Global financial interconnectedness and spillovers between the G20 countries

Even after the global financial crisis of 2008-09, the international interconnectedness of national financial systems continued to deepen, albeit at a slower pace than before. The extent to which the coronavirus pandemic has influenced this trend can only be assessed in greater detail once a certain amount of time has passed. Despite this, the pandemic has once again emphatically raised the question of the extent to which the deepening interconnectedness between financial systems has changed advanced and emerging market economies' susceptibility to shocks.

A look at the development of global capital flows and their volatility shows that an abrupt outflow or reversal of capital flows can pose significant challenges, particularly for countries with less developed financial systems. As demonstrated by the global financial crisis, however, financial crises and the risk of contagion are not problems that affect only emerging market economies. As open economies are interconnected in financial and real economic terms, shocks in one country can also have an impact on other countries, which can in turn have feedback effects on the country in which the shock originated. To an increasing degree, this also applies to the relationships between advanced economies and emerging market economies. The analysis of spillover effects in the equity markets of the G20 countries shows that spillovers from advanced economies to emerging market economies continue to surpass those from emerging market economies to advanced economies. It is also shown that spillover effects can rise sharply and abruptly during periods of stress, such as the present phase triggered by the outbreak of the COVID-19 pandemic. Furthermore, the COVID-19 pandemic has also revealed increased vulnerabilities in individual G20 emerging market economies.

First and foremost, this has presented substantial challenges to national economic policy. Alongside stability-oriented economic policy, the further expansion of local capital markets, the build-up of foreign currency reserves and the implementation of macroprudential measures are appropriate for containing these vulnerabilities. Capital flow measures can also help to ensure financial stability. However, national policy measures alone are not always sufficient to combat the negative repercussions of highly volatile capital flows. In such cases, assistance from the international community, such as financial support from the International Monetary Fund (IMF), can supplement national efforts.

Development of cross-border capital flows

Growing capital flows increase interconnectedness within the global financial system

The international interconnectedness of financial systems has risen considerably since the 1980s. While the majority of international capital flows still take place between advanced economies, the share of capital flows attributable to emerging market economies has risen to a globally significant level. This development has been driven by advances in information and communication technologies, which have made it considerably easier to transfer assets across borders. In addition, emerging market economies have sought to take advantage of the benefits of international capital flows by opening up and developing their financial markets, which had previously been closed.

International capital flows can have considerable benefits …

Capital flows can have a positive impact on the recipient country if foreign capital is used to fund investment and stimulate economic growth. Furthermore, an international dispersion of financial assets allows investors to purchase higher-yielding assets as well as to better diversify risks and thereby reduce the total risk of investment.

… but also harbour risks

However, for emerging market economies in particular, inflows and outflows of capital can often present major challenges to financial stability, especially if the capital flows exhibit a high level of volatility. In relatively underdeveloped institutional environments, sudden stops in inflows or sharp rises in outflows can more quickly result in financial and currency crises, sometimes at considerable cost to the affected countries. However, very sharp increases in inflows can also pose challenges to macroeconomic and financial stability.

Increasing focus on gross flows instead of net flows in order to assess potential vulnerabilities

In order to more effectively identify potential vulnerabilities, the analysis of capital flows has changed in recent years. Up until the global financial crisis, analyses had centred mostly on net capital flows; since then, the focus has shifted to gross capital flows. Here, it should be noted that the gross flows have already been netted out and therefore may also have negative values.[1] This change in focus is due, amongst other reasons, to the fact that both components of the net figure – gross inflows from non-resident investors and gross outflows from resident investors – are generally larger and more volatile than net inflows. They can thus be indicative of spillover effects and vulnerabilities that, due to netting, are not necessarily reflected in equivalent changes in net capital flows. In addition, looking at gross figures allows for an analysis of different behavioural patterns between resident and non-resident investors. For example, the economic policy implications of strong net capital inflows can differ depending on whether these inflows are the result of increased investment from abroad or the repatriation of funds by resident investors.[2]

Following a sharp rise before the global financial crisis, gross capital inflows have since seen more subdued development …

The development of capital flows is shown in the balance of payments data for the G20 countries (see the chart on p. 55).[3] In this context, the strongest growth in gross capital flows worldwide was recorded in the first few years of the new millennium.

The trend of rising capital flows was interrupted by the global financial crisis. Following the collapse of Lehman Brothers in September 2008, there was initially a massive slump in global gross capital inflows. Although these

---

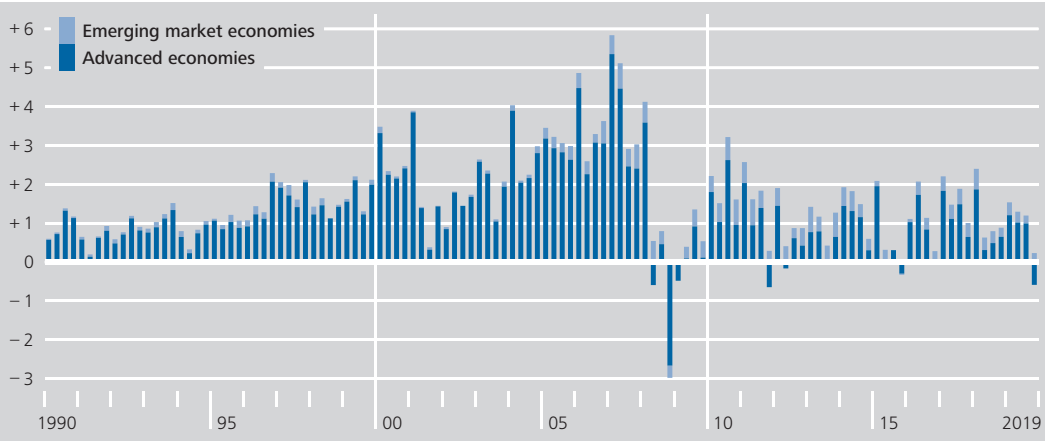
1 "Gross capital inflows" refer to the purchases less sales of domestic assets by non-residents within a specific period. Accordingly, "gross capital outflows" are the purchases less sales of foreign assets by residents. "Net capital inflows" are the difference between gross capital inflows and gross capital outflows. See Committee on the Global Financial System (2009). Net capital flows can be interpreted as the financial counterpart to the current account balance and thus provide an opportunity for approximating the impact of non-resident investors on the domestic economy. See Borio and Disyatat (2015).

2 See Obstfeld (2014) and Forbes and Warnock (2012).

3 Here and in the rest of this article, the focus is on the countries belonging to the Group of 20 (G20). The European Union, which is also a G20 member, is disregarded. The G20 emerging market economies comprise Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Turkey. The advanced economies in the G20 are Australia, Canada, France, Germany, Italy, Japan, South Korea, the United Kingdom and the United States.

Gross capital inflows

As a percentage of total GDP of the G20 countries



Source: IMF Balance of Payments.
Deutsche Bundesbank

subsequently recovered, they have grown much more slowly than they had before the global financial crisis. Over time, a growing proportion of gross capital inflows have been attributable to the emerging market economies.[4] Against the backdrop of adjustments to the financial system in the wake of the global financial crisis, the rising attractiveness of the emerging market economies to investors led to comparatively robust capital inflows, while the inflows to and outflows from the advanced economies declined.[5]

… with a changed structure of capital flows

In addition to their volumes, the composition of capital flows also changed significantly in the aftermath of the global financial crisis (see the chart on p. 56). For example, their structure reveals a decline in cross-border loans, especially from banks.[6] This applies mainly to advanced economies, but also, to a lesser extent, to some of the G20 emerging market economies.[7] In several emerging market economies, the withdrawal of foreign banks was offset by increasing significance of the bond market. Bank loans and portfolio investment now fund emerging market economies in roughly equal measure.

