CHAPTER 4

TRADING PLACES: REAL SPILLOVERS FROM G20 EMERGING MARKETS
ONLINE ANNEXES

Online Annexes 4.1–4.5 provide the data sources, methodology, additional results and robustness tests to complement the discussion of the main findings in the main text.

Online Annex 4.1. Stylized Facts and Data

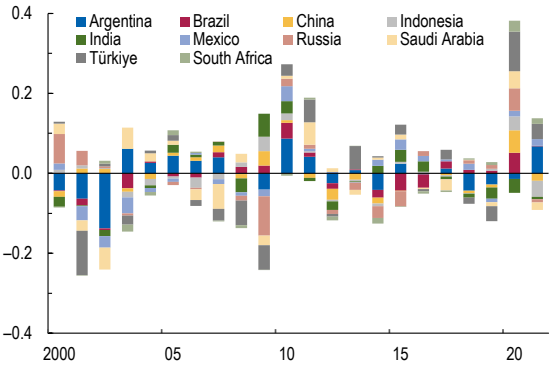
This online annex provides the details behind the descriptive evidence on the increasing footprint of G20 emerging markets presented in the initial sections of the main text. It also provides additional exhibits that complement those in the main text.

Growth Surprises

Growth surprises for a given country *i* in year *t* are defined as the difference between the outturn in year *t* and the projected growth rate, as published in the April vintages of the IMF *World Economic Outlook* of year *t-1*:

$$GS_{it} = Growth_{it}^{Act} - Growth_{it-1}^{Proj} \quad (1)$$

Online Annex Figure 4.1.1. Idiosyncratic Growth Surprises
(Percent)



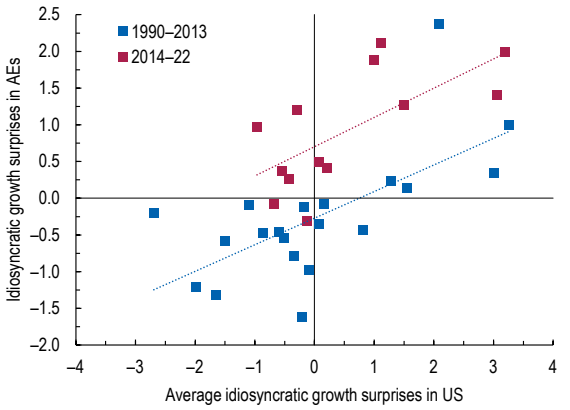
Source: IMF staff calculations.
Note: Growth surprises are defined as $GS_{it} = Growth_{it}^{Act} - Growth_{it-1}^{Proj}$ (using the April WEO projections) while idiosyncratic growth surprises ($\hat{\gamma}_{it}$) defined as the residual of this regression: $GS_{it} = \tau_t + \vartheta_i + \gamma_{it}$

These surprises are the result of common shocks and of an idiosyncratic component, which can be identified as a residual of growth surprises against country (ϑ_i) and year (τ_t) fixed effects. In particular, the idiosyncratic growth surprises ($\hat{\gamma}_{it}$) are computed from the following regression, estimated with annual data between 1990 and 2022, using different WEO vintages:

$$GS_{it} = \tau_t + \vartheta_i + \gamma_{it} \quad (2)$$

These surprises are used to provide preliminary descriptive evidence of the potential spillovers from G20 EMs to advanced economies, which is shown in Figure 4.2 in the main text. The correlation between the average idiosyncratic growth surprises in G20 EMs increased and became statistically significant in the period 2014-2022. By contrast, this association is positive but much weaker and not statistically significant in the first part of the sample (Online Annex Table 4.1.1). As a benchmark, the same analysis done considering the idiosyncratic growth surprises in the U.S. shows that the correlation with the idiosyncratic growth surprises in other advanced economies

Online Annex Figure 4.1.2. Correlation across Idiosyncratic Growth Surprises
(Percent)



Source: IMF staff estimates.
Note: Growth surprises are defined as $GS_{it} = Growth_{it}^{Act} - Growth_{it-1}^{Proj}$ (using the April WEO projections) while idiosyncratic growth surprises ($\hat{\gamma}_{it}$) defined as the residual of this regression: $GS_{it} = \tau_t + \vartheta_i + \gamma_{it}$. AEs = advanced economies; *WEO* = *World Economic Outlook*.

(excluding the U.S.) is positive and statistically significant throughout the entire period (Online Annex Figure 4.1.2), suggesting that the role of G20 EMs in the global economy has become more relevant in the last decade.

Online Annex Table 4.1.1. Correlation across Idiosyncratic Growth Surprises

Dep. Var. Growth surprises in AEs	(1)	(2)	(3)
Average growth surprise G-20 EM x I(1990-2013)	-0.0459	-0.0311	
	(0.075)	(0.080)	
Average growth surprise G-20 EM x I(2014-2022)	0.5153**	0.4619**	
	(0.204)	(0.217)	
Average growth surprise U.S. x I(1990-2013)			0.4336***
			(0.063)
Average growth surprise U.S. x I(2014-2022)			0.4444***
			(0.133)
Observations	297	264	264
R-squared	0.023	0.018	0.187
Sample	AEs	AEs (ex. U.S.)	AEs (ex. U.S.)
Country FE	Y	Y	Y

Sources: IMF staff calculations

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies Growth surprises are defined as the estimated residual (γ) of equation (2).

G20 EM Trade Integration

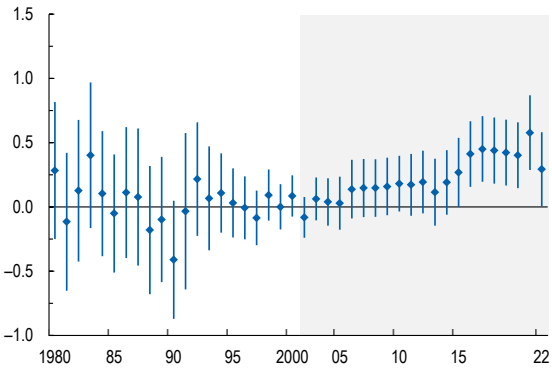
To measure the increased integration of G20 EMs in global trade, the chapter estimates a standard gravity model for bilateral trade on annual data from 1980 to 2022 from the IMF Direction of Trade Statistics:

$$imports_{sdt} = \sum_{t=1980}^{2022} \beta_t\, t \times G20EM + \tau_{st} + \upsilon_{dt} + \psi_{sd} + \varepsilon_{sdt} \qquad (3),$$

where the logarithm of goods imports from the source country s to the destination country d in year t is a function of a dummy variable equal to one if either the source or destination country is a G20 EM and zero otherwise, interacted with the year dummies (t). As is standard in gravity models, equation (3) absorbs any time varying push and pull unobservable factors adding source country s year (γ_{sd}) and destination country d year (υ_{dt}) fixed effects. The country-pair fixed effects (ψ_{sd}) capture all bilateral

Online Annex Figure 4.1.3. Increase in G20 Emerging Markets Global Trade Excluding China

(Log points)



Sources: IMF, *Direction of Trade Statistics*; and IMF staff calculations.
Note: The chart is based on a standard gravity trade model estimated with IMF DOTS data in which the dependent variable is the log of bilateral goods trade. The model includes country pair, source x year and destination x year fixed effects. The chart plots the yearly coefficient of a dummy for the bilateral pairs involving G20 EMs (the reference year is 2001). EMs = emerging markets.

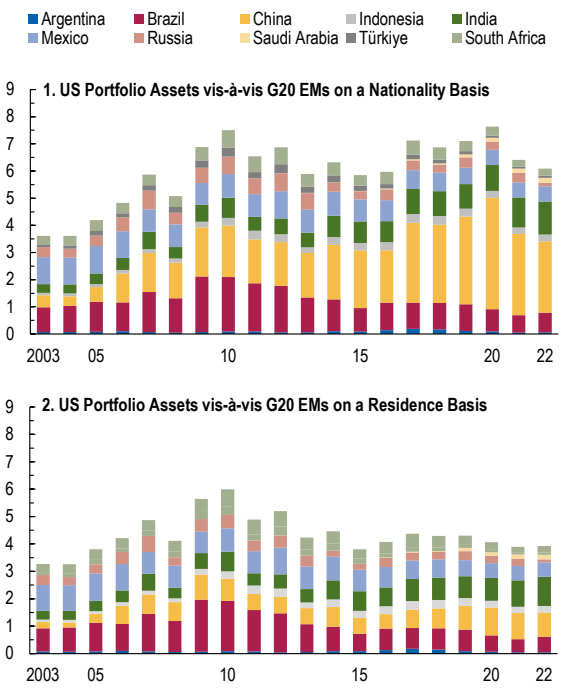
(time-invariant) sources of heterogeneity, such as geographical distance, cultural differences, and historical measures of colonial ties.

The set of estimated coefficients β_t measure the difference in trade involving G20 EMs compared with trade flows among other countries. Figure 4.3 in the main text shows that trade with G20 EMs accelerated following China's accession to the WTO in 2001 and more so in the second half of the 2010s. However, it is important to note that, while China plays an important role in the increasing trade integration of G20 EMs, this trend is not uniquely attributable to China, but is common to other G20 EMs, as shown by the Online Annex Figure 4.1.3.

G20 EM Financial Integration

Online Annex Figure 4.1.4 complements the analysis in the chapter on portfolio flows from advanced economies to G20 EMs (Figure 4.4) by zooming in on US portfolio assets. Using the security-level data on US cross-border portfolio holdings collected by Bertaut, Bressler and Curcuru (2019) from the Treasury International Capital (TIC) system, panel 1 reports US portfolio assets vis-a-vis individual G20 EMs, on a nationality basis, as share of total US portfolio assets abroad. The chart shows an increase in this share from 3 percent in the early 2000s to around 7 percent in the early 2020s, driven largely by US assets in China and, to a lesser extent, India. This increase parallels the one documented in the main text on bank flows from G5 economies.

Online Annex Figure 4.1.4. US Portfolio Assets vis-à-vis G20 Emerging Markets
(Percent of total assets)



Source: Bertaut et al (2019).
Note: EMs = emerging markets.

Panel 2 in Online Annex Figure 4.1.4 reports US portfolio assets vis-a-vis individual G20 EMs on a residence basis, also as a share of total US portfolio assets abroad. The notable difference between the two panels is that the increase in US portfolio assets in China on a nationality basis is not visible when the data are reported on a residence basis. This signals that most US investment in China in recent years has been channeled through third countries, a pattern documented in Coppola and others (2021).

Are G20 Emerging Market Economies Small and Open?

Given the increased footprint of G20 EMs in the world economy, whether assuming that these economies are small and open is, or remains, a reasonable assumption is examined below.

To this end, this section updates the model developed by Fernandez, Schmitt-Grohé and Uribe (2017). The authors develop a model for a small open economy (SOE) in which domestic fluctuations are affected by a group of global variables that includes commodity prices and an

indicator of international financial conditions. The literature has shown that, in addition to domestic supply-side shocks, these global variables, account for most of the business cycle fluctuations in emerging market economies.

Specifically, the following system is estimated for each G20 EM:

$$\begin{bmatrix} F_t \\ Y_{i,t} \end{bmatrix} = \begin{bmatrix} A & \emptyset \\ B & C \end{bmatrix} \begin{bmatrix} F_{t-1} \\ Y_{i,t-1} \end{bmatrix} + \begin{bmatrix} I & \emptyset \\ D & I \end{bmatrix} \begin{bmatrix} \mu_t \\ \epsilon_{i,t} \end{bmatrix}$$

Where F_t represents the vector of global variables, including the cyclical component of the real price of agriculture, metals, and fuel, as well as a financial variable which is either the real gross return of 3-month US T-Bills, real gross return on US 10-year government bonds, the US real effective exchange rate, or Moody's investment-grade corporate spread. $Y_{i,t}$ corresponds the cyclical component of GDP in a G20 EM. This model assumes that global variables can influence the domestic economy, while the latter cannot affect commodity prices or international finance conditions, contemporaneously or with a lag. This so-called "block exogeneity" is only appropriate for SOEs, which are price-takers in international markets.

The model is estimated on quarterly data available since 1980, except for Russia, for which data is available since 1995.[1] Argentina and Saudi Arabia are not included in the analysis, because of data limitations. For each country, results across two sub-sample periods are reported: before and after the Global Financial Crisis (GFC). The GFC episode itself is not included in either sub-period. Similarly, the post-GFC period excludes the COVID-19 pandemic crisis. These major global events are not included, as the model by Fernandez, Schmitt-Grohé and Uribe (2017) may not be able to explain their dynamics. The post-pandemic period is excluded because the sample is too short to provide reliable estimates.

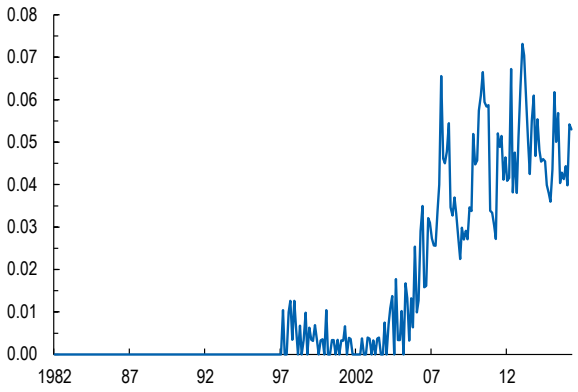
A likelihood ratio test compares unrestricted estimates with those of a model restricted by the block-exogeneity assumption, to identify the emerging markets for which the SOE assumption is or remains valid.

A first test focuses on the incidence of EM fluctuations on one global variable at a time. The results indicate that after the GFC most G20 EMs affect at least one global price, conditional on the block-exogeneity assumption for all other global variables. The increase is notable for agriculture commodity prices and short-term interest rates. The latter result can be rationalized by noting that macroeconomic developments and prospects in emerging market economies, are usually (and increasingly) examined ahead of FOMC meetings in the so-called Greenbook or

[1] Given concerns about measurement problems with China's GDP, notably post GFC, alternative indicators are also used for this country, including the San Francisco Fed's China Cyclical Activity Tracker, and the Li indicator (see Fernald and others, 2020). These indicators correspond to year-on-year growth rates of the cyclical component of GDP. The variable is transformed to obtain quarterly GDP in levels. The level series is subsequently seasonally adjusted. For the other countries, quarterly GDP going back to 1980 is possible using the data put together by Aslam and others (forthcoming), which compiles datasets from multiple sources, including WEO, IFS, OECD, and national statistics offices. The authors use temporal disaggregation techniques to obtain estimates of quarterly GDP in the earlier period, as Abeysinghe and others (2004), for Asian economies.

