EXECUTIVE BOARD MEETING

EBS/23/20

March 15, 2023

To: Members of the Executive Board

From: The Secretary

Subject: **April 2023 World Economic Outlook—Analytical Chapter 4 and Online Annexes**

Board Action:	Executive Directors' **consideration** (Formal)
Tentative Board Date:	**Wednesday, March 29, 2023**
Publication:	Yes, it is intended that the full set of the World Economic Outlook documents will be released to the public at the time of the World Economic Outlook press conference, tentatively scheduled for **Tuesday, April 11, 2023**. The analytical chapters will be made available to the public on the IMF website in advance of the publication of the full document.
Questions:	Mr. Presbitero, RES (ext. 38961) Mr. Ahn, RES (ext. 39620) Mr. Malacrino, RES (ext. 34121) Mr. Habib, RES (ext. 39486)
Additional Information:	The paper will be revised for publication in light of the Executive Board discussion. If Executive Directors have comments, they should notify Mr. Presbitero, Mr. Ahn, Mr. Habib and Mr. Malacrino by **5:30 p.m. on Thursday, March 23, 2023**

CHAPTER 4

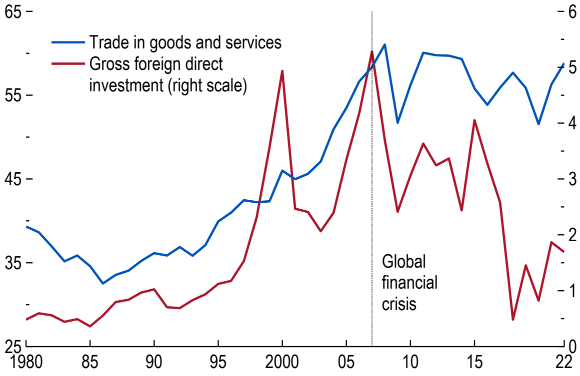
GEOECONOMIC FRAGMENTATION AND FOREIGN DIRECT INVESTMENT

Supply-chain disruptions and rising geopolitical tensions have brought the risks and potential benefits and costs of geoeconomic fragmentation to the center of the policy debate. This chapter studies how such fragmentation can reshape the geography of foreign direct investment (FDI) and, in turn, how FDI fragmentation can affect the global economy. The recent slowdown in FDI has been characterized by divergent patterns across host countries, with flows increasingly concentrated among geopolitically aligned countries, particularly in strategic sectors. Several emerging market and developing economies are highly vulnerable to FDI relocation, given their reliance on FDI from geopolitically distant countries. In the long term, FDI fragmentation arising from the emergence of geopolitical blocs can generate large output losses. These losses may be especially severe for emerging market and developing economies facing heightened restrictions from advanced economies, which are their major sources of FDI. Multilateral efforts to preserve global integration are the best way to reduce the large and widespread economic costs of FDI fragmentation. When multilateral agreements are not feasible, multilateral consultations and processes to mitigate the spillover effects of unilateral policies are required. In a more fragmented world, some countries could reduce their vulnerability by promoting private sector development, while others could take advantage of the diversion of investment flows to attract new FDI by undertaking structural reforms and improving infrastructure.

Introduction[1]

Figure 4.1. "Slowbalization"
(Percent of GDP)

Foreign direct investment sharply declined after the global financial crisis.



Source: IMF staff calculations.

Rising geopolitical tensions and the uneven distribution of the gains from globalization have contributed to increasing skepticism toward multilateralism and to the growing appeal of inward-looking policies (Colantone and Stanig 2018; Rodrik 2018; Autor and others 2020; Pastor and Veronesi 2021). Brexit, trade tensions between the US and China, and Russia's invasion of Ukraine pose a challenge to international relations and could lead to policy-driven reversal of global economic integration, a process referred to as geoeconomic fragmentation (GEF). This process encompasses different channels, including trade, capital, and migration flows.[2] This chapter focuses on one specific channel—the fragmentation of foreign direct investment (FDI), which is cross-border investment through which foreign investors establish a stable and long-lasting influence over domestic enterprises.

A slowdown in globalization—often referred to as "slowbalization"—is not new. For most countries it dates to the aftermath of the global financial crisis (Antràs 2021; Baldwin 2022). A decrease in FDI has been particularly visible, with global FDI declining from 3.3 percent of GDP

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[1] The authors of this chapter are JaeBin Ahn, Benjamin Carton, Ashique Habib, Davide Malacrino, Andrea Presbitero, and Dirk Muir, under the guidance of Shekhar Aiyar, and with support from Shan Chen, Youyou Huang, Carlos Morales, Chao Wang, and Ilse Peirtsegaele. The chapter benefited from comments by Richard Baldwin and seminar participants and reviewers. Eswar Prasad was a consultant for the project.