Sharp decline in gross capital flows expected due to COVID-19

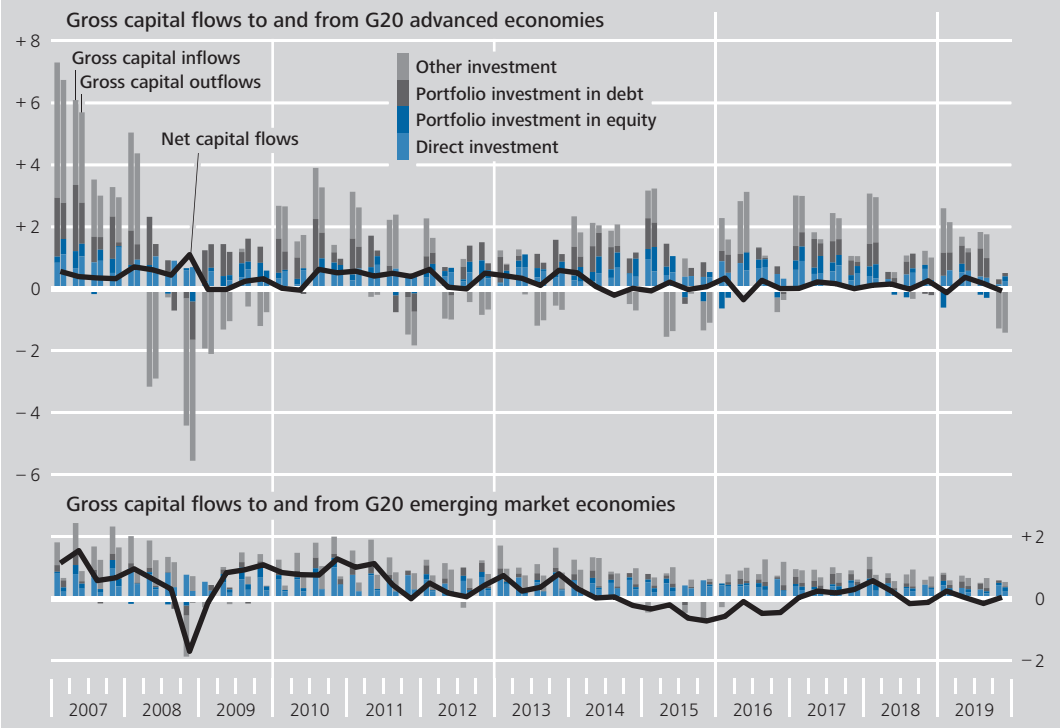
The extent to which the COVID-19 pandemic has changed global capital flows cannot be precisely assessed at present due to the lagged availability of balance of payments data. Nevertheless, in March this year, the inflows to investment funds that invest in equity and bond funds in G20 emerging market economies fell by an unprecedented amount. These capital flows are generally considered to be a good approximation of portfolio investment.[8] In the second quarter of 2020, strong outflows from equity funds continued to be observed, while inflows to bond funds stabilised somewhat. Compared with other crisis episodes that were characterised by high outflows of funds from emerging market economies, not only the volume, but also the rapid speed of the outflows from the emerging market economies over the past few months was especially noteworthy (see the chart on p. 57).[9]

The respective capital flows are determined by differing underlying factors, which are trad-

4 The degree of financial openness – which is calculated as the sum of a country's external claims and liabilities divided by its gross domestic product – has risen significantly faster among the G20 emerging market economies than the G20 advanced economies since the global financial crisis.
5 Although some individual countries, such as China, account for a very large share of capital flows, this article does not discuss specific countries in detail.
6 See Buch and Goldberg (2020).
7 Based on the Consolidated Banking Statistics of the Bank of International Settlements.
8 See Koepke and Paetzold (2020).
9 The EPFR data on inflows to equity and bond funds used here refer to net inflows.

Gross capital flows by type of capital flow*

As a percentage of the GDP of the respective group of countries, quarterly data



Source: IMF Balance of Payments. * Gross capital inflows correspond to the balance of purchases less sales of domestic assets by non-residents; gross capital outflows correspond to the balance of purchases less sales of foreign assets by residents.
Deutsche Bundesbank

Capital flows have different underlying factors

itionally categorised into "pull" and "push" factors. Pull factors comprise influencing factors that originate from the recipient country and affect investors, while push factors are the causes that prevail in the capital-exporting country.[10] In addition, more recent approaches examine what are known as "pipes", which reflect structural factors in the international monetary system.[11]

Portfolio investment and bank loans are more likely to be subject to short-term influences

These factors may exert a stronger or weaker influence depending on the country and situation. Portfolio investment, like other investment, appears to be based more on short-term considerations. It exhibits a significantly negative correlation with the level of risk aversion and interest rates in the capital-exporting country. However, it appears to be increasingly influenced by the prevailing domestic fundamentals and the local risk situation in the recipient country. This suggests that investors are differentiating more clearly between individual emerging market economies.[12]

The volatility of capital flows is driven largely by global factors

While domestic factors, such as growth differentials, can exert a considerable influence on the volume of capital flows in the recipient country, global factors, such as risk aversion or the US monetary policy stance, appear to have a larger impact than domestic factors on the volatility of capital flows in emerging market economies.[13]

Global financial spillover effects

Spillovers increasingly occur between emerging market economies and advanced economies, too

The global financial crisis demonstrated that financial crises and the risk of contagion are not problems that affect only emerging market economies. As open economies are significantly interconnected in financial and real eco-

10 See Calvo et al. (1996).
11 See Carney (2019).
12 See Ahmed et al. (2015).
13 See Bussière et al. (2016), Cerutti et al. (2015) and Pagliari and Hanan (2017).

nomic terms, shocks – i.e. unexpected events – in one country can also have an impact on other countries, which can in turn have feedback effects on the country in which the shock originated; in the literature, these effects are known, respectively, as "spillover" and "spillback". To an increasing degree, this also applies to the relationships between advanced economies and emerging market economies.

Spillover effects are driven by a variety of interconnections between the real economy and financial system

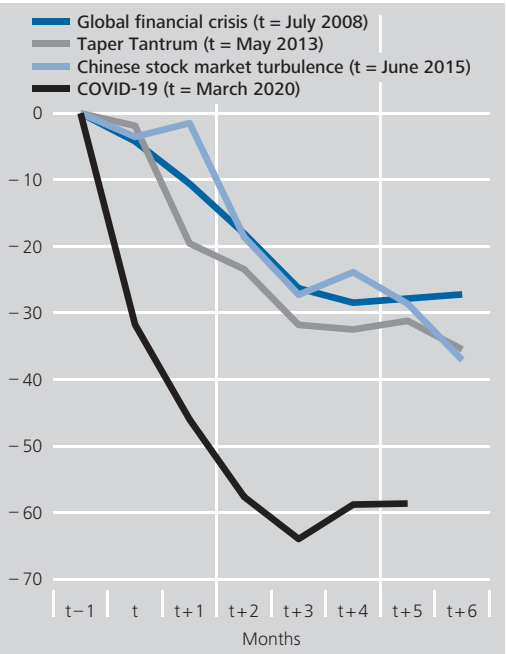
The spillover of shocks can occur through direct and indirect trade channels as well as through direct and indirect financial channels. Direct financial linkages are the result of the cross-border claims and liabilities of banks, other financial institutions, governments, enterprises and households, which can invest or obtain funding abroad via loans, direct investment or portfolio investment. Indirect financial linkages can, for example, arise due to connections via third parties, such as common investors. The wide range of cross-border interconnectivities and dependencies within the global financial system and the real economy are ultimately responsible for the spillover effects between countries and regions. Spillovers can occur through a variety of transmission channels. In this article, spillover effects are measured without focusing on the channels through which the shock is transmitted. The aim of this analysis is to map the development and changes in the spillover effects over time. This allows for an assessment of whether, in the light of the growing significance of the emerging market economies, the mutual dependence between the advanced economies and the emerging market economies has changed permanently or in specific phases over recent years.