Tealbook as per data from Aruoba and Drechsel (2023) (Online Annex Figure 4.1.5). Therefore, to the extent that such developments affect the outlook for the US economy, they can potentially influence movements in U.S. short-term rates.

Online Annex Figure 4.1.5. Times Emerging Markets are Mentioned on FED's FOMC Documents
(Percent of document word count)

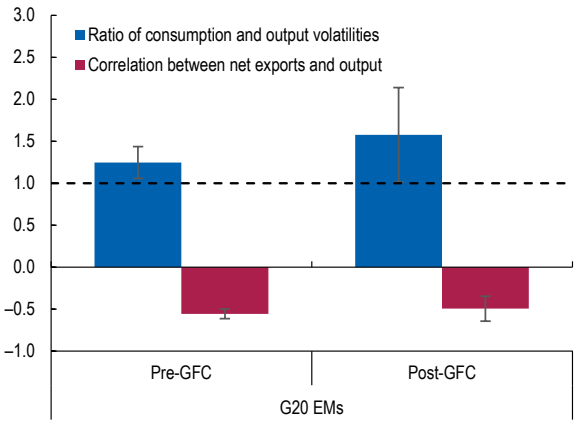


Source: Aruoba and Drechsel (2023).
Note: EMs = emerging markets; FED = federal reserve board; FOMC = Federal Open Market Committee.

A stricter test gauges whether cyclical fluctuations in G20 EMs are weakly exogenous with respect to the entire vector of global variables. Using this criterion, the SOE assumption is only rejected for China across all model specifications, starting on the early 2000s. However, there is some evidence that other emerging market economies may also impact financial variables, even after controlling for their potential effect on commodity prices, including Brazil in the post GFC period, as well as South Africa, Mexico, and Indonesia, if the global vector includes variables associated with investor risk-appetite, such as the investment grade corporate spread. South Africa and Mexico are highly integrated into automotive GVCs, and in the case of Mexico it has led to a high degree of synchronization with the US business cycle (Zlate 2016).

Since G20 EMs excluding China are likely to remain price-takers in the international trade system, an additional exercise is conducted. Following Aguiar and Gopinath (2007), this section examines whether cyclical fluctuations in these countries are driven by shocks to trend growth or transitory shocks around a stable trend. The authors develop a small open economy model, assuming that the permanent income hypothesis holds. In other words, agents' consumption paths change in response to permanent, not transitory, changes in income. Denote the cyclical component of macroeconomic aggregates as follows: output $(\tilde{\boldsymbol{y}})$ and consumption $(\tilde{\boldsymbol{c}})$. And let $\tilde{\boldsymbol{x}}$ denote the ratio of net exports to GDP. The authors find that for emerging market SOEs, the ratio of the volatility of $\tilde{\boldsymbol{c}}$ relative to that of $\tilde{\boldsymbol{y}}$ is higher than unity $(\boldsymbol{\sigma(\tilde{c})/\sigma(\tilde{y}) > 1})$. So even if these macroeconomic aggregates tend to move together, changes in domestic demand often outpace fluctuations in output. In the case of a positive shock, the shortfall in domestic supply would need to be met through net imports, which entails a negative correlation between $\tilde{\boldsymbol{y}}$ and $\tilde{\boldsymbol{x}}$ $\boldsymbol{(\rho(\tilde{y},\tilde{x}) < 0)}$. These stylized facts imply

Online Annex Figure 4.1.6. Average Business Cycle Moments for SOE G20 Emerging Markets
(Percent)



Sources: Aslam and others (forthcoming); Haver Analytics; and IMF Staff calculations.
Note: G20 EMs exclude China. SOE= state-owned enterprise; EMs = emerging markets.

that permanent changes to income are the primary source of fluctuations for these countries.

The estimation of $\sigma(\tilde{c})/\sigma(\tilde{y})$ and $\rho(\tilde{y},\tilde{x})$ is done in a panel of G20 EMs excluding China, India and Mexico, using the GMM estimator for business cycle models developed by Burnside (1999). The results indicate that these economies continue to exhibit emerging market SOE properties identified by Aguiar and Gopinath (2007) (Online Annex Figure 4.1.6).

Online Annex 4.2. Aggregate Spillovers: VAR Analysis

This online annex describes the methodology and output used to analyze empirically aggregate spillovers among G20 advanced and emerging economies and a sample of other EMs based on Structural Vector Autoregression (SVAR) and Global Vector Autoregression (GVAR) models.

Structural VARs

Methodology

Models and data. To quantify the role of spillovers from the G20 EMs to growth in other emerging market and advanced economies, a set of country-specific medium-scale SVARs is estimated. Each SVAR includes real GDP and the CPI index for three sets of countries: a G20 advanced economy, a G20 emerging market and another (non-G20) emerging market (data from World Economic Outlook Database). Within each of these three categories of countries, several are included one at a time, allowing the derivation of estimates of spillovers from each of the 10 G20 EMs to the 9 G20 AEs and to a set of another 19 smaller EMs (see Online Annex Table 4.2.1 for the list of countries included in the analysis).[2] Additional variables are included to capture global factors: the VIX[3], as a proxy of international uncertainty and financial cycles, and a commodity price index[4], capturing global commodity price cycles. Moreover, two growth differentials between pairs of countries are included to sharpen the identification of shocks and enhance the interpretation of results. Hence, each SVAR includes ten variables, as specified in Online Annex Table 4.2.2. Overall, for each of the G20 EMs, 37 models are estimated.[5] The models are estimated with quarterly data spanning from the first quarter of 2001 to the third quarter of 2023. The choice of the starting period allows to avoid modelling the large shocks in some emerging market economies experienced in the 1980s and 1990s, while at the same time fully capturing the period of China's WTO membership and the increasing role of G20 EMs in the global economy.

Identification. The models identify domestic aggregate demand and domestic aggregate supply shocks for each of the G20 EMs, each of the G20 AEs, and each of the smaller EMs, using a combination of sign and zero restrictions, illustrated in Online Annex Table 4.2.2. In general, standard sign restrictions allow to differentiate domestic demand from domestic supply shocks,

[2] The set of non-G20 emerging market economies is chosen to correspond to the same set of non-G20 EMs included in the GVAR model (see next section), to enhance comparability of results.

[3] Data from Chicago Board Options Exchange, CBOE Volatility Index: VIX [VIXCLS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/VIXCLS, monthly averages of daily data.

[4] Data from World Bank Commodities Price Data (The Pink Sheet); https://www.worldbank.org/en/research/commodity-markets, total commodity price index, monthly averages.

[5] The 37 models for each of the G20 EMs include: 28 models with the U.S. as advanced economy and, one at a time, each of the other 28 emerging market economies (e.g., the other 9 G20 EMs and the 19 non-G20 EMs) plus 9 other models with the other 9 advanced economies, one at a time, and a smaller emerging market economy (either South Africa, as the smallest amongst the G20 EMs, or Türkiye, in the case of the models with South Africa as the reference G20 EM).

while standard zero restrictions allow to differentiate domestic from foreign shocks (see, for example, Copestake and others 2023). The latter set of restrictions imply that shocks from smaller economies are assumed to be transmitted to larger economies only with a lag of one quarter. Thus, for example, in the case of the model with data for the U.S., Mexico and Chile, it is assumed that shocks from Chile (with an average weight of 0.4 percent of the total GDP of our sample of countries in nominal GDP PPP U.S. dollar terms over the sample period 2000-2023) can have an effect on real GDP in the U.S. (corresponding share equal to 20.8 percent) and Mexico (corresponding share equal to 2.6 percent) with a lag of one quarter and shocks from Mexico can exert an immediate effect on real GDP in Chile, but they have an impact on US real GDP only after one quarter.

Online Annex Table 4.2.1. List of Countries Included in the Structural VAR Analysis

G20 Advanced Economies (i)		G20 Emerging Economies (j)		Other Emerging Economies (k)	
United States	20.8%	China	18.8%	Bulgaria	0.2%
Japan	5.9%	India	7.8%	Belarus	0.2%
Germany	4.5%	Russia	4.1%	Chile	0.4%
France	3.2%	Brazil	3.4%	Colombia	0.7%
United Kingdom	3.2%	Indonesia	2.9%	Ecuador	0.2%
Italy	2.8%	Mexico	2.6%	Georgia	0.05%
Korea	2.1%	Türkiye	2.1%	Croatia	0.1%
Canada	1.9%	Saudi Arabia	1.8%	Hungary	0.3%
Australia	1.3%	Argentina	1.0%	Kazakhstan	0.4%
		South Africa	0.8%	Moldova	0.03%
				Malaysia	0.8%
				Peru	0.4%
				Philippines	0.8%
				Poland	1.2%
				Romania	0.5%
				Thailand	1.2%
				Tunisia	0.1%
				Ukraine	0.5%
				Vietnam	0.8%

Source: IMF staff calculations.
Note: The percentage value next to each country refers to the average weight in the total sample of countries over 2000-2023 based on GDP PPP US dollars.

Online Annex Table 4.2.2. Identification Restrictions

Variable \ Shock	G20 AEi aggregate supply	G20 AEi aggregate demand	G20 EMj aggregate supply	G20 EMj aggregate demand	other EM_k aggregate supply	other EM_k aggregate demand
G20 AE_i real GDP	+	+	0	0	0	0
G20 AE_i CPI	-	+	(0)	(0)	(0)	(0)
G20 EM_j real GDP			+	+	0	0
G20 EM_j CPI			-	+	(0)	(0)
other EM_k real GDP					+	+
other EM_k CPI					-	+
growth(G20 AE_i)-growth(G20 EM_j)	(+)	(+)				
growth(G20 AE_i)-growth(other EM_k)	(+)	(+)				
VIX		(-)*				
Commodity Price Index		(+)*		(+)*		

Source: IMF staff calculations.
Note: All restrictions are imposed on impact only. * Restrictions only imposed for shocks from the U.S. and China. For the list of countries see Annex Table 4.2.1.

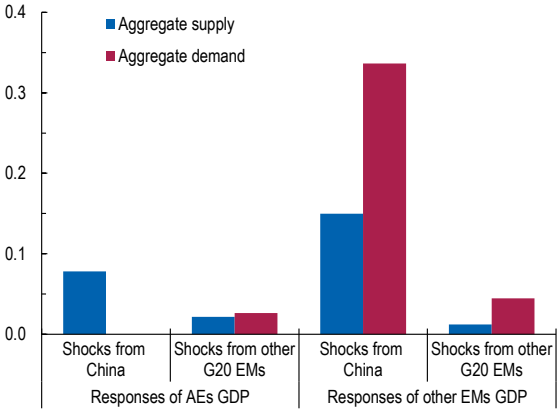
Restrictions in brackets are not strictly necessary for the identification of the shocks of interest but sharpen the identification of shocks and enhance the interpretation of results. Thus, for example, it is assumed that shocks from smaller economies are transmitted with a one quarter lag only to prices in larger economies. Moreover, the restrictions on the growth differentials imply that shocks in advanced economies have a larger immediate effect on their own GDP growth than on growth in emerging market economies. Expansionary (contractionary) aggregate demand shocks from the U.S. and China are assumed to imply an increase (decrease) in the commodity price index on impact, given the role of these economies in the global demand for commodities. Finally, it is assumed that shocks from the United States have an immediate impact on the VIX (downwards if expansionary), reflecting the likely impact of the US economy in the world on global uncertainty and the global financial cycle. Note that shocks from economies other than the U.S. and China are also allowed to affect the VIX and commodity prices immediately, but the sign of such impact is not imposed. Such choice is informed by the results of the small open economy block exogeneity tests (see Online Annex 4.1). However, looking at the impulse responses of the VIX and commodity prices to shocks from other emerging market economies provides a complementary assessment of such a hypothesis.

Estimation. The SVARs are estimated with standard Bayesian methods, with the Minnesota prior hyper-parameters chosen to maximize the marginal data density, following Giannone, Lenza and Primiceri (2015). A correction for heteroskedasticity is imposed for the period of high volatility cluster occurring during the first phase of the COVID-19 pandemic, i.e., in the first three quarters of 2020 (assuming volatility increases by a factor of 10), following the approach of Lenza and Primiceri (2022). MATLAB procedures based on the Canova-Ferroni toolbox are used (see Ferroni and Canova 2022).

Output and Additional Results

Estimates of spillovers can be summarized with impulse response functions (IRFs), historical decompositions (HDs), and forecast error variance decompositions (FEVDs). Spillovers to output tend to be significant over multiple years, while those to consumer prices are often more concentrated in the short term. Thus, results of the VAR analysis are reported for effects on output over three years and for the impact on consumer prices over one year.

Online Annex Figure 4.2.1. Aggregate Growth Spillovers from G20 Countries
(Percent, three years ahead, median)

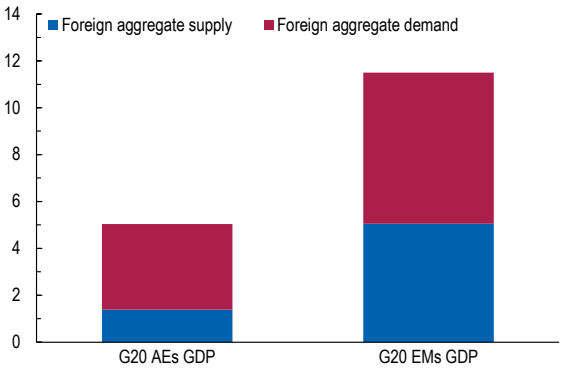


Source: IMF staff calculations.
Note: The figure shows three-year-ahead impulse responses of GDP to aggregate demand and aggregate supply shocks originating from China and other G20 EMs (simple average). AEs = advanced economies; EMs = emerging markets.

IRFs capture the impact of each shock—aggregate demand (AD) and aggregate supply (AS)—originating from each economy to GDP and CPI of each country included in the model, as well as to the control variables. They provide an estimate of the effects of such shocks if a shock of a certain size materializes. To enhance the comparability of spillover estimates across countries, shocks are normalized to lead to a one percent increase four quarters

ahead in GDP of the country of origin of the shock. Figure 4.7 (panel 2) in the main text reports the one-year ahead and three-years ahead median impulse responses of commodity prices to AD shocks originating from China, the U.S. and other G20 EMs (weighted average).[6] All estimates are significant except for those of shocks from other G20 EMs (median estimates are considered to be significant if the range delimited by the 16th and 84th percentiles does not cross the zero line).[7] Online Figure 4.2.1 reports the IRFs of real GDP of AEs and EMs to shocks originating in China and other G20 EMs.

