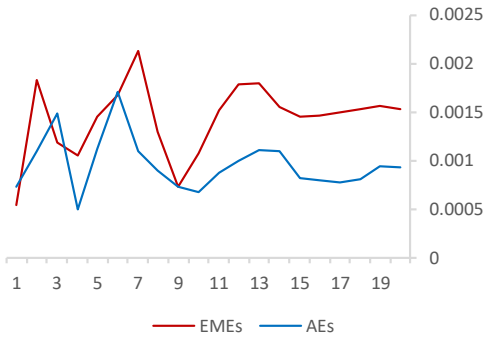


(B.3)

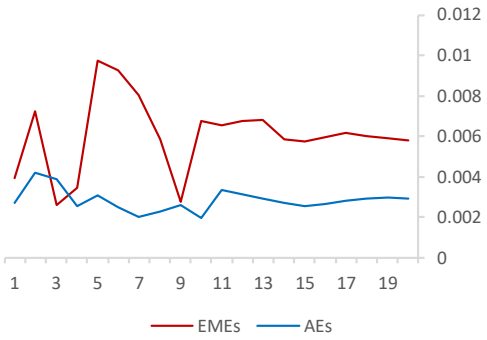
Panel C. EMEs vs AEs



(C.1)



(C.2)



(C.3)

Figure 3. Decomposition of the FX resilience index ranking
This figure is associated with Table 8, illustrating the contributions of each of the seven mitigating factors to the FX resilience index.