Greater focus on financial spillovers in the literature

In recent years, the empirical literature has increasingly been exploring the issue of cross-border spillover effects. While empirical analyses used to look, in particular, at real economic transmission channels such as trade or commodity markets, increasing financial globalisation has lately brought a greater focus on analysing financial spillover effects.[14]

Inflows to G20 emerging market funds during various periods of crisis*

US$ billion, cumulative



Source: EPFR. * Monthly data on inflows to investment funds that invest in equity and bond funds in G20 emerging market economies, t=month of crisis, t+1=month of crisis plus one month.
Deutsche Bundesbank

There are two major strands to the literature on this topic. The first comprises network models aimed at investigating the causal mechanisms of financial contagion. Such analyses are based on balance sheet and macroeconomic fundamentals. Network models gained in importance following the Asian financial crisis of 1997-98 and the global financial crisis of 2007-08, with the work of Allen and Gale (2000) as well as Forbes and Rigobon (2002) representing seminal contributions.[15]

The second strand of the literature is concerned with econometric models that use market data to identify spillover effects without making any further assumptions about the dynamics of shock transmission.[16] For example, the ap-

14 See IMF (2016) and Bank for International Settlements (2018).
15 Comprehensive overviews of existing methods for modelling contagion effects can be found in Upper (2011), Dungey et al. (2005) and Glasserman and Young (2016).
16 See Bricco and Xu (2019).

proach of Diebold and Yılmaz, discussed back in the July 2019 issue of the Bundesbank's Monthly Report, centres on a simple and widely applicable quantitative measure for spillovers and their evolution over time, revealing trends, cycles and breaks.[17] This method does not focus on how shocks are transmitted, but rather provides a measure for estimating the intensity of spillover effects. The methodology can thus be applied to measure the strength of spillovers between the G20 countries.

At the same time, the approach offers a way of assessing spillover effects in the current COVID-19 pandemic (see p. 62).

Estimating spillovers between the equity markets of the G20 member states

The outbreak of the pandemic saw share prices tumble heavily across all G20 countries – including countries where case numbers had hitherto not been quite as high as elsewhere. In the first half of 2020, the German stock market index DAX and the Euro Stoxx 50 dropped by more than 35% at the peak of the slump and the US stock market index S&P 500 fell by more than 30% compared with the end of 2019. Stock market price data are available at high frequency and respond quickly to news, so the spillover index described earlier is calculated for the yields of G20 benchmark stock indices (see the box on pp. 59 ff.). These are daily price data in local currency for the period from January 1999 to August 2020. In order to control for the different time zones, the yield on each individual stock index is calculated from Friday to Friday. A spillover index value of 100 indicates that the total variance of a variable is attributable to spillovers of shocks in other variables. A value of zero, on the other hand, signals an absence of discernible spillovers.

A country transmits more spillovers than it receives when the difference between its index of spillovers to other countries and its index of spillovers from other countries is greater than zero. In the literature, this is also referred to as the net spillover index.[18] The analysis suggests that certain countries tend to act more as a sender rather than as a recipient of spillovers: Germany, with a net spillover index of 32, sends on average more spillovers to other G20 countries, while Turkey (-26) and Argentina (-17), for example, are on the receiving end of spillovers from the other G20 countries. As is to be expected, spillovers between countries belonging to the same region, for example in Europe between Germany and Italy (11 from Germany to Italy and 9 in the other direction) or between Mexico and Brazil in Latin America (8 from Mexico to Brazil and 7 vice versa) are typically larger than those between two countries from different regions, such as between Germany and Brazil (from Germany to Brazil 6, 4 vice versa). At 62.5, the spillover index measuring the average spillovers between the countries of the G20 indicates that a large proportion of the variance of all variables is attributable to spillover effects from other variables.

Spillovers within the emerging market economies and advanced economies groupings appear more pronounced than between them

Since the focus is on looking at the countries as groups, the next step is to analyse the average spillovers between the emerging market economies and the advanced economies. A simultaneous shock in all G20 emerging market economies or all G20 advanced economies is assumed (for more, see the bottom of the box on p. 62). It is apparent at aggregated level, too, that spillovers within the two country groupings are larger than spillovers from emerging market economies to advanced economies and vice versa. Moreover, averaged over the complete analysis period from January 1999 to June 2020, advanced economies transmitted more spillovers to emerging market economies than they received from them, with the spillover index reaching 42. However, at 29, the spillover index from emerging market economies is not negligible.

Applying a dynamic analysis …

Repeating the analysis for rolling windows of 100 weeks each (i.e. roughly two years) makes it possible to represent the spillover matrix for all G20 countries and the group spillover matrix in chart form. The value of the spillover index

17 See Deutsche Bundesbank (2019).
18 See Diebold and Yılmaz (2015).

The Diebold and Yılmaz spillover index

Unlike other methods based on macroeconomic or balance sheet data, which are usually published only a few times per year, the Diebold and Yılmaz (2009, 2012, 2015) approach to estimating spillover effects uses daily market data. This enables their approach to produce a high-frequency measure of spillover effects that adapts more quickly than other indicators to changes in the data,[1] lending this spillover measure some of the greatest predictive power amongst existing indicators.[2]

Since the Diebold and Yılmaz spillover index also requires only minimal assumptions, this methodology is employed in a wide variety of papers. It can be applied to price-based analyses as well as to quantitative variables and can also be used to model potential transmission channels. In this box, the approach will be used to estimate financial spillovers based on equity market returns of the benchmark indices of G20 countries.

The spillover index is based on a rolling estimate of VAR models in which the variances of the forecast errors are decomposed. On this basis, a time-varying index is then constructed.

The estimate for a single time window then follows the reduced-form $\mathrm{VAR}(p)$ model:

$$y_t = \sum_{h=1}^{p} \Phi_h y_{t-h} + \varepsilon_t,$$

where y_t is a vector with observations of all N endogenous variables. In the present case, these are the daily returns of the benchmark indices[3] of the G20 countries.[4] Φ represents an $N \times N$ matrix with regression coefficients that refer to the observations of the endogenous variable (y_{t-h}) lagged by p units of time. ε_t denotes the error term not explained by the model, where $(\varepsilon_t)_{t \geq 0} \overset{iid}{\sim} (0, \Sigma)$ and $E[\varepsilon_t \varepsilon_{t'}'] = 0 \ \forall \ t \neq t'$. In the analysis of G20 benchmark equity index[5] returns, an autoregressive lag of $p = 2$ is selected.[6]

The $\mathrm{VAR}(p)$ is then transformed into a "moving average":[7]

$$y_t = \sum_{h=0}^{\infty} A_h \varepsilon_{t-h}.$$

1 See Diebold and Yılmaz (2009). Diebold and Yılmaz argue that, with increasing data frequency, an empirical model is better able to correctly track the time variation of spillover effects. In addition, for certain countries – including some of the G20 emerging market economies – it is difficult to obtain reliable data on the macroeconomic fundamentals and the balance sheets of general government, financial institutions and enterprises.
2 See Arsov et al. (2013). Moreover, the spillover measure is closely related to other known systemic measures of risk such as the CoVaR, introduced by Adrian and Brunnermeier (2016), and the Marginal Expected Shortfall, published in Acharya et al. (2016).
3 Here and in the rest of this box, the focus is on the countries belonging to the Group of 20 (G20). The European Union, which is also a G20 member, is disregarded. In this box, the G20 emerging market economies comprise Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Turkey, and the advanced economies in the G20 are Australia, Canada, France, Germany, Italy, Japan, South Korea, the United Kingdom and the United States.
4 The VIX is additionally used in the estimate in order to control for global risk aversion, which could be a powerful driver of data patterns. The VIX serves here as a sort of "quasi-exogenous" variable that is omitted when calculating the spillover indices. The analysis is also rerun as a VARX model with the VIX as an exogenous variable, which leads to similar results.
5 The benchmark equity indices used here are MERVAL, S&P/ASX 200, Bovespa, S&P/TSX, Shanghai SSE, DAX, CAC 40, FTSE 100, IDX Composite, Nifty50, FSTE MIB, Nikkei 225, KOSPI, S&P/BMV IPC, MOEX, Tadawul All Share, S&P 500 and JSE, and they are called up via Bloomberg. The vast majority of these are price indices. Only the DAX and Bovespa are performance indices. The selected benchmark indices are used in this fashion in other research papers, too.
6 Based on the Akaike Information Criterion (AIC), $p = 2$ is selected.
7 See Lütkepohl (2005) and Kilian and Lütkepohl (2017).

Here, the $N \times N$ coefficient matrix A_h follows the recursion $A_h = \Phi_1 A_{h-1} + \Phi_2 A_{h-2} + \ldots + \Phi_p A_{h-p}$ where A_0 represents an $(N \times N)$ identity matrix. In addition, $A_h = 0$ if $h < 0$. Accordingly, in the "moving average" representation, the current value of a variable is defined via a function of its current and past error terms.