Online Annex Figure 4.2.2. Contribution of Foreign Shocks to Real GDP Volatility
(Percent, three years ahead)



Source: IMF staff calculations.
Note: Fraction of three-year-ahead variance of aggregate GDP of G20 AEs and of G20 EMs explained by shocks to aggregate supply and aggregate demand originating from G20 EMs and G20 AEs, respectively, based on a structural VAR estimated with data from 2001:Q1 to 2023:Q3. AEs = advanced economies; EMs = emerging markets.

HDs illustrate the contribution of each estimated shock to each variable in the system for each quarter. Figure 4.6 (panel 2) in the main text, reports the contribution of shocks to aggregate G20 EM real GDP annualized quarter-on-quarter growth (deviations from contribution of initial conditions). Contributions of domestic shocks are derived as weighted averages of the sum of contributions of domestic aggregate demand and domestic aggregate supply shocks based on a selected structural VAR for each G20 EM country. Contributions of foreign shocks are derived as residual component not explained by domestic shocks. Each selected structural VAR includes real GDP and CPI data for the U.S., the G20 EM of interest and a smaller emerging market economy (South Africa for the models with either China or India or Russia or Brazil or Indonesia or Mexico or Türkiye or Saudi Arabia or Argentina as the G20 EM of interest; and Tunisia for the model with South Africa as the G20 EM of interest), in addition to a commodity price index and the US VIX.

FEVDs provide complementary information on the importance of spillovers as they allow for the quantification of the fraction of the variance of GDP of each country explained by each of the shocks, taking into account the impact of the actual estimated size and frequency of the shocks. In short, they allow for the assessment of the average importance of spillovers for business cycle fluctuations of each country over the historical period spanned by the data. As an illustration, Online Annex Figure 4.2.2, based on a structural VAR with output and consumer prices data for aggregate G20 advanced economies and aggregate G20 EMs, suggests that shocks in G20 EMs can explain around 5 percent of real GDP fluctuations in advanced economies, over a three-year horizon. This is slightly less than half of the effect of advanced

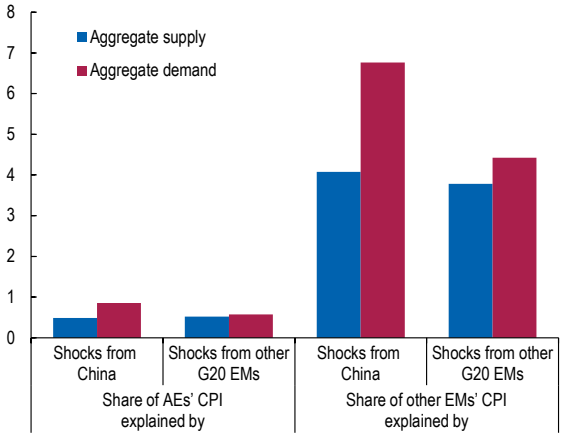
[6] The aggregates of the G20 EMs excluding China are derived as weighted averages of median estimates of all other nine G20 EMs, regardless of whether they are statistically significant or not.

[7] Among the country-specific responses of commodity prices to shocks from other G20 EMs, only that three-years ahead for shocks from India are statistically significant.

economies' shocks on G20 EMs. A sub-sample analysis suggests that spillovers from G20 EMs were contained until the GFC but increased markedly since then, in line with existing evidence (Arezki and Liu 2020). By contrast, spillover from advanced economies remained significant throughout the past two decades.

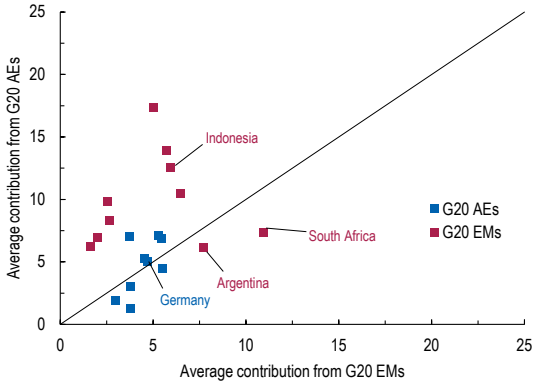
Figure 4.7 (panel 1) in the main text reports the fraction of three-year ahead variance of real GDP of advanced economies (weighted averages) and emerging market economies other than those where the shock originates (weighted averages) explained by aggregate demand and aggregate supply shocks originating from China and from the other G20 EMs (simple averages). Online Figure 4.2.3 reports the fraction of one-year ahead variance of CPI of advanced economies (weighted averages) and emerging market economies other than those where the shock originates (weighted averages) explained by aggregate demand and supply shocks originating from China and from the other G20 EMs (simple averages). While shocks from G20 EMs explain a small fraction of the one-year ahead variance of consumer prices in advanced economies, shocks from China contribute to slightly more than 10 percent of the one-year ahead variation in consumer prices in other emerging markets.

Online Annex Figure 4.2.3. Aggregate Consumer Price Spillovers from G20 Countries
(Percent, one year ahead, median)



Source: IMF staff calculations.
Note: This chart shows the fractions of one-year-ahead variance of CPI explained by domestic aggregate demand and aggregate supply shocks in each G20 EM (considering China separately and taking the average of the other G20 EMs) on recipient' economies output (weighted averages of median estimates.) AEs = advanced economies; EMs = emerging markets.

Online Annex Figure 4.2.4 Fraction of GDP Variance Explained by Shocks from G20 Countries, by Country
(Percent, three years ahead)



Source: IMF staff calculations.
Note: Blue (red) dots are averages of the fractions of three-year-ahead variance of GDP of G20 AEs (G20 EMs) explained by shocks (sum of aggregate demand and supply shocks) originating from G20 countries (excluding shocks from the U.S. and China) (median estimates). AEs = advanced economies; EMs = emerging markets.

Comparing growth spillovers from advanced and emerging economies over the entire sample period shows that the relative importance of G20 advanced and emerging markets (excluding the United States and China) in explaining GDP fluctuations is broadly comparable for several countries. Although most countries are still predominantly exposed to shocks in advanced economies (Indonesia is an example), some experience more symmetric effects (Argentina, Germany), and others are more greatly impacted by shocks in emerging markets, with South Africa as example (Online Annex Figure 4.2.4).

Global VAR

Methodology

This chapter also employs a Global Vector Autoregressive (GVAR) model, a large system modeling economic interdependencies between countries. The GVAR approach involves estimating 63 country-specific VARX models including 34 advanced economies and 29 emerging market economies, which taken together account for over 90 percent of global output (see Online Annex Table 4.2.1). The model includes as endogenous variables: real GDP, CPI inflation, the real exchange rate, the short-term rate and the long-term rate, while foreign variables are incorporated through predetermined bilateral trade weights to capture global influences (see Online Annex Table 4.2.3 for a description of variables and sources). The model includes separately two distinct commodity blocks capturing the oil and metal markets, including their prices, production, inventory, and global demand, as this modelling structure has been shown to best capture the commodity price channel (Gauvin and Rebillard 2018). For the baseline estimation, the weight matrix is constructed using bilateral trade averages from 2000 to 2019. Moreover, the model is also estimated using more recent trade data spanning from 2017 to 2019.

Online Annex Table 4.2.3. Data and Sources for the GVAR Model

Variable	Description	Sources
GDP	Logarithm of real GDP	World Economic Outlook Database
Inflation	The rate of inflation, calculated as difference of the logarithm of CPI	World Economic Outlook Database
Short-term interest rate	Nominal short-term interest rate per quarter, in percent	World Economic Outlook Database
Long-term interest rate	Nominal long-term interest rate per quarter, in percent	World Economic Outlook Database
Equity price	Logarithm of the nominal equity price index deflated by CPI	World Economic Outlook Database
Exchange rate	Logarithm of the real exchange rate expressed in US dollars deflated by CPI	World Economic Outlook Database
Oil price	Logarithm of the nominal price of oil in US dollars	Haver Analytics
Metal price	Logarithm of the nominal price of metal in US dollars	Haver Analytics
Oil production	Logarithm of oil production (mil. Barrels/Day)	Haver Analytics
Oil inventories	Logarithm of forward consumption in OECD (in days)	Haver Analytics
Metal inventories	Logarithm of LME copper warehouse stocks (EOP, Metric Tons)	Haver Analytics
Global activity proxy	Global real economic activity index in industrial commodity markets (NSA)	Haver Analytics
Trade flows	Bilateral goods trade in US dollars, annual	IMF Direction of Trade Statistics

Unlike traditional vector error correction models as in Pesaran and others (2004) and Dees and others (2007), this chapter employs Bayesian VARs with stochastic volatility for estimation (Feldkircher and Huber 2016), which can be particularly important for modelling emerging economies. It also explores four distinct alternative priors: the Minnesota (MN) prior, the Stochastic Search Variable Selection (SSVS) prior, the Normal-Gamma (NG) prior, and the Horseshoe (HS) prior. The findings indicate that the model employing the SSVS prior with one lag structure exhibits the best performance, particularly concerning residual autocorrelation and cross-country residual correlation. This is not surprising, as this type of prior has been shown to have the best performance in such models (Cuaresma and others 2015), as it allows for country specificity (unlike the other priors which apply a uniform degree of shrinkage for all countries).

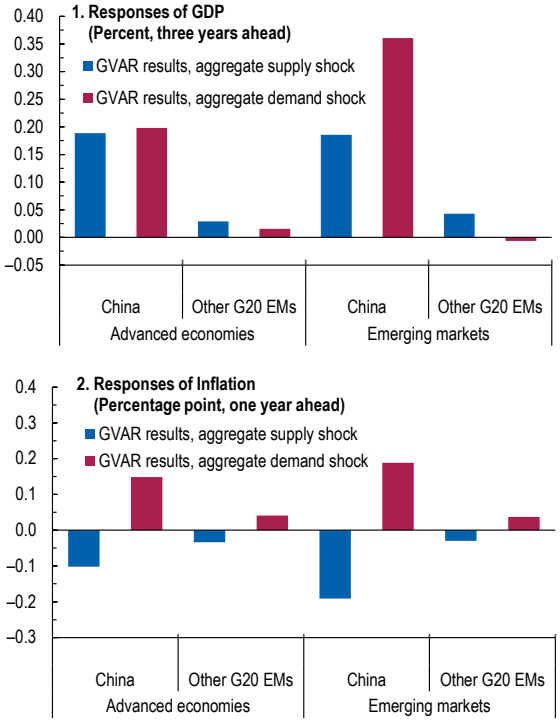
Identification techniques from the VAR literature are applicable to the global solution derived from the GVAR model. Due to the GVAR model's reliance on an exogenous measure of the interconnectedness among cross-sectional units, full identification of the global model is not

necessary. Consequently, much of the GVAR research focuses on local model identification. In this analysis, the local identification of structural shocks is achieved by imposing sign restrictions within the country of interest. To differentiate demand and aggregate supply shocks, this chapter employs an identification strategy similar to the one used in Feldkircher and Huber (2016). More specifically, aggregate demand shocks are assumed to generate a positive co-movement between output and prices, while aggregate supply shocks would cause a negative relationship between the two. The restrictions are imposed for four quarters (quarters zero to three), in order to improve the identification of the shocks (Mountford and Uhlig 2009).

Additional Results

China's growth shocks have more sizable spillovers than those from other G20 EMs, and they are larger for emerging market economies than for advanced economies. Online Annex Figure 4.2.5 panel 1 shows the effects of shocks originating in China and in other G20 EMs, normalized to lead to a one percentage increase in GDP. China's spillovers from positive aggregate demand shocks leads to an increase in GDP after three years of about 0.2 percent in advanced economies and 0.36 percent in emerging market economies after three years. Aggregate supply shocks in China exhibit significantly smaller spillovers to both advanced and emerging market economies (both around 0.18). Finally, spillovers from both types of shocks in the other G20 EMs are much smaller than those from China and equal to about 0.02 percent, on average.[8]

Online Annex Figure 4.2.5. Spillovers to Output and Inflation



Source: IMF staff calculations.
Note: Reported results are cross-country aggregates using PPP GDP weights of impulse responses which are significant on the basis of 68 percent credible intervals. The figures for "Other G20 EMs" represent simple averages of Argentina, Brazil, Indonesia, India, Mexico, Russia, Saudi Arabia, South Africa, and Türkiye. EMs = emerging markets.

The relative dominance of spillovers from China aligns closely with findings from the previous literature, with most studies suggesting that a one percentage increase in Chinese GDP growth could lead to spillovers ranging between 0.15 and 0.5 percent on world output, which however in general does not distinguish between

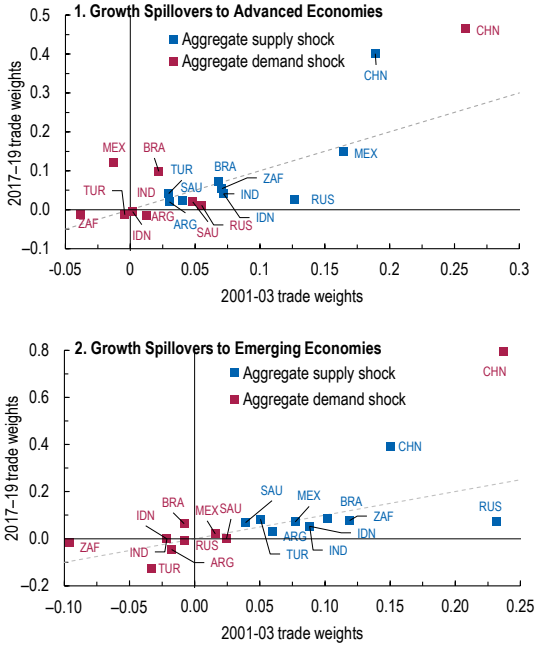
[8] Reported results are cross-country aggregates using PPP GDP weights of impulse responses which are significant on the basis of 68 percent credible intervals.

demand and supply shock separately (see Cesa-Bianchi and others 2012, Dizioli and others 2016; Cashin and others 2016).[9]

Shocks originating from China can have a sizeable impact on global inflation. A positive aggregate demand shock from China, which raises domestic output and inflation by 1 percentage point, leads to 0.15 percentage point higher inflation in advanced economies, and 0.19 percentage point higher inflation in emerging markets, after one year (Online Annex Figure 4.2.5 panel 2). Over the same horizon, a positive aggregate supply shock from China would reduce inflation by 0.1 percentage point in advanced economies and 0.19 percentage point in emerging markets.