[2] Aiyar and others (2023) present signs of geoeconomic fragmentation along different dimensions (for example, trade, capital flows, and reassessments of geopolitical risk), analyze several channels through which such fragmentation could propagate through the global economy, and discuss how the rules-based multilateral system must adapt to the changing world. See the April 2023 *Global Financial Stability Report* for an analysis of the effects of geoeconomic fragmentation on financial flows, with implications for financial stability and macro volatility.

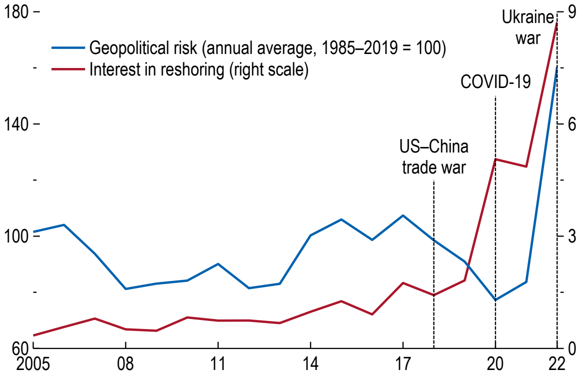
in the 2000s to 1.3 percent between 2018 and 2022 (Figure 4.1; see also UNCTAD 2022 for an overview of recent trends in FDI). While a range of factors have contributed to this protracted phase of slowbalization, the fragmentation of capital flows along geopolitical fault lines and the potential emergence of regional geopolitical blocs are novel elements that could have large negative spillovers to the global economy.

Firms and policymakers are increasingly looking at strategies for moving production processes to trusted countries with aligned political preferences to make supply chains less vulnerable to geopolitical tensions.[3] A text-mining analysis of earnings call reports from a large sample of multinational corporations shows a sharp spike in firms' interest in reshoring and friend-shoring (Figure 4.2), occurring at the same time that the average geopolitical distance across country pairs started increasing. Recently, US Treasury Secretary Janet Yellen (2022) argued that rather than relying heavily on countries with which the US has geopolitical tensions, US firms should move toward friend-shoring of supply chains to a large number of trusted countries. In Europe, the French government has been urging the EU to accelerate production targets, weaken state aid rules, and develop a "Made in Europe" strategy to counter domestic production subsidies provided by the US Inflation Reduction Act (Tamma and Stolton 2023). In China, too, government directives aim to replace imported technology with local alternatives to reduce dependence on geopolitical rivals (Bloomberg News 2022). Rising interest in reshoring is a significant reversal of the division of production pursued through offshoring, driven predominantly by differences in labor and input costs (Feenstra 1998; Antràs and Yaple 2014).

Figure 4.2. Rising Geopolitical Tensions and Foreign Direct Investment Fragmentation

(Index; frequency of mentions of reshoring on right scale)

Recent years have seen increasing geopolitical risk and companies' interest in reshoring and friend-shoring.



Sources: Bailey, Strezhnev, and Voeten (2017); Hassan and others (2019); NL Analytics; and IMF staff calculations.
Note: The interest in reshoring measures the frequency of mentions of reshoring, freind-shoring or near-shoring in firms' earning calls.

The importance of friend-shoring goes beyond just announcements and translates into investment-screening measures motivated by national security purposes (UNCTAD 2023). Recent large-scale policies implemented by major countries to strengthen domestic strategic manufacturing sectors suggest that a shift in cross-border capital flows is about to take place. Most notable is a series of recent bills adopted against the backdrop of rising US-China trade tensions—such as the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act and the Inflation Reduction Act in the US and the European Chips Act—that could affect multinational corporations' production and sourcing strategies, prompting efforts to reconfigure their supply-chain networks (Box 4.1).

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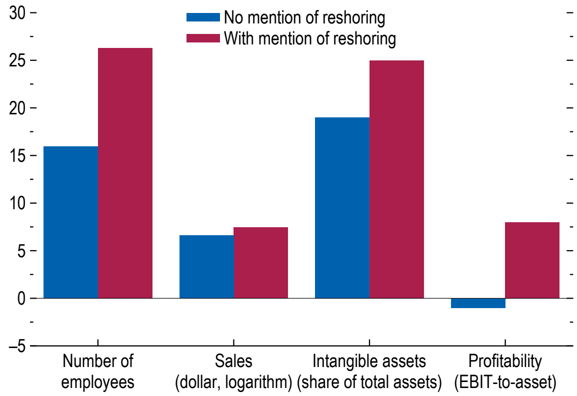
[3] The term "reshoring" refers to a country's transfer of (part of the) global supply chain back home (or geographically closer to home in the case of "nearshoring"). "Friend-shoring" limits supply-chain networks and the sourcing of inputs to countries allied with a home country and trusted partners that share similar values. The chapter uses these terms in relation to the decision to relocate FDI (rather than to the more general decision of where to source inputs).