In the next step, impulse response functions are created in order to estimate the time profile of a shock δ which hits the system at time t up to time $t + H$ given the absence of any other shocks to the system. The forecasting horizon $H = 10$ is chosen here.[8] Instead of the Cholesky decomposition, the generalised VAR framework of Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998) is used. The advantage of the generalised framework is that no assumptions regarding the causal relationships between the disturbance terms are necessary. However, the downside is that contemporaneous causal effects cannot be modelled.[9] Instead of shocking all elements of ε_t, only the jth element in ε_t is shocked, and the impacts of other shocks are disregarded assuming multivariate normal distribution of ε_t. The shock δ_j in the variable $\varepsilon_{j,t}$ of one standard deviation $\sigma_{jj}^{\frac{1}{2}}$ at time t creates a generalised impulse response function (GIRF) of:

$$\begin{aligned} GIRF(h) = {} & E[y_{t+h} | \varepsilon_{j,t} = \delta_j, \omega_{t-1}] \\ & - E[y_{t+h} | \omega_{t-1}] \\ = {} & \sigma_{jj}^{\frac{1}{2}} A_h \Sigma e_j \end{aligned}$$

where $h = 0, 1, \ldots, H$ is the forecast horizon, $\sigma_{jj}^{\frac{1}{2}}$ the standard deviation of the error term of the jth equation, A_h the coefficient matrix, $\sum$ the covariance matrix of the error term ε_t and e_j a selection vector of dimension $(N \times 1)$ where the jth element takes a value of one and all other elements take a value of zero. $\omega_{(t-1)}$ comprises all information known up until time $(t-1)$. The $GIRF$s model the dependent variables' responses to shocks to each variable in the system. A shock with a magnitude of one standard deviation to each error term is simulated separately on each equation, producing a total of N^2 $GIRF$s.

In the next step, the impulse response functions are used to calculate the forecast error variance (FEV) for each variable. It gives the dispersion of each variable which, owing to the shock that occurred in ε_t, would have been impossible to forecast between t and $t+H$. For the variable y_i the FEV is given as $FEV(y_{i,t+H} | \omega_t) = \sum_{h=0}^{H-1} e_j' A_h \sum A_h' e_j$. A shock to the variable j directly impacts the variable itself but, due to the dynamic structure of the VAR model, can also affect all other variables in the system. The contributions by each of the individual shocks to the FEVs of the respective variables can be calculated using a forecast error variance decomposition $(FEVD)$. The FEV of variable i (H steps ahead) explained by a shock in the equation of variable j is calculated as:

$$\Theta_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_j' A_h \sum e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \sum A_h' e_i)}.$$

The results for all i variables and j shocks can be represented in an $N \times N$ matrix where the element Θ_{ij} represents the share in the FEV of variable i explained by a

8 The ten-step-ahead forecasting horizon is a standard assumption in the literature. See Diebold and Yılmaz (2009).

9 Alternative approaches generally require additional assumptions. Although a Cholesky decomposition leads to orthogonal shocks and thus allows for unequivocal identification, it also requires additional assumptions concerning the contemporaneous causal relationships between the variables. The approach proposed by Bettendorf and Heinlein (2019) presented in the July 2019 issue of the Bundesbank's Monthly Report (see Deutsche Bundesbank (2019)) likewise presumes the existence of a clear causal structure between the error terms.

Spillover matrix

$i \downarrow$ $j \rightarrow$	Country 1	Country 2	…	…	Country N	Index of spillovers to country i from countries $j \neq i$
Country 1	$\widetilde{\Theta}_{11}$	$\widetilde{\Theta}_{12}$	…	…	$\widetilde{\Theta}_{1N}$	$\widetilde{\Theta}_{1\leftarrow j,j\neq 1}$
Country 2	$\widetilde{\Theta}_{21}$	$\widetilde{\Theta}_{22}$	…	…	$\widetilde{\Theta}_{2N}$	$\widetilde{\Theta}_{2\leftarrow j,j\neq 2}$
⋮	⋮	⋮	⋱	⋱	⋮	⋮
⋮	⋮	⋮	⋱	⋱	⋮	⋮
Country N	$\widetilde{\Theta}_{N1}$	$\widetilde{\Theta}_{N2}$	…	…	$\widetilde{\Theta}_{NN}$	$\widetilde{\Theta}_{N\leftarrow j,j\neq N}$
Index of spillovers from country j to countries $i \neq j$	$\widetilde{\Theta}_{i\leftarrow 1,i\neq 1}$	$\widetilde{\Theta}_{i\leftarrow 2,i\neq 2}$	…		$\widetilde{\Theta}_{i\leftarrow N,i\neq N}$	SI

Deutsche Bundesbank

shock to variable j.[10] Element $\Theta_{AR,DE}$, for instance, would be the share in the FEV of the return of Argentina's equity price index attributable to shocks in the model equation for the return of the German DAX. Since, in the generalised framework, shocks in each variable are not necessarily orthogonal, the shares in the FEV of a variable explained by shocks do not necessarily add up to 100%. Accordingly, each element of the $FEVD$ matrix is normalised with the respective row total, i.e. $\widetilde{\Theta}_{ij} = \frac{\Theta_{ij}}{\sum_{j=1}^{N}\Theta_{ij}}$, which means that $\sum_{j=1}^{N}\widetilde{\Theta}_{ij} = 1$ and $\sum_{i,j=1}^{N}\widetilde{\Theta}_{ij} = N$. The FEV of each variable in the system is thus equally weighted, which means that the rows of the normalised matrix can be compared with one another. This enables the variance shares in both the rows and the columns of the normalised matrix to be added up and compared for different variables.

Off-diagonal entries in the normalised $FEVD$ matrix ($\widetilde{\Theta}_{ij}$ where $i \neq j$) are used as a measure of spillover effects between the variables in the system. In order to obtain a spillover index SI for the estimated period, the total of all off-diagonal entries is divided by the total of all entries in the matrix:

$$SI = \frac{\sum_{i,j=1,i\neq j}^{N}\widetilde{\Theta}_{ij}}{\sum_{i,j=1}^{N}\widetilde{\Theta}_{ij}} = \frac{\sum_{i,j=1,i\neq j}^{N}\widetilde{\Theta}_{ij}}{N}.$$

This measure can also be used to measure directional spillovers from variable j to all other variables $i = 1, \ldots, N$:

$$\widetilde{\Theta}_{\blacksquare\leftarrow j} = \frac{\sum_{i=1,i\neq j}^{N}\widetilde{\Theta}_{i\leftarrow j}}{N},$$

and, by analogy, directional spillovers to variable i from all variables $j = 1, \ldots, N$:

$$\widetilde{\Theta}_{i\leftarrow\blacksquare} = \frac{\sum_{j=1,i\neq j}^{N}\widetilde{\Theta}_{i\leftarrow j}}{N}.$$

For each variable in the system, the directional "from" and "to" spillover indices can be used to calculate a net spillover index that shows whether a variable is more likely to be the source or recipient of spillover effects. The normalised $FEVD$ matrix, the directional spillover indices, the net spillover index and the total spillover index are presented in a spillover matrix (see the table above).

To gain an overview of the development and intensity of spillovers between ad-

10 In the generalised framework, causal spillovers – in the sense that spillover effects are only propagated from one given country to another country – can be modelled only using lagged variables. The results would be skewed accordingly if such effects materialised and spilled over at the same time (see Bettendorf and Heinlein (2019)).

vanced economies and emerging market economies, a measure of a group spillover index is formed. This is done by assuming a systemic shock in all countries within a group G (in this case, the nine advanced economies of the G20, AE, and the ten G20 emerging market economies, EME) and then analysing their combined impact on all countries outside the group. When looking at the group as a whole, a spillover matrix in which the row total for each of the individual entries equals one is additionally created by transforming the entries into $\widetilde{\Theta}_{AE\leftarrow j} = \frac{\sum_{i\in AE}\sum_{j=1}^{G}\widetilde{\Theta}_{ij}}{AE}$ and $\widetilde{\Theta}_{EME\leftarrow j} = \frac{\sum_{i\in EME}\sum_{j=1}^{G}\widetilde{\Theta}_{ij}}{EME}$.