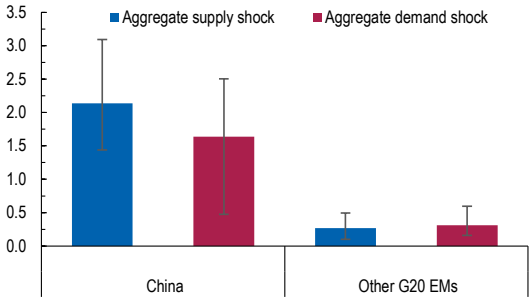
Consistent with China increasing its global trade integration after its accession to the WTO, spillovers from China sharply increased over the past two decades, while they have changed less markedly for the other G20 EMs. In line with the evidence documented in the stylized facts, spillovers from China, both on the demand and supply side, have approximately doubled over the past two decades prior to the COVID-19 pandemic. This can be seen comparing spillovers estimated from the GVAR model when using more recent trade weights (2017-19), against those from a model estimated trade weights from the beginning of the sample (2001-03)—see Online Annex Figure 4.2.6. Spillovers from some of the other G20 EMs (such as Türkiye and Saudi Arabia), in particular to other emerging market economies, have slightly increased, potentially because of their stronger interlinkages through GVCs and commodities. By contrast, spillovers from some other countries—notably Russia—have declined.

Online Annex Figure 4.2.6. Growth Spillovers
(Percentage point, three years ahead)



Source: IMF staff estimates.
Note: The chart shows the cross-country aggregates using 2001–03 (2017–19) PPP GDP weights of three-year-ahead impulse responses which are significant on the basis of 68 percent credible intervals.

Online Annex Figure 4.2.7. Impact on Oil Prices
(Percent, one year ahead)



Source: IMF staff calculations.
Note: This figure shows the one-year-ahead impulse responses of the oil price to a 1 percentage point per year positive domestic aggregate demand and aggregate supply shocks in each G20 EM on the price of oil. The bars represent the median impulse responses and the lines identify the 68 percent credible intervals. Other G20 EMs represents the average of impulse responses to shocks originating in Argentina, Brazil, Indonesia, India, Mexico, Russia, Saudi Arabia, South Africa, and Türkiye. EMs = emerging markets.

[9] The estimation of the effects of shocks from G20 EMs separating demand from supply shocks is a novel contribution. Copestake and others (2023) adopt a similar approach using a SVAR to estimate spillovers from aggregate demand and supply shocks in China.

China's growing role in the global economy also translates into its capacity to affect global commodity prices. In particular, aggregate demand shocks emanating from China raise oil prices by about 2.2 percent, while aggregate supply shocks also increase oil prices by 1.6 percent. Spillovers from shocks in other G20 EMs are small (around 0.25 percent), consistent with their weaker overall spillovers (Online Annex Figure 4.2.7).

Online Annex 4.3. Firm-level Analysis of Spillovers

This online annex provides the details behind the country-level and firm-level evidence on FDI spillovers in host countries featured in the main text.

Data and Sample

To explore the effect of idiosyncratic growth surprises in G20 EMs on firms' performance, the chapter uses cross-country firm-level panel data from Orbis. The original dataset covers 42 countries from 2000 to 2022. The analysis considers the period from 2000 to 2019 to avoid results being contaminated by the COVID-19 pandemic. The Orbis dataset contains corporate balance sheet and income statement information for both public and private firms, retrieved from Orbis Historical Financial database in October 2023, and other characteristics of firms, such as industry classification, date of incorporation, and legal status from Current Orbis database. The cleaning procedure follows the steps discussed by Kalemli-Özcan and others (2024), and Díez, Fan and Villegas-Sanchez (2021). The analysis reported in the main text drops firms that have less than five yearly observations, as well as financial firms and those in the public sector. Thus, the sample includes non-financial private sector firms, both in manufacturing and trade. Firms in sectors not covered by the EORA input-output tables are also dropped. The EORA tables are used to construct measures of input and output linkages to measure the exposure to the idiosyncratic growth surprises in G20 EMs. The final sample includes more than 63 million observations, with almost 6.5 million unique firms: 3.6 million in advanced economies and 2.9 million in emerging market economies. Excluding G20 EMs from this sample (Brazil, China, India, Indonesia, Mexico and Türkiye), to avoid them being the source and the recipient of the shock at the same time leaves almost 55 million observations. Finally, the baseline regression is run on almost 34 million observations corresponding to 4.8 million firms. Summary statistics on the distribution over years, sectors, and countries are reported in Online Annex Tables 4.3.1-4.3.3.

Online Annex Table 4.3.1. Sample, by Country

Advanced economies			Emerging market economies		
Country	# Obs.	Share (%)	Country	# Obs.	Share (%)
AUS	29,180	0.09%	BGR	653,370	1.93%
AUT	39,145	0.12%	COL	530,866	1.57%
BEL	280,891	0.83%	CZE	406,059	1.20%
CAN	11,202	0.03%	DZA	24,601	0.07%
DEU	239,914	0.71%	EST	312,138	0.92%
DNK	85,226	0.25%	HUN	1,274,430	3.77%
ESP	4,897,204	14.49%	LVA	180,271	0.53%
FIN	561,895	1.66%	MAR	164,528	0.49%
FRA	5,013,649	14.84%	MYS	718,802	2.13%
GBR	867,589	2.57%	PHL	86,177	0.26%
GRC	160,154	0.47%	POL	549,221	1.63%
IRL	18,941	0.06%	ROU	2,165,802	6.41%
ITA	4,712,390	13.95%	SVK	446,474	1.32%
JPN	1,427,883	4.23%	SVN	458,990	1.36%
KOR	1,456,852	4.31%	THA	1,387,547	4.11%
NLD	37,370	0.11%	VNM	518,296	1.53%
NOR	791,721	2.34%			
PRT	1,839,505	5.44%			
SWE	1,402,968	4.15%			
USA	36,232	0.11%			
Total	23,909,911		Total	9,877,572	

Online Annex Table 4.3.2. Sample, by Sector

Sector	# Obs.	Share (%)
Agriculture	904,253	2.68
Construction	6,546,135	19.37
Electrical and Machinery	1,121,939	3.32
Electricity, Gas and Water	550,394	1.63
Fishing	69,609	0.21
Food & Beverages	915,379	2.71
Hotels and Restraurants	2,268,951	6.72
Maintenance and Repair	1,687,439	4.99
Metal Products	1,450,194	4.29
Mining and Quarrying	154,870	0.46
Other Manufacturing	923,789	2.73
Petroleaum, Chemical and Non-Metallic ..	1,093,674	3.24
Post and Telecommunications	1,645,843	4.87
Retail Trade	5,315,806	15.73
Textiles and Wearing Apparel	698,912	2.07
Transport	1,875,164	5.55
Transport Equipment	232,699	0.69
Wholesale Trade	5,368,671	15.89
Wood and Paper	963,762	2.85

Online Annex Table 4.3.3. Sample, by Year

Year	# Obs.	Share (%)
2002	736,673	1.88
2003	919,829	2.34
2004	1,150,134	2.93
2005	1,301,978	3.32
2006	1,502,540	3.83
2007	1,836,681	4.68
2008	1,939,378	4.94
2009	2,071,487	5.28
2010	2,187,368	5.57
2011	2,213,281	5.64
2012	2,452,023	6.25
2013	2,639,963	6.72
2014	2,701,754	6.88
2015	2,960,510	7.54
2016	3,146,812	8.01
2017	3,353,203	8.54
2018	3,196,471	8.14
2019	2,952,886	7.52

Methodology

The firm-level analysis estimates spillovers from idiosyncratic growth surprises in G20 EMs (defined as discussed in Online Annex 4.1) on firm revenue growth. Identification comes from a shift share approach, in which the common shifter is the idiosyncratic growth surprise in G20 EMs and the exposures are measures of output and input linkages computed at the country-sector level. In particular, output and linkages measure the share of global demand coming from G20 EM consumers and firms (sales of intermediate inputs and final goods to emerging market economies), and the share of total inputs which are supplied by G20 EM industries, respectively. Following Lane (forthcoming) and Copestake and others (2023), *direct* linkages are defined as:

$$Output_{cst}^{EM} = \frac{\sum_j Sales_{cs\to EM\,jt} + Final\ Demand_{cs\to EM_t}}{\sum_W \sum_j Sales_{cs\to W\,jt} + \sum_W Final\ Demand_{cs\to W_t}}, \text{ and}$$

$$Input_{cst}^{EM} = \frac{\sum_j Sales_{EM\,jt\to cs}}{\sum_W \sum_j Sales_{W\,jt\to cs}},$$

where *c* (W), *s* and t refer to country (world), sector and year. These indicators are constructed using input-output tables from the EORA Global Supply Chain Database.[10] An important caveat is that these measures capture only *direct* exposures to G20 EMs, while missing *indirect* ones (for example, firms which sell to non-G20 firms which, in turn, sell to consumers in G20 EMs). The evolution of input and output linkages for the median G20 EM is shown in Figure 4.5 (panel 2) in the main text.

[10] Data and additional information are available here: Eora Global MRIO (worldmrio.com).

For this approach to be valid, both elements of the interaction terms should not suffer from endogeneity. While reverse causality is not likely to be an issue in this setting, given that aggregate variables would not depend on firm level outcomes, omitted variable bias could still be a threat to identification. To minimize concerns on the exposure variable (defined at the country-sector-year level), it is taken as time invariant by regressing it against country-sector and year fixed effects. The standardized estimated country-sector fixed effects are taken as measures of exposure for input ($Input_{cs}^{EM}$) and output ($Exposure_{cs}^{EM}$) linkages.

In practice, spillovers are estimated from the following equation:

$$(y_{isc,t+j} - y_{isc,t-1})/y_{isc,t-1} = \beta_1 Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM} + \beta_2 Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM} + \lambda X_{isc,t-1} + \mu_i + \theta_{ct} + \vartheta_{cs} + \varepsilon_{isct}$$

(with $j = 0, \ldots, 4$),

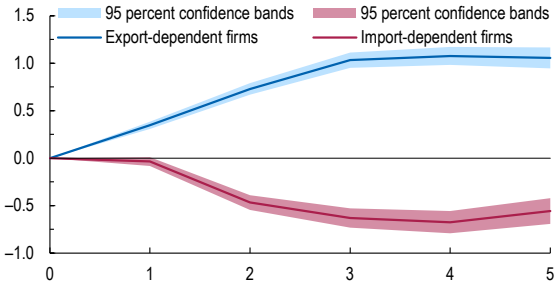
in which the growth in revenue (y) of firm I in sector s and country c over a 1- to 5-year horizon ($t+j$) is a function of firm characteristics, $X_{isc,t}$, (including lagged revenues), a standard set of fixed effects (at the firm, country-year, and country-sector level), and the interaction between the exposure variables to G20 EMs ($Input_{cs}^{EM}$ and $Output_{cs}^{EM}$) and the idiosyncratic growth surprise in G20 EMs ($\hat{\gamma}_{ct}^{EM}$). Firm fixed effects (μ_i) take into account differences in performance due to time-invariant unobservable factors, while country-year fixed effects (θ_{ct}) absorb the role of domestic macroeconomic developments and mitigate the concern that $\hat{\gamma}_{ct}^{EM}$ could pick up correlated macroeconomic factors which could also drive firm performance. Standard errors are clustered at the firm level.

In other words, this exercise compares two firms with similar observable characteristics which differ in the intensity of their exposure to macroeconomic developments in G20 EMs, depending on the intensity of output and input linkages of the sector (and country) of the firms. The coefficients β_1 and β_2 trace the differential effect of a one standard deviation increase in the exposure to idiosyncratic growth surprises in G20 EMs—as an aggregate, or for each country individually—on firm revenue growth, as reported in Figure 4.9 in the main text.

Results

The main results are reported in the main text. This section reports all the estimated coefficients in Online Annex Table 4.3.4, based on the entire sample (panel 1) or on the restricted sample based on the sample when j=5 in the equation above (panel 2). Online Annex Table 4.3.5 reports the results for the idiosyncratic growth surprise in each G20 EM separately (which are used to generate panel 2 of Figure 4.9 in the main text), plus the U.S., taken as a benchmark to assess the relative size of spillovers from G20 EMs. In addition, Online Annex Figure 4.3.1 reports the baseline

Online Annex Figure 4.3.1. Spillovers from G20 Advanced Economies to Firm Revenue Growth
(Percentage points)



Sources: Eora Global Supply Chain Database; Orbis; and IMF staff calculations.
Note: The chart plots the impulse responses of firm revenue growth to a domestic growth surprise in G20 advanced economies for firms more exposed to output (in blue) or input (in red) linkages, compared with similar, less-exposed firms.

results reported in Figure 4.9 (panel 1) in the main text but estimated considering idiosyncratic growth surprise in (and exposure to) G20 advanced economies. Results show that spillovers to firms particularly reliant on demand from G20 advanced economies are about twice as large as those to firms dependent on demand from G20 EMs (shown in Figure 4.9, panel 1, in the main text). Also, downstream spillovers are on average negative, suggesting that import-competition effects adversely affect firms more dependent on inputs supplied by G20 advanced economies.

Online Annex Table 4.3.4. Firm-level Spillovers, Baseline Results for G-20 EMs

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4310***	0.4461***	0.4063***	0.2668***	0.2380***
	(0.011)	(0.018)	(0.022)	(0.025)	(0.029)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0332**	-0.0103	0.0260	0.0238	0.0224
	(0.015)	(0.025)	(0.032)	(0.036)	(0.041)
Observations	33,787,483	28,179,190	23,418,680	19,593,920	16,341,735
R-squared	0.201	0.338	0.420	0.483	0.532
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4591***	0.4178***	0.3559***	0.2141***	0.2380***
	(0.012)	(0.020)	(0.024)	(0.027)	(0.029)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0415**	-0.0176	0.0292	0.0689*	0.0224
	(0.017)	(0.027)	(0.034)	(0.039)	(0.041)
Observations	16,105,295	15,503,783	15,380,060	15,454,487	16,341,735
R-squared	0.239	0.350	0.430	0.494	0.532
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm revenue in t-1 and t-2). Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Online Annex Table 4.3.5. Firm-level Spillovers, Country-specific Results

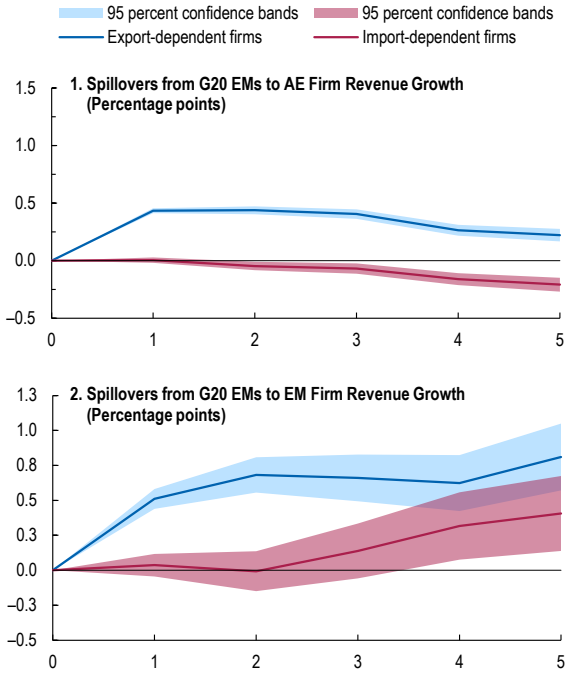
Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: Argentina					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0174***	-0.0088***	-0.0056**	-0.0249***	-0.0367***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0121***	0.0039	0.0009	-0.0044	-0.0016
	(0.002)	(0.003)	(0.003)	(0.004)	(0.005)
Panel 2: Brazil					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0080	0.0060	0.0407***	0.0235	0.0088
	(0.007)	(0.011)	(0.015)	(0.019)	(0.020)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0912***	-0.0737***	-0.0868***	-0.0459*	-0.0103
	(0.010)	(0.016)	(0.021)	(0.026)	(0.027)
Panel 3: China					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.2284***	0.2584***	0.1774***	0.0643***	0.1694***
	(0.009)	(0.014)	(0.017)	(0.020)	(0.022)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0961***	-0.0696***	-0.1257***	-0.0141	0.0775***
	(0.012)	(0.018)	(0.022)	(0.026)	(0.029)
Panel 4: Indonesia					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0081	0.0855***	0.1480***	0.1454***	0.1475***
	(0.017)	(0.030)	(0.038)	(0.043)	(0.044)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0115	0.0227	0.0503**	0.0971***	0.1015***
	(0.011)	(0.020)	(0.025)	(0.029)	(0.031)
Panel 5: India					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.2356***	0.2649***	0.2442***	0.1843***	0.1928***
	(0.005)	(0.008)	(0.009)	(0.009)	(0.010)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0048	-0.0476***	-0.0370***	0.0035	-0.0012
	(0.006)	(0.008)	(0.009)	(0.010)	(0.010)
Panel 6: Mexico					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0990***	0.1418***	0.1091***	0.1534***	0.1033***
	(0.005)	(0.008)	(0.010)	(0.012)	(0.014)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0330***	-0.0751***	-0.0857***	-0.1629***	-0.0605***
	(0.006)	(0.008)	(0.011)	(0.014)	(0.016)
Panel 7: Russia					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0336***	-0.0243***	-0.0002	-0.0041	-0.0128*
	(0.003)	(0.005)	(0.006)	(0.007)	(0.007)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0514***	-0.0681***	-0.0769***	-0.0989***	-0.0993***
	(0.005)	(0.008)	(0.010)	(0.011)	(0.011)
Panel 8: Saudi Arabia					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0300***	0.0492***	0.0960***	0.0270***	-0.0297***
	(0.003)	(0.005)	(0.006)	(0.007)	(0.007)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0105***	0.0172***	0.0015	-0.0292***	-0.0375***
	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)
Panel 9: Türkiye					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0353***	-0.0015	-0.0433***	-0.0734***	-0.1004***
	(0.003)	(0.005)	(0.007)	(0.008)	(0.009)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0429***	0.1072***	0.1845***	0.2328***	0.2450***
	(0.005)	(0.007)	(0.010)	(0.012)	(0.013)
Panel 10: South Africa					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.2002***	0.1972***	0.0033	-0.2453***	-0.0012
	(0.013)	(0.017)	(0.022)	(0.024)	(0.026)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0481***	0.1485***	-0.1023***	-0.2824***	-0.2420***
	(0.013)	(0.017)	(0.022)	(0.024)	(0.026)
Panel 11: United States					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.5650***	0.8979***	1.0065***	1.0386***	1.0930***
	(0.014)	(0.025)	(0.032)	(0.039)	(0.045)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	-0.0758***	-0.2125***	-0.3750***	-0.5846***	-0.7169***
	(0.029)	(0.050)	(0.066)	(0.081)	(0.091)
Observations	16,105,295	15,503,783	15,380,060	15,454,487	16,341,735
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm revenue in t-1 and t-2). Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Robustness Tests

Results are robust to (i) splitting the sample between firms headquartered in advanced economies and in non-G20 EMs (Online Annex Figure 4.3.2); (ii) taking firm sales as the dependent variable (Online Annex Table 4.3.6); (iii) including firm size (measured by the logarithm of assets) and the share of long-term debt in total liabilities as additional controls (Online Annex Table 4.3.7); (iv) excluding countries with lower or less stable coverage in terms of sales (Online Annex Table 4.3.8); (v) computing the exposure variables taking the simple averages over the sample periods of the input and output linkages defined at the country-sector-year level (Online Annex Table 4.3.9); and (vi) clustering the standard errors at the country-year level. In the latter exercise, standard errors are larger and the effect on output-dependent firms become no longer significant after 4 years.

Online Annex Figure 4.3.2. Firm-Level Spillovers



Sources: Eora Global Supply Chain Database; Orbis; and IMF staff calculations.
Note: Figures plot the impulse responses of firm revenue growth to a domestic growth surprise in G20 EMs for firms more exposed to output (in blue) or input (in red) linkages, compared to similar, less exposed, firms. AEs = advanced economies; EMs = emerging markets.

Online Annex Table 4.3.6. Spillovers on Firm Sales

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{y}_{ct}^{EM}$	0.4463***	0.4586***	0.4206***	0.2866***	0.2990***
	(0.011)	(0.017)	(0.022)	(0.025)	(0.029)
$Output_{cs}^{EM} * \hat{y}_{ct}^{EM}$	0.0590***	0.0145	0.0464	0.0293	-0.0031
	(0.014)	(0.024)	(0.030)	(0.034)	(0.039)
Observations	31,830,783	26,559,346	22,098,876	18,497,035	15,478,153
R-squared	0.200	0.334	0.415	0.476	0.530
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{y}_{ct}^{EM}$	0.4737***	0.4468***	0.3877***	0.2478***	0.2990***
	(0.012)	(0.020)	(0.024)	(0.027)	(0.029)
$Output_{cs}^{EM} * \hat{y}_{ct}^{EM}$	0.0411**	-0.0461*	-0.0069	0.0566	-0.0031
	(0.017)	(0.027)	(0.033)	(0.037)	(0.039)
Observations	15,244,226	14,684,402	14,570,787	14,639,955	15,478,153
R-squared	0.235	0.346	0.426	0.490	0.530
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm sales in t-1 and t-2). Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Online Annex Table 4.3.7. Firm-level Spillovers, Additional Controls

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4327***	0.4405***	0.3810***	0.1955***	0.1488***
	(0.011)	(0.017)	(0.021)	(0.024)	(0.027)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0275*	-0.0343	-0.0030	0.0038	0.0054
	(0.015)	(0.024)	(0.030)	(0.034)	(0.037)
Observations	33,398,010	27,853,124	23,141,001	19,352,575	16,138,785
R-squared	0.225	0.385	0.477	0.544	0.593
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4473***	0.3780***	0.2920***	0.1255***	0.1488***
	(0.012)	(0.019)	(0.022)	(0.025)	(0.027)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0443***	-0.0170	0.0332	0.0713**	0.0054
	(0.017)	(0.026)	(0.032)	(0.036)	(0.037)
Observations	15,905,282	15,314,277	15,191,748	15,265,001	16,138,785
R-squared	0.265	0.402	0.490	0.556	0.593
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm sales in t-1 and t-2) and the lagged values of size (measured as the logarithm of total assets) and of the ratio of long term liabilities over total liabilities. Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Online Annex Table 4.3.8. Firm-level Spillovers, Restricted Sample

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.5128***	0.5160***	0.4681***	0.3255***	0.3298***
	(0.012)	(0.019)	(0.024)	(0.028)	(0.032)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.1453***	0.1231***	0.1511***	0.1360***	0.0948**
	(0.017)	(0.028)	(0.036)	(0.041)	(0.046)
Observations	29,320,873	24,590,428	20,666,684	17,500,010	14,745,699
R-squared	0.196	0.324	0.406	0.479	0.538
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.5773***	0.5373***	0.4583***	0.3015***	0.3298***
	(0.014)	(0.022)	(0.026)	(0.030)	(0.032)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.1456***	0.0895***	0.1458***	0.1845***	0.0948**
	(0.019)	(0.031)	(0.038)	(0.044)	(0.046)
Observations	14,522,818	13,981,882	13,869,329	13,935,571	14,745,699
R-squared	0.242	0.355	0.436	0.502	0.538
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm sales in t-1 and t-2). The sample include only 27 countries with more balanced coverage over time. Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Online Annex Table 4.3.9. Firm-level Spillovers, Alternative Exposure Variables

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4346***	0.4518***	0.4136***	0.2745***	0.2459***
	(0.011)	(0.018)	(0.022)	(0.026)	(0.029)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0365**	-0.0017	0.0396	0.0403	0.0396
	(0.015)	(0.025)	(0.032)	(0.037)	(0.041)
Observations	33,787,483	28,179,190	23,418,680	19,593,920	16,341,735
R-squared	0.201	0.338	0.420	0.483	0.532
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4635***	0.4246***	0.3645***	0.2223***	0.2459***
	(0.012)	(0.020)	(0.024)	(0.027)	(0.029)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0466***	-0.0053	0.0470	0.0882**	0.0396
	(0.017)	(0.028)	(0.035)	(0.039)	(0.041)
Observations	16,105,295	15,503,783	15,380,060	15,454,487	16,341,735
R-squared	0.239	0.350	0.430	0.494	0.532
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm sales in t-1 and t-2). The exposure variables are computed as simple averages over the sample period of the exposures defined at the country-sector-year level. Standard errors in parenthesis are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and

Online Annex Table 4.3.10. Firm-level Spillovers, Alternative Clustering

Dependent variable: Firm revenue growth over:	1 year	2 years	3 years	4 years	5 years
Panel 1: whole sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4310***	0.4461***	0.4063***	0.2668	0.2380
	(0.113)	(0.151)	(0.155)	(0.178)	(0.211)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0332	-0.0103	0.0260	0.0238	0.0224
	(0.076)	(0.099)	(0.110)	(0.130)	(0.131)
Observations	33,787,483	28,179,190	23,418,680	19,593,920	16,341,735
R-squared	0.201	0.338	0.420	0.483	0.532
Panel 2: restricted sample					
$Input_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.4591***	0.4178**	0.3559**	0.2141	0.2380
	(0.131)	(0.167)	(0.170)	(0.185)	(0.211)
$Output_{cs}^{EM} * \hat{\gamma}_{ct}^{EM}$	0.0415	-0.0176	0.0292	0.0689	0.0224
	(0.082)	(0.098)	(0.113)	(0.131)	(0.131)
Observations	16,105,295	15,503,783	15,380,060	15,454,487	16,341,735
R-squared	0.239	0.350	0.430	0.494	0.532
Country-Year FE	Y	Y	Y	Y	Y
Country-Sector FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y

Note: Each regression include two lages of the dependent variable (firm sales in t-1 and t-2). Standard errors in parenthesis are clustered at the country-year level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Online Annex 4.4. Global Trade Model

This online annex illustrates the calibration of the multi-country, multi-sector network model of global trade developed by Huo, Levchenko, and Pandalai-Nayar (2019) and Bonadio and others (2021, 2023)—hereafter the BHLP model—the scenarios, and the sensitivity tests. It also provides some additional results.

The Model

This section begins with a condensed exposition of the BHLP model, following closely the exposition in the user manual.[11] It is a multi-region, multi-sector general-equilibrium global network model which considers a static global economy with N regions, indexed by n and m, and J sectors, indexed by j and i, in each region. Sectoral output is tradeable between regions, with iceberg trade costs and balanced trade,[12] while labor is immobile between regions. Each household in each country n, indexed by $\omega \in [0,1]$, supplies labor to a sector in their region depending on its sector-specific labor productivity, with the objective to maximize a utility function which is increasing and linear in final consumption $\mathcal{F}_n(\omega)$ and decreasing and concave in labor supply.

Final consumption is an aggregate of sectoral output from all $N \times J$ region-sectors which follows a nested CES functional form. The upper nest aggregates across sector aggregates $\mathcal{F}_{nj}(\omega)$,

$$\mathcal{F}_n(\omega) = \left(\sum_j \zeta_{nj}^{\frac{1}{\rho}} \mathcal{F}_{nj}(\omega)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}},$$

where ζ_{nj} is a taste parameter and ρ is the elasticity of substitution. The lower nest aggregates output of sector j sourced from different regions m,

$$\mathcal{F}_{nj}(\omega) = \left(\sum_m \mu_{m,nj}^{\frac{1}{\gamma}} \mathcal{F}_{m,nj}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}},$$

where $\mu_{m,nj}$ is a taste parameter and γ is the elasticity of substitution across regions.

Firms are competitive, with a representative firm in sector j in region n producing using physical capital, human capital, and intermediate inputs, following the production function:

$$Y_{nj} = Z_{nj} \left(K_{nj}^{\alpha_j} H_{nj}^{1-\alpha_j} \right)^{\eta_j} X_{nj}^{1-\eta_j},$$

where z_{nj} is region-sector specific total factor productivity (TFP), K_{nj}, H_{nj} are physical and human capital inputs, respectively, and X_{nj} is an aggregate of intermediate inputs. The

[11] https://alevchenko.com/bhlp_code.html

[12] The model allows for exogenous trade imbalances, but this feature is not used here.

parameters α_j and η_j determine the capital share of value added and the value-added share of revenue, respectively. The intermediate goods aggregate X_{nj} combines sectoral output from all $N \times J$ region-sectors following a nested CES functional form. The upper nest aggregates across sectoral aggregates $X_{i,nj}$,

$$X_{nj} = \left(\sum_i \vartheta_{i,nj}^{\frac{1}{\varepsilon}} X_{i,nj}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

where $\vartheta_{i,nj}$ is a technological parameter and ε is the elasticity of substitution. The lower nest aggregates output of sector j sourced from different regions m,

$$X_{i,nj} = \left(\sum_m \mu_{mi,nj}^{\frac{1}{\nu}} X_{mi,nj}^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}},$$

where $\mu_{mi,nj}$ is a technological parameter and ν is the elasticity of substitution.

As mentioned above, all sectoral output is traded internationally subject to iceberg trade costs $\tilde{\tau}_{m,nj}^{f}, \tilde{\tau}_{mi,nj}^{x}$ for final goods and intermediate inputs, respectively. These depend on the source region m and destination region-sector nj for final goods, and on the source region-sector mi and destination region-sector nj for intermediate inputs.

Note that the extensive margin—in other words, which economy-sectors take inputs from which other economy-sectors, and which economies' final consumption sources inputs from which economy-sectors—is fixed in this model. All adjustment to shocks takes place along the intensive margin.