The index of spillovers from emerging market economies to advanced economies is given as:

$$\widetilde{\Theta}_{AE\leftarrow EME} = \frac{\frac{1}{AE}\sum_{i\in AE}\sum_{i\in EME}\widetilde{\Theta}_{ij}}{G}$$

and, conversely, the index of spillovers from advanced economies to emerging market economies as:

$$\widetilde{\Theta}_{EME\leftarrow AE} = \frac{\frac{1}{EME}\sum_{i\in EME}\sum_{i\in AE}\widetilde{\Theta}_{ij}}{G}.$$

The spillover matrix described above and the reduced-form group spillover matrix are estimated repeatedly for rolling time windows of length w in order to identify the dynamics of the spillover effects over time. The $T-w$ spillover matrices which this produces can be displayed in spillover plots.

for a given point in time is calculated on the basis of the corresponding window covering the last 100 weeks.[19]

The group spillover index between emerging market economies and advanced economies (black line) is lower than that between all G20 countries (grey dashed line). This is because the latter also reflects spillovers between advanced economies amongst themselves and emerging market economies amongst themselves, and these tend to be relatively high. For the purposes of the grouped perspective, these are, however, included in the respective own share for the grouping – i.e. the diagonal entries in the group spillover matrix.

… reveals an increase in spillovers during periods of stress

The adjacent table shows the indices of group spillover (the non-diagonal entries) from emerging market economies to advanced economies and vice versa. These are plotted in the chart on p. 63 as light blue and dark blue lines. This dynamic representation allows an assessment of how spillovers have evolved over time. One can see that spillover effects have in-

Very significant rise in spillover effects during the COVID-19 pandemic

Index of spillovers between emerging market economies and advanced economies in the G20*

G20 benchmark equity indices, average values, January 1999 to August 2020

Item	from …		Spillover index
	emerging market economies	advanced economies	
Emerging market economies	58	42	.
Advanced economies	29	71	.
Spillover index	.	.	36

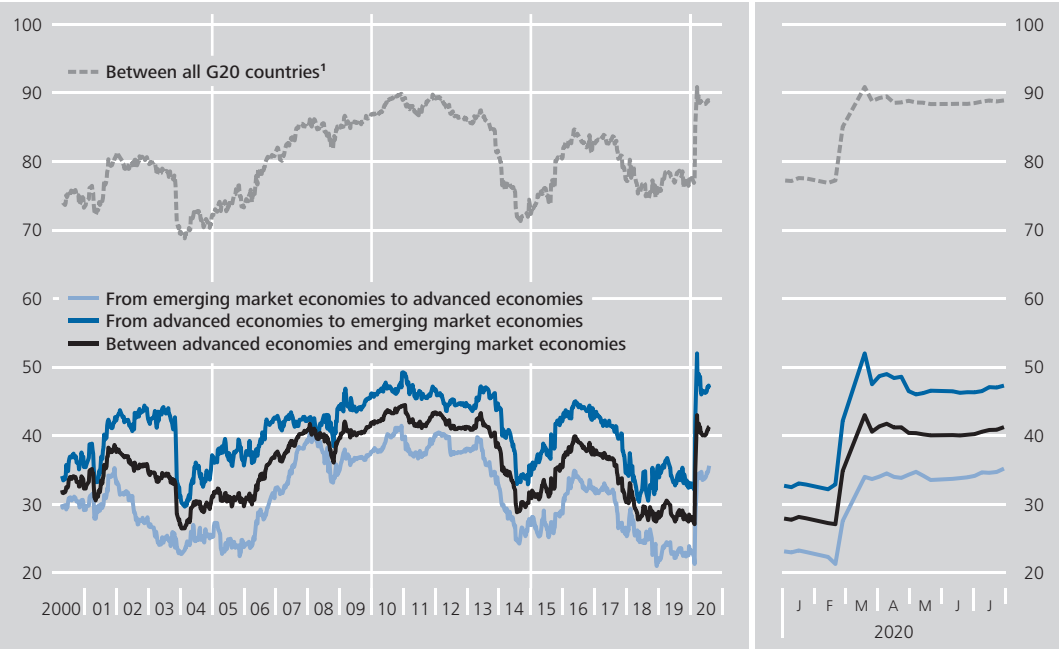
Sources: Bloomberg and Bundesbank calculations. * For the purposes of this analysis, the G20 emerging market economies comprise Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Turkey, and the advanced economies in the G20 are Australia, Canada, France, Germany, Italy, Japan, South Korea, the United Kingdom and the United States.

Deutsche Bundesbank

19 Note that the calculations discounted points in time for which there were no data for one or more variables. This means that any 100-week window refers to the last 100 weeks when data were available for all variables.

Spillover index* for G20 benchmark equity indices

%, weekly data, averages calculated on a rolling basis over the preceding 100 weeks



Sources: Bloomberg and Bundesbank calculations. * Spillover indices measure the strength of spillover effects. They are calculated by performing a generalised forecast error variance decomposition in a VAR(2) model with a ten-day forecast horizon and row normalisation based on Koop et al. (1996), Pesaran and Shin (1998) and Diebold and Yılmaz (2009, 2012). The spillover indices describe the percentage of the variance explained by foreign shocks in the respective periods. 1 Includes spillover effects from advanced economies to emerging market economies and vice versa but also spillover effects within the group of advanced economies and that of emerging market economies – for instance, spillovers from Germany to France.

Deutsche Bundesbank

creased especially when financial markets have experienced phases of heightened stress, such as the bursting of the dotcom bubble in 2000, the global financial crisis and the onset of the COVID-19 pandemic. These final two events represent the strongest and, above all, most rapid rise in spillovers in the period covered by the analysis. That the COVID-19 pandemic is so clearly reflected in the estimation results is striking. Having said that, compared with other crisis periods, this pandemic has hit all countries hard and, most importantly, unexpectedly. It remains to be seen how spillover effects will evolve over time and whether a prolonged period of high spillovers will set in, as it did in the wake of the global financial crisis.

Vulnerabilities in emerging market economies

The rise in international capital flows and the rapidity with which capital markets respond have fundamentally changed the conditions for national economic policy in open economies.

Crises in individual emerging market economies can spread to others …

In particular, as shown above, countries are vulnerable to shocks or spillovers emanating from other countries. In the past, crises in one country have already been known to spread to other emerging market economies or induce wake-up calls for investors.[20] With emerging market economies now more deeply integrated into the global financial system, this could also increasingly entail spillbacks to advanced economies.

… and can also exert spillback effects on advanced economies

It is also conceivable that, where investors harbour mistrust towards a country with high levels of debt and pursuing economic policies that do not inspire confidence, such sentiments may spread to other countries with similar issues, be they an emerging market economy

20 See Ahnert and Bertsch (2015).

A heatmap for the external stability of selected emerging market economies

Similarly to international institutions, the Bundesbank calculates and assesses a variety of metrics that shed light on the external stability of selected emerging market economies (EMEs).[1] These include a metric for assessing a country's foreign currency reserve adequacy (ARA), exchange market pressure (EMP), and inflows from investment funds that invest in EMEs. Warning signals can be derived from these indicators in the event that certain thresholds are exceeded or undershot. By colour-coding the number of such warning signals for each country and each point in time, they can be presented visually in the form of a heatmap.

The three selected indicators and the definition of the warning signals are described in more detail below.