The changes in response to shocks of economic variables such as region real output, region-sector value added, and sector prices are computed using the exact hat algebra approach of Dekle and others (2008).[13] This method makes use of the fact that the impact on these changes of most of the model parameters—e.g., taste parameters $\zeta_{nj}, \mu_{m,nj}$, technological parameters $\vartheta_{i,nj}, \mu_{mi,nj}$, sectoral productivities Z_{nj}, and trade costs $\tilde{\tau}_{m,nj}^{f}, \tilde{\tau}_{mi,nj}^{x}$—is only through expenditure shares which can be measured directly in one year of the dataset. This means that the only parameters that need to be set explicitly are $\eta_j, \alpha_j, \rho, \gamma, \varepsilon, \nu$ discussed above, the labor supply elasticity ψ, and a parameter μ controlling the variance of labor productivity endowments across sectors. The parameters η_j are set to match the sector-level value-added share of output averaged across countries. Finally, as K_{nj} is exogenous and medium-/long-term counterfactuals are the main interest here, α_j is set to zero for all j, a standard choice in the trade literature which represents an equipped labor parametrization with no explicit role for physical capital. This leaves only the elasticities $\rho, \gamma, \varepsilon, \nu, \psi$ and the distributional parameter μ to be set based on estimates in the literature.

[13] For an extended discussion, see Costinot and Rodriguez-Clare (2014).

Data and Calibration

The analysis uses data for the year 2018 from the OECD Inter-Country Input-Output (ICIO) Tables (OECD 2021). The data decomposes economic activity into 45 sectors in each of 66 economies, including 36 advanced economies, 26 emerging market economies, four developing economies, and an aggregate of the rest of the world.[14] The sectors are listed in Online Annex Table 4.4.5. Where results are aggregated across economies, aggregation is performed using GDP at purchasing power parity.

The calibrated parameters are drawn from the literature looking at counterfactuals at medium-/long-term horizon. Their specific values and sources are documented in Online Annex Table 4.4.1 below. Sensitivity analysis is described later in this section.

Online Annex Tabe 4.4.1. Trade Model Parameters

Parameter	Description	Value	Source
α_j	Capital Share	0	Equipped labor model, as in Bonadio and others (2023), Caliendo and others (2022), Alvarez and Lucas (2007).
ρ	Final goods substitution elasticity across sectors	0.95	Caliendo and Parro (2015) which uses Cobb-Douglas.
γ	Final goods substitution elasticity across countries	4	Caliendo and others (2022) which uses a value of 5.
ε	Intermediate goods production substitution elasticity across sectors	0.95	Caliendo and Parro (2015), which uses Cobb-Douglas.
ν	Intermediate goods substitution elasticity across countries	4	Caliendo and others (2022), which uses a value of 5.
ψ	Frisch elasticity of labor supply	1	Bonadio and others (2023), taken from estimates in Chetty and others (2011).
μ	Human capital distribution parameter	1.5	Bonadio and others (2023), taken from estimates in Galle and others (2023)

Scenarios

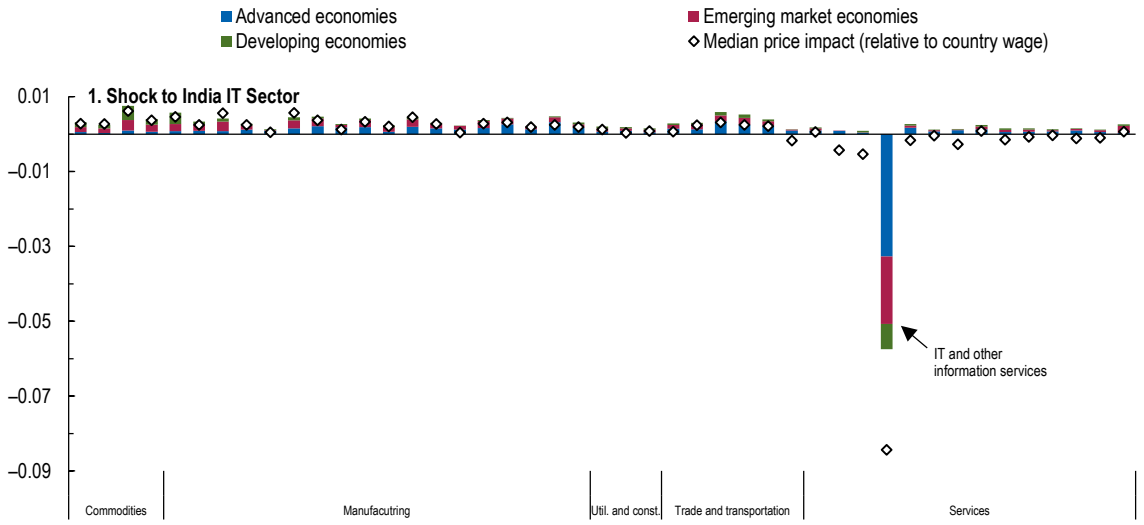
The analysis simulates the global economy under four different sets of shocks to sectoral total factor productivity, described in the main text and reviewed here: (1) negative 2.5 percent TFP shock to all sectors in all G20 EMs, (2) negative 2.5 percent TFP shock to GVC sectors (described below) in all G20 EMs, (3) negative 2.5 percent TFP shock to the Construction sector in China, (4) positive 2.5 percent TFP shock to the IT sector in India.

The sectors shocked in the GVC scenario are based on the sectors identified with the GVC tradable sector in the GIMF analysis discussed in Online Annex 4.5 below and reported in Online Annex Table 4.5.1.

The first three scenarios are described in the main text. Sectoral reallocation in the fourth scenario, from a positive shock to India's IT sector, is shown in Online Annex Figure 4.4.1 below. There is significantly less heterogeneity in the sectoral responses when compared to the

[14] To avoid convergence issues, when bringing the model to the data, zeroes in the global input-output matrix are replaced by the minimum of observed positive values. This has a negligible impact, as discussed in the user manual.

Online Annex Figure 4.4.1. Changes in Sectoral Value Added and Prices
(Percent)



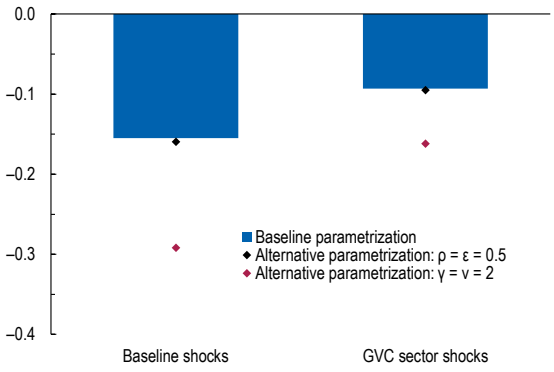
Sources: Bonadio, Huo, Levchenko, and Pandalai-Nayar (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables; and IMF staff calculations.
Note: Sample contains 36 advanced economies, 26 emerging market economies, 4 low-income developing economies, and a rest of the world region. Developing economies include the rest of the world region. Bars indicate the change in global sectoral value added excluding countries shocked in each scenario.

impact of the same size TFP shock to China's construction sector. The most significant impact is a reduction in value added in the IT sector outside of India, driven by advanced economies and EMs. All other sectors expand, particularly energy commodities production. This result suggests that the main impact of expansion in the IT sector in India is to increase competition with other countries' IT sectors.

Sensitivity Analysis

Online Annex Figure 4.4.2 documents how the impact on global GDP excluding G20 EMs in the baseline and GVC scenarios differs in two alternative parameterizations with lower elasticities. In one, the elasticities γ, ν are set equal to 2 instead of 4, which means that each region's sector j is less substitutable with other regions' sector j output, in both final consumption (γ) and production (ν). In the other, the elasticities ρ, ε are set equal to 0.5 instead of 0.95, which means that sector j output is less substitutable with sector $j' \neq j$ output, in both final consumption (ρ) and production (ε). The results with these lower elasticities can to some extent can be interpreted as a shorter-term counterfactual than with

Online Annex Figure 4.4.2. Spillovers Impact on GDP: Sensitivity to Elasticities
(Percent)

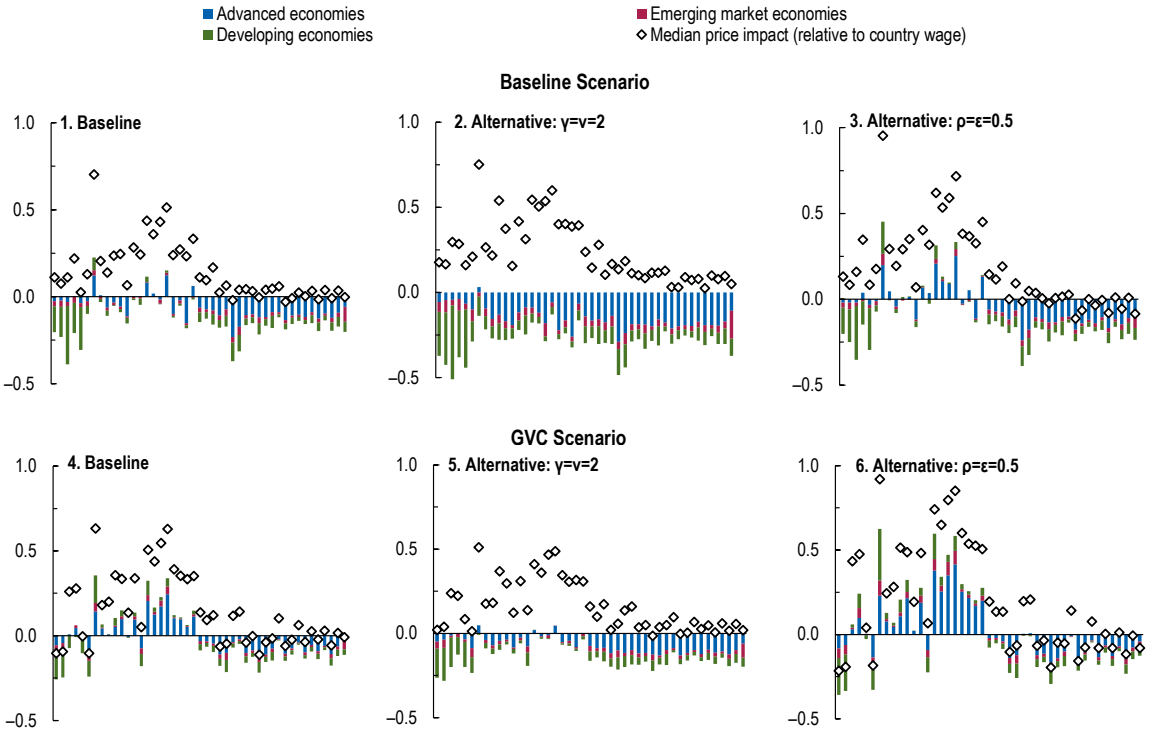


Sources: Bonadio, Huo, Levchenko, and Pandalai-Nayar (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables; and IMF staff calculations.
Note: Sample contains 36 advanced economies, 26 emerging market economies, 4 low-income developing economies, and a rest of the world region. The impact on GDP excludes countries shocked in each scenario.

higher elasticities, as substitution to different suppliers and production technologies, as well as changes in tastes in consumption, occur gradually over time.

In the alternative parametrization with lower γ, ν, the impact is about twice as large, from 0.155 (0.093) percent of GDP to 0.29 (0.16) percent of GDP in the Baseline (GVC) scenario. With lower γ, ν, the decline in output of G20 EMs has a larger impact as it is less substitutable with other countries' output. On the other hand, the parametrization with lower ρ, ε only negligibly increases the impact to 0.16 (0.095) percent of GDP in the Baseline (GVC) scenario. This reflects the fact that the shocks are to all sectors in a particular region rather than to all regions in a particular sector.

Online Annex Figure 4.4.3. Changes in Sectoral Value Added and Prices
(Percent)



Sources: Bonadio, Huo, Levchenko, and Pandalai-Nayar (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); Organisation for Economic Co-operation and Development, *Inter-Country Input-Output Tables*; and IMF staff calculations.
Note: Sample contains 36 advanced economies, 26 emerging market economies, 4 low-income developing economies, and the rest of the world region. Developing economies include the rest of the world region. Bars indicate the change in global sectoral value added excluding countries shocked in each scenario.

While the impact on global GDP outside of G20 EMs increases with a lower elasticity, the overall impact on global GDP decreases very slightly.[15]

Online Annex Figure 4.4.3 documents how sectoral reallocation varies in the Baseline and GVC scenarios when considering the alternate parametrizations described above. As before, in both cases the sensitivity is similar. With a lower trade elasticity, there are far fewer sectors which

[15] Results available upon request.

expand, and those that do, expand by less, as the output of G20 EMs is less substitutable. By contrast, with a lower cross-sector elasticity, more sectors expand—and those that do expand by more, as output from sectors in which G20 EMs specialize is more essential to the global economy, prompting higher prices and therefore a larger increase in supply elsewhere.

Employment Sensitivity: Methodology and Additional Results

Table 4.1, in the main text, is constructed using the following methodology. For each of the 19 countries in the data (G20 EMs and G20 AEs excluding Australia), the elasticity of sectoral value added to productivity shocks in all sectors of other countries is calculated by solving a first-order approximation to the trade model around the no shock equilibrium. This elasticity is then multiplied by the sectoral employment share within the affected country to derive the elasticity of that country's total employment via the sector in question to all possible sectoral productivity shocks in the other 18 countries. This yields, for each of the 19x45 affected country-sectors, a list of employment elasticities to the 18x45 other country-sector productivity shocks. For the complementarity table, the three largest positive elasticities are kept for each affected country; for the competition table, the three negative elasticities largest in magnitude are kept for each affected country. This yields, for each of the 19 affected countries, three source country-sectors with the most important impact on the affected country's employment via a single sector in the affected country. For each income group for the affected country and each source sector, the number of source country-sectors in advanced economy source countries and emerging market source countries is computed and reported in Table 4.1.

Online Annex Table 4.4.2 reports the results of the exercise on employment sensitivities using data for 2000 instead of 2018 as in the main text. The results on both complementarity and competition show that G20 EMs played a much less important role in 2000. For complementarity, only three of the 57 affected country-sectors are most affected by shocks to sectors in G20 EMs—one in advanced economies and two in emerging markets—compared to 34 when using data from 2018. For competition, six of the sectors are most affected by a sector in the G20 EMs, compared to 28 when using data from 2018. These results provide further confirmation of the increased global trade footprint of G20 EMs between 2000 and 2018.

Online Annex Table 4.4.3 reports the results of a similar exercise looking at the sectors in G20 economies with the three largest positive and negative spillovers on aggregate employment in each G20 economy, again from a positive TFP shock, using data from 2018. The results are broadly similar regarding complementary linkages, though commodities play a more important role, particularly in spillovers to advanced economies. On the other hand, the results for competition show a significantly smaller role for wholesale and retail trade. As this sector is large, accounting for approximately 15 percent of employment, it figures more prominently as a source of concentrated employment spillovers than as a source of overall employment spillovers. Finally, Online Annex Table 4.4.4 shows the results using data from 2000. The reduced prominence of G20 EMs in the table provides additional confirmation of their increased potential for generating spillovers to both advanced economies and other emerging markets.

Online Annex Table 4.4.2. Sectors in G20 Economies with the Largest Employment Spillovers (2000)

Advanced Economies			Emerging Markets		
Source Group	Source Sector	Number of Destination Sectors Affected	Source Group	Source Sector	Number of Destination Sectors Affected
		1. Complementarity			
AE	Motor vehicles, trailers and semi-trailers	9	AE	Computer, electronic and optical equipment	10
AE	Financial and insurance activities	7	AE	Wholesale and retail trade	7
AE	Computer, electronic and optical equipment	6	AE	Motor vehicles, trailers and semi-trailers	4
AE	Professional, scientific and technical activities	1	AE	Financial and insurance activities	3
AE	Agriculture, hunting, forestry	1	AE	Machinery and equipment	3
AE	Basic metals	1	EM	Motor vehicles, trailers and semi-trailers	1
AE	Machinery and equipment	1	AE	Other transport equipment	1
EM	Computer, electronic and optical equipment	1	EM	Mining and quarrying, energy producing products	1
		2. Competition			
AE	Wholesale and retail trade	18	AE	Agriculture, hunting, forestry	8
AE	Accommodation and food service activities	2	AE	Wholesale and retail trade	7
AE	Computer, electronic and optical equipment	2	EM	Agriculture, hunting, forestry	3
AE	Land transport and transport via pipelines	1	AE	Textiles, textile products, leather and footwear	3
AE	Machinery and equipment	1	AE	Manufacturing; repair and installation of machinery	2
AE	Professional, scientific and technical activities	1	AE	Education	2
AE	Agriculture, hunting, forestry	1	EM	Wholesale and retail trade	1
EM	Wholesale and retail trade	1	AE	Food products, beverages and tobacco	1
			AE	Other transport equipment	1
			AE	Mining and quarrying, energy producing products	1
			EM	Mining and quarrying, non-energy producing products	1

Sources: Bonadio and others (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables; OECD Trade in Employment Database; and IMF staff calculations.
Note:Sample covers G20 economies, excluding Australia; regional aggregates for Asia and Pacific, Middle East and Central Asia, Europe, and Western Hemisphere; and a rest of the world aggregate. Computed using the contribution to total employment from each economy-sector's response to all possible positive productivity shocks from the source economy-sector. The source sectors driving the top three sector responses by economy in which employment positively co-moves with the economy-sector in which the shock originates, are summarized under "complementarity" (panel 1), while negative co-movement between economy-sectors is summarized under "competition" (panel 2). Thus, the entries in the two columns "Number of Destination Sectors Affected" in each panel sum to 57 = 19 economies x 3 sectors. AE = advanced economy; EM = emerging market.

Online Annex Table 4.4.3. Sectors in G20 Economies with the Largest Employment Spillovers (2018)

Advanced Economies			Emerging Markets		
Source Group	Source Sector	Number of Destination Economies Affected	Source Group	Source Sector	Number of Destination Economies Affected
		1. Complementarity			
EM	Computer, electronic and optical equipment	7	EM	Computer, electronic and optical equipment	8
EM	Textiles, wearing apparel, leather and related products	7	EM	Basic metals	3
AE	Motor vehicles, trailers and semi-trailers	5	EM	Machinery and equipment	3
AE	Financial and insurance activities	3	EM	Mining and quarrying, energy producing products	3
EM	Mining and quarrying, energy producing products	3	AE	Financial and insurance activities	2
EM	Mining and quarrying, non-energy producing products	1	EM	Coke and refined petroleum products	2
EM	Motor vehicles, trailers and semi-trailers	1	AE	Chemical and chemical products	1
			AE	Coke and refined petroleum products	1
			AE	Mining and quarrying, energy producing products	1
			AE	Motor vehicles, trailers and semi-trailers	1
			AE	Wholesale and retail trade	1
			EM	Chemical and chemical products	1
			EM	Electrical equipment	1
			EM	Motor vehicles, trailers and semi-trailers	1
			EM	Textiles, textile products, leather and footwear	1
		2. Competition			
AE	Accommodation and food service activities	6	EM	Agriculture, hunting, forestry	7
AE	Machinery and equipment	2	AE	Agriculture, hunting, forestry	3
AE	Motor vehicles, trailers and semi-trailers	2	EM	Food products, beverages and tobacco	3
EM	Accommodation and food service activities	2	EM	Mining and quarrying, energy producing products	3
EM	Education	2	EM	Textiles, textile products, leather and footwear	3
EM	Machinery and equipment	2	AE	Mining and quarrying, energy producing products	2
EM	Motor vehicles, trailers and semi-trailers	2	AE	Motor vehicles, trailers and semi-trailers	2
EM	Other transport equipment	2	EM	Mining and quarrying, non-energy producing products	2
AE	Administrative and support services activities	1	AE	Coke and refined petroleum products	1
AE	Computer, electronic and optical equipment	1	AE	IT and other information services	1
AE	Professional, scientific and technical activities	1	AE	Food products, beverages and tobacco	1
AE	Wood and products of wood and cork	1	AE	Mining and quarrying, non-energy producing products	1
EM	Agriculture, hunting, forestry	1	AE	Wholesale and retail trade	1
EM	Computer, electronic and optical equipment	1			
EM	Textiles, textile products, leather and footwear	1			

Sources: Bonadio and others (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables; OECD Trade in Employment Database; and IMF staff calculations.
Note: Sample covers G-20 economies, excluding Australia; regional aggregates for Asia and Pacific, Middle East and Central Asia, Europe, and Western Hemisphere; and a rest of the world aggregate. Computed using the impact on total employment in each economy from all possible positive productivity shocks at the source economy-sector level. The three source economy-sectors with the largest employment responses by country in which employment in the affected economy positively co-moves with the economy-sector in which the shock originates are summarized under "complementarity" (panel 1), while negative impacts are summarized under "competition" (panel 2). Thus, the entries in the two columns "Number of Destination Economies Affected" in each panel sum to 57 = 19 economies x 3 source sectors. AE = advanced economy; EM = emerging market.

Online Annex Table 4.4.4. Sectors in G20 Economies with the Largest Employment Spillovers (2000)

Advanced Economies			Emerging Markets		
Source Group	Source Sector	Number of Destination Economies Affected	Source Group	Source Sector	Number of Destination Economies Affected
		1. Complementarity			
AE	Computer, electronic and optical equipment	10	AE	Computer, electronic and optical equipment	9
AE	Motor vehicles, trailers and semi-trailers	8	AE	Motor vehicles, trailers and semi-trailers	6
AE	Financial and insurance activities	4	AE	Financial and insurance activities	4
EM	Mining and quarrying, energy producing products	2	AE	Chemical and chemical products	3
AE	Machinery and equipment	1	AE	Machinery and equipment	3
AE	Mining and quarrying, energy producing products	1	AE	Wholesale and retail trade	3
AE	Basic metals	1	AE	Other transport equipment	1
			EM	Mining and quarrying, energy producing products	1
		2. Competition			
AE	Accommodation and food service activities	8	AE	Agriculture, hunting, forestry	7
AE	Motor vehicles, trailers and semi-trailers	3	AE	Textiles, textile products, leather and footwear	7
AE	Machinery and equipment	3	EM	Agriculture, hunting, forestry	5
AE	Computer, electronic and optical equipment	3	AE	Mining and quarrying, energy producing products	3
AE	Professional, scientific and technical activities	2	AE	Manufacturing nec; repair and installation of equipment	2
AE	Textiles, textile products, leather and footwear	2	AE	Basic metals	2
AE	Wood and products of wood and cork	1	AE	Coke and refined petroleum products	1
AE	Paper products and printing	1	EM	Mining and quarrying, energy producing products	1
AE	Other transport equipment	1	EM	Mining and quarrying, non-energy producing products	1
AE	Air transport	1	AE	Mining and quarrying, non-energy producing products	1
AE	Manufacturing nec; repair and installation of equipment	1			
AE	Agriculture, hunting, forestry	1			

Sources: Bonadio and others (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables; OECD Trade in Employment Database; and IMF staff calculations.
Note: Sample covers G-20 economies, excluding Australia; regional aggregates for Asia and Pacific, Middle East and Central Asia, Europe, and Western Hemisphere; and a rest of the world aggregate. Computed using the impact on total employment in each economy from all possible positive productivity shocks at the source economy-sector level. The three source economy-sectors with the largest employment responses by country in which employment in the affected economy positively co-moves with the economy-sector in which the shock originates are summarized under "complementarity" (panel 1), while negative impacts are summarized under "competition" (panel 2). Thus, the entries in the two columns "Number of Destination Economies Affected" in each panel sum to 57 = 19 economies x 3 source sectors. AE = advanced economy; EM = emerging market.

Online Annex Table 4.4.5. Sector Numbers and Names

ICIO Code	Sector	Name
01T02	1	Agriculture, huting, forestry
03	2	Fishing and aquaculture
05T06	3	Mining and quarrying, energy producing products
07T08	4	Mining and quarrying, non-energy producing products
09	5	Mining support service activities
10T12	6	Food products, beverages and tobacco
13T15	7	Textiles, textile products, leather and footwear
16	8	Wood and products of wood and cork
17T18	9	Paper products and printing
19	10	Coke and refined petroleum products
20	11	Chemical and chemical products
21	12	Pharmaceuticals, medicinal chemical and botanical products
22	13	Rubber and plastics products
23	14	Other non-metallic mineral products
24	15	Basic metals
25	16	Fabricates metal products
26	17	Computer, electronic and optical equipment
27	18	Electrical equipment
28	19	Machinery and equipment, nec
29	20	Motor vehicles, trailers and semi-trailers
30	21	Other transport equipment
31T33	22	Manufactuing nec; repair and installation of equipment
35	23	Electricity, gas, steam and air conditioning supply
36T39	24	Water supply; seweage, waste management and remediation activities
41T43	25	Construction
45T47	26	Wholesale and retail trade
49	27	Land transport and transport via pipelines
50	28	Water transport
51	29	Air transport
52	30	Warehousing and support activities for transportation
53	31	Postal and courier activities
55T56	32	Accommodation and food service activities
58T60	33	Publishing, audiovisual and broadcasting activities
61	34	Telecommunications
62T63	35	IT and other information services
64T66	36	Financial and insurance activities
68	37	Real estate activities
69T75	38	Professional, scientific and technical activities
77T82	39	Administrative and support services
84	40	Public administation and defence; compulsory social security
85	41	Education
86T88	42	Humand health and social work activities
90T93	43	Arts, entertainment and recreation
94T96	44	Other service activities
97T98	45	Activities of households as employers; undifferentiated goods- and services- services-producing activities of households for own use

Source: Bonadio and others (2021, 2023); Huo, Levchenko, and Pandalai-Nayar (2019); OECD Inter-Country Input-Output Tables.

Online Annex 4.5. Modeling the Impact of a G20 Upside Scenario

This online annex provides a summary of key elements of the IMF's Global Integrated Monetary and Fiscal model (GIMF) and its calibration, and the methodology used to construct a G20 EM upside scenario, along with some further results.

Description of The Global Integrated Monetary and Fiscal Model (GIMF)

Summary of the Model Structure

The IMF's GIMF is an annual, multi-region, micro-founded dynamic stochastic general equilibrium model (DSGE) of the global economy. In this chapter, GIMF comprises 10 regions: the United States, EU+, other advanced economies, China, India, Southeast Asia, Middle East and CIS (also referred to as "oil exporters"), Mexico, other Latin America, and the other EMDEs.[16] Alongside the standard elements, a tradable sector related to global value chains (GVC) was added for this chapter, referred to hereafter as "the GVC sector." More detailed expositions of the model can be found in Kumhof and others (2010) for the basic theory, Anderson and others (2013) for the basic properties, and Carton and Muir (2024) for both the theory and properties of GIMF with a GVC sector.

Some households are modeled as non-Ricardian, finitely lived, overlapping generations, as found in Blanchard (1985), Buiter (1988), Weil (1989), and Yaari (1962). These saving households choose consumption, savings, and labor supply to firms. The remaining households are liquidity constrained, consuming all their income every period and setting their labor supply in proportion to that of the saving households. This reinforces the short-term non-Ricardian properties of the model.

Profit-maximizing firms (owned by households) operate in monopolistically competitive markets, and produce goods in non-tradable, tradable, and the GVC sectors. These three types of goods are based on sectors from the OECD Inter-Country Input-Output Tables (OECD 2021), presented in Online Annex Table 4.5.1.

[16] Specifically, the regions comprise the following countries: United States is alone; EU+ is the European Union and Switzerland; other advanced economies is Australia, Canada, Iceland, Israel, Japan, Korea, New Zealand, Norway, and the United Kingdom; China and India are alone; Southeast Asia is Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam; Middle East and CIS (Commonwealth of Independent States) is Kazakhstan, Morocco, Russia, Saudi Arabia, and Tunisia; Mexico is alone; other Latin America is Argentina, Brazil, Chile, Colombia, Costa Rica, and Peru; and other EMDEs includes South Africa, and Türkiye plus the regions of sub-Saharan Africa, the Caribbean, other Central Asia, other Latin America, other Middle East, and Oceania, and any remaining EMDEs.