The ARA indicator shows whether a country has sufficient reserves to compensate for an outflow of foreign currency in the event of a temporary crisis. The magnitude of potential outflows is determined on the basis of historical experience (i.e. from past balance of payments crises) and current macroeconomic conditions. If the existing foreign currency reserves are lower than the threshold value derived from them, a warning signal is emitted in the corresponding quarter. The indicator was originally developed by the International Monetary Fund (IMF). The Bundesbank uses a slightly modified version.[2]

The EMP indicator measures the exchange market pressure affecting a country's currency (i) at time t. Various options for estimating the EMP indicator are discussed in the literature.[3] The indicator used here is derived from the unweighted average of the bilateral rate of change in the exchange rate against the US dollar $(\Delta\% S)$,[4] the percentage change in foreign reserves $(\Delta\% R)$ and the difference in short-term domestic interest rates relative to the short-term interest rate level of the United States (ΔI):[5]

$$EMP_{i,t} = \frac{1}{3}(\Delta I_{i,t} - \Delta\% S_{i,t} - \Delta\% R_{i,t}).$$

A warning signal is triggered when the value of the EMP indicator exceeds its long-term, country-specific average by 1.5 times the standard deviation of the index.[6]

Overall, the EMP indicator is less persistent than the ARA indicator. Warning signals thus only appear for relatively short periods of time in the EMP indicator. One reason for this is that in contrast to the ARA indicator, the EMP indicator is not based on levels, but rather on rates of change (within a quarter). The latter generally revert quickly to their average values. The variables exam-

---

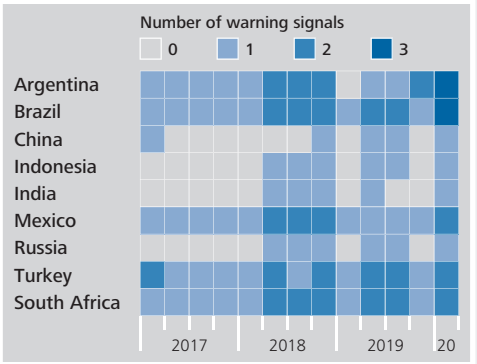
1 The EMEs are a selection of those represented in the G20 (Argentina, Brazil, China, India, Indonesia, Mexico, Russia, South Africa and Turkey). In addition to this, the Bundesbank also studies individual countries that are currently subject to especial external exposure on account of particular events or that are in the spotlight for any other reason on an ad hoc basis.
2 See IMF (2011, 2015) and Deutsche Bundesbank (2017).
3 See Hossfeld and Pramor (2018).
4 Indirect quotation: an increase in the exchange rate represents an appreciation of the respective domestic currency.
5 The indicator based on the unweighted average has proven to be a particularly robust measure in empirical studies.
6 The EMP indices are adjusted for statistical outliers when calculating the standard deviation. Without such adjustment, particularly severe crises would distort the standard deviation upwards to such an extent that smaller crises would no longer be identified. An outlier is defined as an absolute value that exceeds the country-specific absolute minimum of the EMP index by 100. This threshold value was chosen so that known crisis periods from the past could be identified as successfully as possible.

ined by the EMP indicator would thus have to experience above-average change over a relatively long period of time to trigger a signal lasting over several quarters. By contrast, if holdings of foreign currency reserves fall under the threshold value and remain there, this is enough to trigger a persistent signal in the ARA indicator.

The inflows from investment funds that invest in a specific country serve as a timely indicator for the gross capital flows into that country.[7] A warning signal is triggered as soon as the sum of investment in debt securities and equity instruments demonstrates that international investors have withdrawn funds from a country over one quarter. In this context, it is rather unusual for the countries under observation to display an outflow of funds exceeding a period of three months. The threshold value is therefore selected to ensure that even marginal outflows trigger a warning signal. This indicator correlates strongly across the individual EMEs, suggesting that investors tend to make their investment decisions for several EMEs at the same time. That said, country-specific factors, which may even occasionally outweigh cross-border influences, also play a role.

Each of the three indicators can be studied individually in order to identify tensions in a specific area of international capital flows. However, severe tensions often appear in several different indicators at the same time, as the individual indicators are not independent of each other. If, for example, international investors shift their focus away from a particular investment location, the effect of this is unlikely to be restricted to capital outflows. The currency of the affected country may also come under pressure, resulting in a persistent outflow of foreign reserves if the central bank attempts to bolster the national currency. This may ultimately mean that the critical mass of foreign reserves is undershot.

Heatmap for warning signals regarding the external stability of emerging market economies' capital flows



Deutsche Bundesbank

The three indicators can be summarised in a heatmap, which paints a clear yet nuanced picture of a country's external vulnerability. The total number of warning signals from the various indicators is added up for each point in time and each country. The corresponding sum is then colour-coded to provide a general overview. For instance, a country's cell is shaded light grey if no warning signal appears at the corresponding point in time across all indicators. If there is a single warning signal, the cell is shaded light blue. If there are two or three warning signals, the cell is shaded medium blue or dark blue respectively. A dark blue signal is thus interpreted to mean that, at the point in question, a country's foreign currency reserves are too low, it is subject to exchange rate pressure and, at the same

7 The data are based on the monthly reports of EPFR Global. These reports depict the inflows from investment funds that submit information to EPFR Global. The values can therefore only be taken as an approximation of the official balance of payments data. As the official data are generally only published after a significant delay, developments in international capital flows can be assessed considerably sooner with the data used here.

time, international investors are withdrawing funds from that country.

The heatmap (see the chart on p. 65) shows the results for the EMEs of the G20. The period under review runs from the first quarter of 2017 to the first quarter of 2020.

The chart clearly illustrates the increase in external vulnerability associated with the COVID-19 pandemic in the first quarter of 2020. On account of the pandemic-related uncertainty regarding future global economic developments, investors appear to have withdrawn capital from EMEs to a greater extent. This resulted in the relevant indicator showing a warning signal for all countries under observation during the first three months of 2020, and also explains why there is at least a light blue signal on the heatmap for each country.

As the estimated ARA indicator in the first quarter of 2020 also confirms an insufficient stock of foreign currency reserves in the case of Argentina, Brazil, Mexico, Turkey and South Africa, these countries display at least a medium blue signal.

The heatmap even shows dark blue signals for two of the countries under observation. This can be attributed to the fact that heightened exchange market pressure could be observed for Argentina and Brazil in addition to the aforementioned warning signals.

A heatmap can be used to depict key developments and relationships in a timely and concise manner. Even so, it should always be embedded into a more comprehensive analysis rather than serving as a replacement for this; in spite of the extensive analyses behind the individual indicators, external sector developments are ultimately presented in a highly simplified manner. This reflects the fact that the warning signals and indicators are, in part, based on strong assumptions and are subject to estimation uncertainty. For example, a stable relationship between the observable variables during past and possible current crises is assumed. Even summarising the indicators by giving all warning signals the same weighting represents a considerable simplification. Ultimately, the three indicators under consideration deliver only a limited overview of the developments in international capital movements. Nevertheless, the results provide key indications as to which countries' capital flows merit closer analysis with regard to external stability.

or an advanced economy. The magnitude of the distortions experienced in the countries is therefore contingent not only on the external impulse but also on the domestic vulnerabilities of the countries.

Vulnerabilities in G20 emerging market economies significantly higher in some cases as a result of COVID-19

The box on pp. 64 ff. takes a closer look at the external vulnerability of emerging market economies belonging to the G20. Analysing past financial market and balance of payments crises reveals that exchange market pressure on the domestic currency, foreign currency reserve holdings and the behaviour of international investors are key factors. Critical values are determined for these three indicators; whenever they exceed or fall below these markers, a warning signal is triggered. The investigation shows that the external stability of certain countries deteriorated sharply during the COVID-19 pandemic. This is particularly true of Argentina and Brazil, which breached the predefined thresholds for all three criteria. This does not necessarily mean that the other countries are less at risk of external imbalance, however. Examining the selected indicators and the warning signals triggered can only furnish initial reference points for a more in-depth analysis. This is partly because it is not possible to take all potential threats into account. Furthermore, the threshold values in question were calculated on the basis of historical crisis patterns and with transmission mechanisms assumed to hold constant. These may change over time, however.

Economic policy options for utilising the benefits of cross-border capital flows

Appropriate economic policy can influence the impact of capital flows

Capital flows to emerging market economies have, in recent decades, been highly volatile: periods of strong inflows have been followed by times where inflows have suddenly dried up or where there have even been massive outflows. The forces driving these phenomena may lie in the emerging market economies themselves, but may also be the product of global trends.

By implementing appropriate policy measures, emerging market economies can help ensure that capital inflows do not have a destabilising effect and instead bring sustainable economic benefits. Well-developed and regulated financial systems and, above all, sound macroeconomic policies can bolster resilience; they can help to prevent crises and to give economic policymakers room for manoeuvre when challenging economic conditions arise.