Online Annex Table 4.5.1. Definition of GIMF's Production Sectors

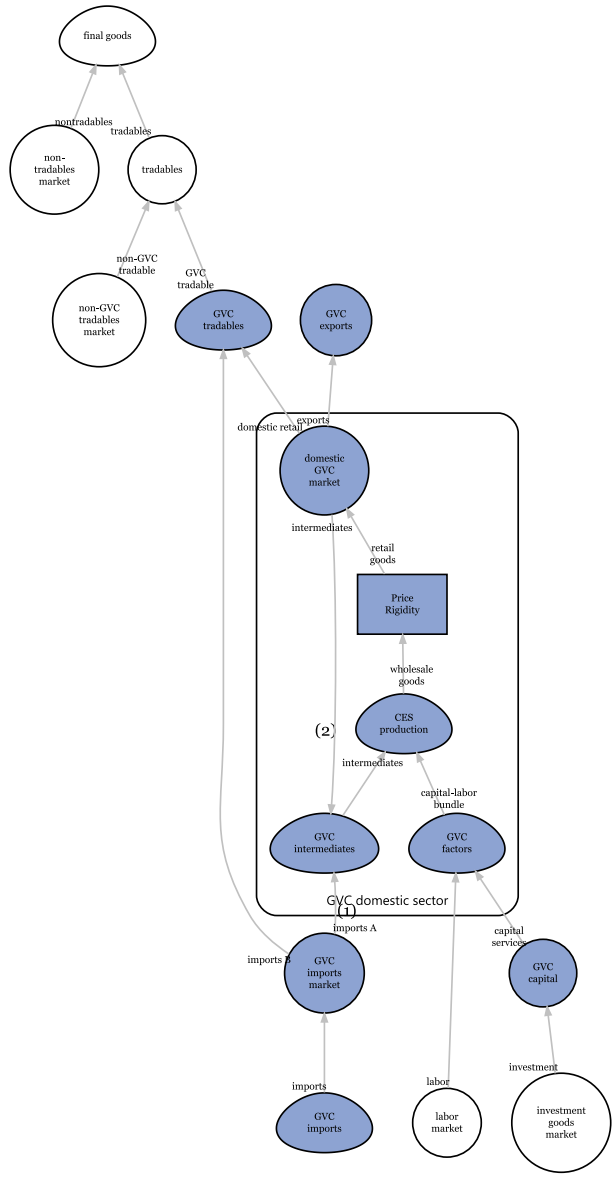
Nontradables		Tradables		GVC goods	
Code	Sector Name	Code	Sector Name	Code	Sector Name
D35	Electricity and natural gas	D01T02	Agriculture, hunting, forestry	D05T06	Mining (energy)
D36T39	Water	D03	Fishing	D07T08	Mining (non-energy)
D41T43	Construction	D09	Mining (support)	D13T15	Textiles, leather and footwear
D45T47	Wholesale and retail trade	D10T12	Food	D16	Wood and wood products
D53	Postal services	D23	Other non-metallic products	D17T18	Paper products and printing
D61	Telecommunications	D49	Land transport	D19	Coke and refined oil products
D68	Real estate	D52	Warehousing	D20	Chemicals
D77T82	Administration	D55T56	Hotels and restaurants	D21	Pharmaceutical products
D84	Public administration	D58T60	Publishing and broadcasting	D22	Rubber and plastics
D85	Education	D64T66	Finance and insurance	D24	Basic metals
D86T88	Health			D25	Fabricated metal products
D90T93	Arts			D26	Computers and electronics
D94T96	Other services			D27	Electrical equipment
D97T98	Households as employers			D28	Other machinery
				D29	Motor vehicles
				D30	Other transport equipment
				D31T33	Repair
				D50	Water transport
				D51	Air transport
				D62T63	Information Technology
				D69T75	Professional

Source: OECD (2021) and IMF staff classification.

To produce those goods, firms in the three sectors invest, along the lines of the Bernanke, Gertler and Gilchrist (1999) financial accelerator. For each sector, investment cumulates to the capital stock chosen by firms to maximize their profits. Firms need to finance their investment, but their retained earnings are insufficient provide full financing, so they must borrow from financial intermediaries. However, firms could potentially go bankrupt, which requires costly monitoring by financial intermediaries. Therefore, firms can be perceived as riskier as financial conditions worsen, leading to endogenously determined corporate risk premia.

Of the three production sectors, the GVC sector is more complex than the others, as seen in Online Annex Figure 4.5.1. GVC goods are not only used to produce final goods, but also as inputs in the production of GVC goods themselves. The sector is intended to represent industries such as semiconductors, with chips going into the production of computers sold to consumers (a final good), or as inputs into automobile-parts (another GVC good). Production in the GVC sector combines a bundle of capital and labor with already produced GVC goods, which are both imported (labeled (1)) and domestically sourced (labeled (2)). The produced output is then split between inputs into final goods or directed back as inputs into the production of other GVC goods, both domestically and abroad. Known as roundabout production (Basu 1995), this process amplifies the impact of spillovers of foreign shocks, especially for open economies with large GVC sectors.

Online Annex Figure 4.5.1. The Global Value Chain Sector in GIMF



Source: Carton and Muir (2024)

Regions trade final goods (consumption and investment), and GVC and non-GVC tradable intermediate goods. The flows of these goods are tracked bilaterally. Trade flows react to demand, supply, and pricing (i.e., the terms of trade and bilateral real exchange rates) conditions.

Monetary and fiscal policies are set to passively respond to shocks according to inflation forecast-based targeting and debt-GDP ratio targeting rules respectively.

Summary of the Calibration

Each region's economy is calibrated using the OECD Inter-Country Input-Output Tables for 2018 (OECD 2021), drawing on its national accounts and fiscal ratios. National accounts ratios are summarized in Online Annex Table 4.5.2. The size of the various sectors works in tandem with more specific parameterizations in the various sectors, such as consumption and international trade, discussed below.

For consumption, the intertemporal elasticity of substitution is common across regions at 0.2. The share of liquidity constrained households varies based on level of financial market development, and is set at 25 percent for the United States, EU+, the other advanced economies, and China, and at 50 percent for the other EM regions. Since the EM regions have higher shares of liquidity constrained households, they are less able to smooth their consumption under temporary shocks or implement gradual adjustments under permanent shock, so they have more volatility in GDP, which can lead to larger spillovers to the advanced economies. But temporary spillovers from EMs on advanced economies will be muted by the lower share of liquidity-constrained households, unlike in the EMs.

Online Annex Table 4.5.2 Domestic Sector Calibration
(percent of region's GDP, unless noted otherwise)

	United States	European Union +	Other Advanced Economies	China	India	Southeast Asia	Middle East and CIS	Mexico	Other Latin America	Rest of the World
Share of Global GDP (%, US$)	24.4	18.9	8.7	16.7	3.2	2.3	3.2	1.2	2.3	16.7
Domestic Demand										
Household Consumption	65.4	54.9	56.3	51.7	56.7	57.9	52.2	63.0	63.0	61.2
Private Investment	17.3	21.1	19.9	18.5	26.8	26.4	23.0	22.0	17.1	19.0
Trade										
Aggregate Exports	11.4	20.1	23.4	17.4	20.1	44.2	34.5	36.3	16.2	25.5
Consumption	*3.5*	*6.4*	*5.4*	*5.1*	*6.2*	*14.9*	*5.9*	*8.8*	*4.4*	*7.8*
Investment	*1.6*	*3.1*	*3.6*	*3.1*	*3.3*	*4.6*	*1.2*	*6.4*	*0.8*	*1.2*
Non-GVC Tradable	*2.5*	*3.5*	*3.9*	*1.8*	*2.6*	*7.7*	*4.7*	*4.8*	*3.8*	*3.6*
GVC Tradable	*3.8*	*7.1*	*10.5*	*7.5*	*8.0*	*17.0*	*22.7*	*16.3*	*7.2*	*13.0*
Aggregate Imports	11.4	20.1	23.4	17.4	20.1	44.2	34.5	36.3	16.2	25.5
Consumption	*2.9*	*6.5*	*7.1*	*4.0*	*2.4*	*8.9*	*15.3*	*9.2*	*5.3*	*8.0*
Investment	*1.4*	*2.8*	*2.4*	*1.6*	*2.3*	*6.1*	*8.2*	*4.1*	*2.1*	*4.9*
Non-GVC Tradable	*1.7*	*3.8*	*4.1*	*2.6*	*2.9*	*8.0*	*3.6*	*5.2*	*2.6*	*3.7*
GVC Tradable	*5.4*	*7.0*	*9.8*	*9.2*	*12.5*	*21.2*	*7.4*	*17.8*	*6.2*	*8.9*

Source: OECD (2021) and IMF staff calculations.
Note: "European Union +" comprises the European Union and Switzerland.

Region size and openness to trade also differentiate the role of regions in the global economy. Regions with smaller shares of global GDP will have less impact on the global neutral interest rate. A region's degree of openness determines the size of the spillovers it faces from shocks in the rest of the world. Usually, a high degree of openness indicates large trade flow abroad, so its impact on other regions that more-closed regions that are of a larger size than itself – for example the impact of southeast Asia can be as much as India, even though it is only two-thirds the size.

Many of the elasticities in GIMF are calibrated the same across regions, including for trade and the combination of various goods to produce final goods. However, each region has a unique set of related bias parameters, which, given the elasticities, are computed based on the calibration of key steady-state ratios based on OECD (2021).

Online Annex Table 4.5.3. Calibration of Key Production and Trade Elasticities, All Regions

Elasticity between =>	*Capital-Labor / GVC*	*Domestic / Imported*	*Different Regions*
Consumption	-	1.5	1.5
Investment	-	1.5	1.5
Non-GVC Tradables	-	1.5	1.5
GVC Tradables	0.5	0.8*	0.8

Source: IMF staff calculations.
* Elasticity between domestic and imported when using GVC tradables in the production of final goods or of other GVC tradables.

For this chapter, the most important elasticities are related to trade and combining imports and domestically-produced goods to produce intermediate and final goods (Online Annex Table 4.5.3). Generally, substitution between domestic goods and imported goods, and between different regions for those imports, are elastic, with a benchmark elasticity of 1.5. However, demand for goods in the GVC sector are assumed to be relatively inelastic at 0.8. This captures that GVCs are dependent on specific sources for inputs and destinations for outputs, that are hard to alter.

For final consumption and investment goods, which are important in the formulation of the upside scenario, they are a highly inelastic combination of nontradable goods and a tradable goods bundle, with an elasticity of substitution of 0.5. Even the tradable goods bundle itself is somewhat inelastic at 0.95, as it is assembled from non-GVC and GVC tradable intermediate goods.

More Details on the G20 EM Upside Scenario

Online Annex Table 4.5.4: 70th Percentile of Upside Scenario GDP Impacts on EMs
(Deviation of real GDP growth from WEO baseline)

	Year 3 2026	Year 5 2028
All EM Regions	0.7	0.9
India	0.7	1.0
Southeast Asia	0.5	0.6
Middle East and CIS	1.3	1.5
Mexico	2.5	3.0
Other Latin America	1.1	1.4
Other EMDEs	0.2	0.3

Source: IMF staff calculations.
Note: "CIS" is the Commonwealth of Independent States; "EMDEs" is emerging markets and developing countries

The G20 EM (excluding China) upside scenario is strongly linked to the historical experience of the G20 EMs. Those regions' high degree of volatility admits the possibility of G20 EM upside growth surprises that could offset the downside scenario focused on China that is discussed in the chapter. The upside scenario is based on shocks to short-term aggregate demand (household consumption and private investment) in the G20 EMs excluding China, over a period of five years (the forecast horizon).[17] The size of the shock represents a likely upside to the current WEO baseline: there is a 30 percent probability that growth in each EM ex-China could be higher than envisaged in this scenario, or alternatively 70 percent probability that growth is lower than envisaged in this scenario. The size and path of each G20 EM's shock profile is specific to the growth distribution of each G20 EM. For regions that comprise not only G20 EMs (Middle East and CIS with Russia and Saudi Arabia, other Latin America with Argentina and Brazil, southeast Asia with Indonesia, and other EMDEs with Türkiye and South Africa), each G20 EM's shock profile is scaled according to their GDP share within the region to construct the shock profile for the aggregated EM region.

Therefore, the other G20 EMs upside scenario could have growth averaging up to 0.7 percentage points higher for the other G20 EMs over the WEO forecast horizon (Online Annex Table 4.5.4). The fifth-year impacts on real GDP growth range from a maximum of 0.3 percentage points for the other EMDEs (where South Africa and Türkiye are only a small portion of the region) to 1 percentage points for India, 1.5 percentage point for the Middle East

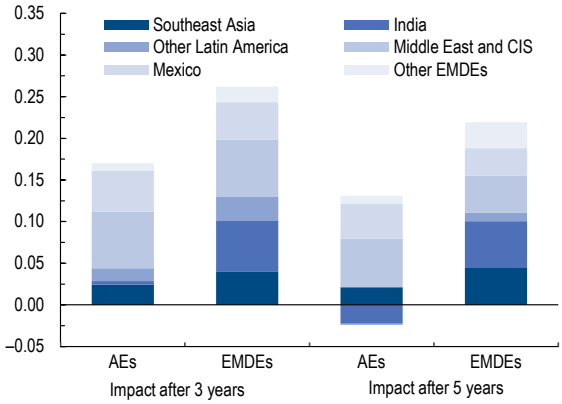
[17] For more on the WEO's confidence bands for the G20 economies, please see "Box 1.2. Risk Assessment Surrounding the World Economic Outlook's Baseline Projections" in Chapter 1, and for specifics on the methodology to generate them, refer to Andrle and Hunt (2020). For more on the model used, the G20 Model, part of the IMF's Flexible System of Global Models (FSGM), see Anderson and others (2015).

and CIS due to oil exports, and 3 percentage points for Mexico. This could push up global growth, on average, by at most 0.5 percentage points.

Recall from Figure 4.12 in the main text that EM spillovers on advanced economies and China would be generally positive but small from the upside scenario, primarily through GVCs. Both advanced economies and China growth could be up to 0.1 percent higher on average in the first three years, but then the effect would subside. The other G20 EMs shocks would also generate spillovers among the EMDE regions, accounting for about 15 percent of the impact of the upside scenario to 2026. The EM spillovers on EMDEs is larger than those on advanced economies (Online Annex Figure 4.5.2), since the upside scenario is based on higher G20 EM aggregate demand for final goods, of which EMDEs produce more than advanced economies.

Online Annex Figure 4.5.2. Contributions of G20 Emerging Markets to Upside Scenario Spillovers on the Level of Real GDP

(Percentage point deviation from the WEO baseline)



Source: IMF staff calculations.
Note: AEs = advanced economies; EMs = emerging markets; EMDEs = emerging markets and developing economies; CIS = Commonwealth of Independent States.

The contributions to the level of spillovers on the level of real GDP after 3 and 5 years from the individual G20 EM shocks vary substantially between advanced economies and EMDEs, as seen in Online Annex Figure 4.5.2. The largest G20 contributors are those with the greater likelihood of a larger shock relative to the other G20 EMs (outlined in Online Annex Table 4.5.4 above). But there are also domestic factors at play from each G20 EM, identified below.

The largest spillovers to advanced economies after 3 and 5 years would be from the Middle East and CIS (hydrocarbon exports), followed by Mexico (its extensive two-way trade relationship with the United States) and southeast Asia (its significant trade with China and advanced economies). The EMDEs as a group would experience the most spillovers from India (supplier to other EMDEs of intermediate goods through GVCs, and final consumption and investment goods, and major user of their raw materials), followed by Middle East and CIS (hydrocarbon exports, as with advanced economies), and then southeast Asia (supplier of final consumption goods).

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