Developing local capital markets can lessen vulnerability to crises

A potential starting point in terms of expanding this scope for economic policy action lies in developing local capital markets. This would improve access to borrowing in local currency, and therefore reduce financing needs in foreign currency for a given debt level, which is considered one of the major reasons behind heightened financial system vulnerability. This has prompted many emerging market economies to push forward with the development of local capital markets in recent years.[21] Almost everywhere, this has been accompanied by a significant increase in the proportion of local currency debt, which shifts the exchange rate risk for that portion of debt to foreign creditors. While issuance in local currency has become established practice for government securities, corporate debt continues to be predominantly denominated in foreign currency. Moreover, events in spring 2020 showed that markets for debt instruments denominated in domestic currency are also exposed to heightened volatility not least due to international investors selling off debt instruments issued by emerging market economies.[22] Since foreign investors' investment motives need not be geared only to local circumstances but also to regional developments or to the behaviour of other investors, building up a sufficiently large base of domestic investors might be helpful in

21 This has also been accompanied by a significant increase in debt, however. According to the BIS, public debt on the capital market rose across a broad base of emerging market economies from 18% of gross domestic product in 2000 to 37% in 2017. See Wooldridge (2020).
22 This appears to be due to the presence of a small number of large investment funds in these countries and a tendency toward herd behaviour. See Wooldridge (2020).

limiting volatility from this source. However, emerging market economies often still lack the supporting infrastructure, such as liquid derivatives markets, which facilitate local trading.

When capital flows exhibit a high degree of volatility, flexible exchange rates can, in principle, absorb some of the external shocks. Monetary policy can also respond, with the classic instruments being interest rate adjustment or interventions in the foreign exchange market. Recent IMF analyses suggest that, contrary to previous assumptions, the transmission of interest rate policy decisions in emerging market economies which have adopted inflation targeting can be as effective as in advanced economies.[23]

Foreign exchange reserves are an important tool in avoiding crises

Sufficiently large foreign exchange reserves can increase the options available to emerging market economies. First, foreign exchange reserves built up in good times have an important positive signalling function, meaning that, in a best-case scenario, the mere existence of high reserves can prevent investors from losing confidence and a crisis from breaking out. Second, solid reserve buffers can be used to temporarily offset capital outflows in the event of a crisis and thus limit excessive exchange rate fluctuations. However, interventions of this type should only function as an adjustment mechanism during periods of heightened volatility in capital flows. They should not be used to replace necessary economic policy corrections or prevent fundamentally necessary adjustments to the (real) exchange rate in the long term.

Isolated foreign exchange market interventions during the COVID-19 pandemic

Given the current economic turmoil, it is difficult to unequivocally assess the intervention behaviour of most countries as these data are often confidential. According to the IMF, individual countries such as Brazil, Russia, Turkey and Indonesia have intervened in the foreign exchange market on a number of occasions since February 2020 or, like India, have carried out foreign exchange swaps.[24]

Macroprudential measures may also influence capital flows and are often implemented

In addition to the instruments mentioned above, countries may also implement measures to influence capital flows more directly. This category covers macroprudential policies but also capital controls. Since the financial crisis, macroprudential measures have increasingly been employed as an economic policy tool and are mostly used to influence credit growth and financial institutions' leverage by curbing or facilitating the inflow of capital. They are often used as preventative measures to stop imbalances from emerging in the financial system, and typically tend to be long-term. Despite their growing use, however, there has so far been little empirical evidence on the extent to which macroprudential measures are able to reduce spillover effects.[25] The easing of macroprudential measures is one of the most frequently used economic policy responses to the COVID-19 crisis alongside fiscal and monetary policy responses. Almost every country made use of them in one form or another with the primary objective of facilitating access to liquidity across the individual G20 member states.[26]

Capital controls are often subject to criticism, …

Macroprudential measures may also take the form of capital controls when they affect capital flows. Academic literature and international organisations are largely critical of such measures due to their distortionary effects on capital allocation. However, those taken as part of a longer-term strategy to liberalise capital movements are largely undisputed. They should be used to prevent imbalances from building up as long as the financial systems in question remain relatively underdeveloped.

… but they may have a positive impact on financial stability

As experience of the global financial crisis has shown, capital controls are increasingly being seen as a potential means of safeguarding financial stability. For example, they could be used to change the composition of capital

23 See Brandao-Marques et al. (2020).
24 See IMF (2020a). In the case of Russia, sales of foreign currency from the National Welfare Fund on 10 March 2020 are due to the oil price falling below the reference value. See also IMF (2020b).
25 See Buch and Goldberg (2020).
26 See IMF (2020a).

flows in favour of capital flows with low volatility. In the case of critical capital outflows, capital controls could also be regarded as a legitimate policy instrument under certain conditions. This thinking is outlined in the Institutional View,[27] authored by the IMF in 2012, which considers the deployment of capital controls as a possible policy option depending on country-specific considerations. Owing to the side effects associated with this instrument, for instance with regard to circumventions, measures regulating capital movements should be transparent and temporary. As soon as the critical situation is over, these controls should be lifted. Under no circumstances should they be used to delay necessary macroeconomic adjustments. According to the IMF, no G20 country has yet introduced additional capital controls in the context of the current COVID-19 pandemic.

International community can provide support

The grave global consequences of the COVID-19 pandemic have once again made it clear that the associated challenges at the national level may be beyond the financial capacities of less developed countries in particular. These require supplementary international policy approaches, policy advice and financial support. The latter can be provided through official financial assistance from countries and organisations, the IMF, multilateral and regional development banks and/or regional institutions (Regional Financing Arrangements). In addition, the central banks of reserve currency countries may, within their mandate, grant swap lines or repo facilities to other central banks in order to safeguard the liquidity of the money market in foreign currency.[28]

IMF responded swiftly and comprehensively to the COVID-19 pandemic

Owing to its global membership, its mandate and its expertise, the IMF plays a prominent role in helping to combat balance of payments problems. With permanent resources of around €570 billion, funds from credit lines worth around €600 billion for crisis situations and additional trust funds for financial assistance to low-income countries, it has ample financial resources to support members when needed.

During the COVID-19 pandemic, the IMF has already provided financial support to over 85 member countries and has taken a number of measures to assist members more effectively. For example, the access limits for emergency credit (Rapid Credit Facility (RCF) and Rapid Financing Instrument (RFI)) and the annual access limits for financial assistance were temporarily increased. In addition, the priorities of the IMF work programme and internal processes have been revised in order to enable the Fund to respond more quickly to members' requests for assistance. In addition, a new temporary short-term liquidity line was set up for members with very strong economic fundamentals in order to cushion moderate balance of payments needs arising due to tension in the international capital markets.

Conclusion

Still not possible to assess the COVID-19 pandemic's impact on financial market integration

The global interconnectedness of national financial systems has continued to increase over the past two decades, although this trend has lessened somewhat since the global financial crisis. It is not possible at this stage to conclusively assess how the COVID-19 pandemic will affect this trend. Given the high level of global economic integration achieved, emerging market economies and, increasingly, advanced economies are vulnerable to external shocks. Global capital flows are a key transmission channel, and their volatility can present a challenge, especially to countries with less developed financial systems. The current COVID-19 pandemic has shown once again that, dur-

27 The full title is The Liberalization and Management of Capital Flows: An Institutional View. See IMF (2012).
28 Since the global financial crisis, there has been an arrangement between the Federal Reserve, the ECB, the Bank of Japan, the Bank of England, the Bank of Canada and the Swiss National Bank. Following the outbreak of the COVID-19 pandemic, the ECB additionally agreed on temporary and limited swap lines with Bulgaria, Croatia and Denmark. The US Federal Reserve set up similar swap lines with Australia, Brazil, Denmark, Mexico, New Zealand, Norway, Singapore, South Korea and Sweden. Both the Federal Reserve and the ECB have also established securities repurchase agreements with other central banks. See Federal Reserve Board (2020) and European Central Bank (2020).

ing periods of stress, a flight to safe investments, domestic assets and cash can exacerbate tensions for emerging market economies. However, the analysis also shows that, as financial spillovers to and spillbacks from emerging market economies increase, domestic economic policy in advanced economies may also be exposed to potentially destabilising influences.

The G20 countries present a mixed picture in this respect: some countries tend to transmit spillover effects on balance, whilst others mainly receive them. The effects within country groups are more pronounced than between advanced and emerging market economies, although the advanced economies are still responsible for stronger spillovers to the emerging market economies than vice versa. Worth noting is the stark rise in transmission effects at the onset of the COVID-19 pandemic, which exceeded the level of the global financial crisis at an early stage.

The extent of the vulnerabilities is not determined solely by the spillover effects, but also needs to be assessed together with local conditions in the individual countries. This shows that the potential vulnerabilities of individual G20 members have increased markedly in the current crisis. The extent to which these vulnerabilities will materialise is partly determined by each country's economic policy. The development of local capital markets and a sufficient stock of foreign exchange reserves are useful components of a stability-oriented macroeconomic policy. From a financial stability perspective, it may make sense to deploy macroprudential measures as well as – under certain circumstances – measures designed to manage capital flows. Where necessary, the international community can also provide support.

List of references

Acharya, V. V., L. H. Pedersen, T. Philippon and M. Richardson (2016), Measuring Systemic Risk, The Review of Financial Studies, Vol. 30, No 1.

Adrian, T. and M. K. Brunnermeier (2016), CoVaR, American Economic Review, Vol. 106, No 7, pp. 1705-1741.

Ahmed, S., B. Coulibaly and A. Zlate (2015), International Financial Spillovers to Emerging Market Economies: How Important Are Economic Fundamentals?, International Finance Discussion Papers 1135.

Ahnert, T. and C. Bertsch (2015), A Wake-Up-Call Theory of Contagion, Staff Working Papers 15-14, Bank of Canada.

Allen, F. and D. Gale (2000), Financial Contagion, Journal of Political Economy, Vol. 108, No 1, pp. 1-33.

Arsov, I., E. Canetti, L. Kodres and S. Mitra (2013), Near-Coincident Indicators of Systemic Stress, IMF Working Paper, 13/115.

Bank for International Settlements (2018), Financial spillovers, spillbacks, and the scope for international macroprudential policy coordination, BIS Papers No 97.

Bettendorf, T. and R. Heinlein (2019), Connectedness between G10 currencies: Searching for the causal structure, Deutsche Bundesbank Discussion Paper No 06/2019.

Borio, C. and P. Disyatat (2015), Capital flows and the current account: Taking financing (more) seriously, BIS Working Paper No 525.

Bricco, J. and T. Xu (2019), Interconnectedness and Contagion Analysis: A Practical Framework, IMF Working Paper, October 2019.

Brandao-Marques, L., G. Gelos, T. Harjes, R. Sahay and Y. Xue (2020), Monetary Policy Transmission in Emerging Markets and Developing Economies, IMF WP/20/35.

Buch, C. and L. Goldberg (2020), Global Banking: Towards an Assessment of Benefits and Costs, Annual Review of Financial Economics, forthcoming.

Bussière, M., J. Schmidt and N. Valla (2016), International Financial Flows in the New Normal: Key Patterns (and Why We Should Care), CEPII Policy Brief 2016-10, CEPII Research Center.

Calvo, G., L. Leiderman and C. Reinhart (1996), Inflows of Capital to Developing Countries in the 1990s, Journal of Economic Perspectives, Vol. 10 No 2, Spring 1996, pp. 123-139.

Carney, M. (2019), Pull, push, pipes: sustainable capital flows for a new world order, https://www.bankofengland.co.uk/speech/2019/mark-carney-keynote-remarks-at-the-2019-institute-of-international-finance-spring-membership-meeting

Cerutti, E., S. Claessens and D. Puy (2015), Push Factors and Capital Flows to Emerging Markets: Why Knowing Your Lender Matters More Than Fundamentals, IMF WP/15/127.

Committee on the Global Financial System (2009), Capital flows and emerging market economies, CGFS Papers No 33.

Deutsche Bundesbank (2019), Parallels in the exchange rate movements of major currencies, Monthly Report, July 2019, pp. 17-37.

Deutsche Bundesbank (2017), Do sufficient foreign exchange reserve holdings reduce the probability of balance of payments crises?, Monthly Report, October 2017, pp. 23-25.

Diebold, F. X. and K. Yılmaz (2015), Financial and Macroeconomic Connectedness – A Network Approach to Measurement and Monitoring, Oxford University Press.

Diebold, F. X. and K. Yılmaz (2014), On the network topology of variance decompositions: Measuring the connectedness of financial firms, Journal of Econometrics, Vol. 182, No 1, pp. 119-134.

Diebold, F. X. and K. Yılmaz (2012), Better to give than to receive: Predictive directional measurement of volatility spillovers, International Journal of Forecasting, Vol. 28, pp. 57-66.

Diebold, F. X. and K. Yılmaz (2009), Measuring financial asset return and volatility spillovers, with application to global equity markets, The Economic Journal, Vol. 119, No 534, pp. 158-171.

Dungey, D., R. Fry, B. Gonzáles-Hermosillo and V. Martin (2005), Empirical modelling of contagion: a review of methodologies, Quantitative Finance, Vol. 5, pp. 9-24.

European Central Bank (2020), Press Release: New Eurosystem repo facility to provide euro liquidity to non-euro area central banks, 25 June 2020, https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200625~60373986e5.en.html

Federal Reserve Board (2020), Press Release: Federal Reserve announces the establishment of temporary U.S. dollar liquidity arrangements with other central banks, 19 March 2020, https://www.federalreserve.gov/newsevents/pressreleases/monetary20200319b.htm

Forbes, K. J. and R. Rigobon (2002), No Contagion, Only Interdependence: Measuring Stock Market Comovements, The Journal of Finance, Vol. LVII, No 5.

Forbes, K. and F. Warnock (2012), Capital Flow Waves: Surges Stops, Flight, and Retrenchment, Journal of International Economics Vol. 88, pp. 235-251.

Glasserman, P. and H. P. Young (2016), Contagion in Financial Networks, Journal of Economic Literature, Vol. 54, No 3, pp. 779-831.

Hossfeld, O. and M. Pramor, Global liquidity and exchange market pressure in emerging market economies, Deutsche Bundesbank Discussion Paper No 05/2018, April 2018.

International Monetary Fund (2020a), https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19, 31 July 2020.

International Monetary Fund (2020b), Group of Twenty: Implementation of the G-20 Action Plan, July 2020.

International Monetary Fund (2016), Global Financial Stability Report, April 2016.

International Monetary Fund (2015), Assessing Reserve Adequacy – Specific Proposals, IMF Policy Paper, 121914.

International Monetary Fund (2011), Assessing Reserve Adequacy, IMF Policy Paper, 021411b.

Koepke, R. and S. Paetzold (2020), Capital Flow Data – A Guide for Empirical Analysis and Real-Time Tracking, IMF Working Paper, WP/20/171.

Koop, G., M. H. Pesaran and S.M. Potter (1996), Impulse response analysis in nonlinear multivariate models, Journal of Econometrics, Vol. 74, pp. 119-147.

Lütkepohl, H. (2005), New Introduction to Multiple Time Series Analysis, Springer Verlag Berlin Heidelberg.

Obstfeld, M. (2014), Trilemmas and Tradeoffs: Living with Financial Globalization, http://eml.berkeley.edu//~obstfeld/Trilemmas_last%20draft.pdf, 14 August 2020.

Pagliari, M. S. and S. A. Hannan (2017), The Volatility of Capital Flows in Emerging Markets: Measures and Determinants, IMF WP/17/41.

Pesaran, H. H. and Y. Shin (1998), Generalized Impulse Response Analysis in Linear Multivariate Models, Economic Letters, Vol. 58, pp. 17-29.

Upper, C. (2011), Simulation methods to assess the danger of contagion in interbank markets, Journal of Financial Stability, Vol. 7, pp. 111-125.

Wooldridge, P. (2020), Implications of financial market development for financial stability in emerging market economies, https://www.bis.org/publ/othp32.htm, 14 August 2020.