Figure 4.3. Interest in Reshoring and Firm Characteristics

Firms more likely to reshore are larger and more productive.



Sources: Compustat; Hassan and others(2019); NL Analytics; and IMF staff calculations.
Note: Simple averages across firms that mentioned or did not mention reshoring, friend-shoring, and near-shoring in earnings calls. Differences across groups are statistically significant. EBIT = earnings before interest and taxes.

This reconfiguration of supply chains could potentially strengthen domestic security and help maintain a technological advantage. It may also increase diversification, provided the existing supply of inputs is concentrated in a single or a small number of foreign suppliers, such that domestic and close-country sourcing would increase the number of available options. However, as most countries exhibit a marked degree of home bias in sourcing of inputs (see Chapter 2 of the April 2022 *World Economic Outlook*), in most cases reshoring or friend-shoring to existing partners will likely reduce diversification and make countries more vulnerable to macroeconomic shocks.

This chapter studies how GEF could affect the global economy through a shift in the geographic footprint of FDI. While a growing literature investigates the costs of GEF through trade and technological decoupling[4], existing work has not yet looked directly at FDI fragmentation. But this is likely to be a relevant channel though which the emergence of geopolitical blocs could have global spillovers. In fact, FDI accounts for a substantial share of domestic capital stock globally—about 12 percent, on average—and is generally associated with knowledge transfer to domestic firms and economic growth, especially in emerging market and developing economies (Alfaro and others 2004; Javorcik 2004; Kose and others 2009). A relocation of FDI closer to source countries could have direct negative effects on current host economies through lower capital and technological deepening, as firms expressing interest in reshoring and friend-shoring tend to be on average larger, more profitable, and more knowledge-intensive (Figure 4.3).

Against this backdrop, this chapter starts by looking for early signs of FDI fragmentation, using detailed bilateral investment-level data on FDI from 2003 to the end of 2022. It investigates two questions: (1) Is there any evidence of reallocation of FDI across countries, indicating that flows are becoming more fragmented? and (2) Do geopolitical factors contribute to explaining bilateral FDI flows, so that countries deepen their integration with friends and reduce their reliance on foes? The chapter develops a multidimensional index of countries' vulnerability to FDI relocation combining information on the geopolitical distance between source and host countries, share of strategic sector investment in total FDI inflows, and degree of market power enjoyed by the host country.

Next, the chapter turns to quantifying the potential costs of FDI fragmentation and their distribution across countries. To understand the channels through which a potential unwinding of FDI could affect host countries, the chapter empirically examines FDI spillovers, taking both

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[4] See, among others, Cerdeiro and others 2021; Eppinger and others 2021; Felbermayr and others 2022; Giammetti and others 2022; Goes and Bekkers 2022; Javorcik and others 2022. A related literature looks at the effects of Brexit and the 2018–19 US–China trade war; see Caliendo and Parro (2021) and Fajgelbaum and Khandelwal (2022) for an extensive review.

macro- and micro-level approaches. An extensive literature on the economic effects of FDI on host countries does not deliver consistent results when simply looking at aggregate flows (Bénétrix, Pallan, and Panizza 2022). The chapter extends this literature by conducting a country-level analysis of the relationship between GDP growth and FDI separately for horizontal and vertical investment, as the latter is more likely to be affected by GEF. A subsequent firm-level analysis combines investment-level FDI data with a large sample of cross-country firm-level surveys to identify potential spillovers to firm labor productivity within and across sectors along the value chain.

Finally, the chapter calibrates a number of illustrative hypothetical scenarios to provide a sense of the possible long-term economic implications of FDI fragmentation using a multiregion dynamic stochastic general equilibrium (DSGE) model. It employs scenarios to explore the distribution of costs and benefits across economies, including those from spillovers through external demand and the reallocation of production capacity. Fragmentation is modeled as a permanent rise in investment barriers between opposing geopolitical blocs centered on the two largest economies (China and the US), with economies pursuing a nonaligned path potentially facing heightened uncertainty.

The main conclusions from the chapter are as follows:

- The recent slowdown in FDI has been characterized by divergent patterns across host countries, particularly when considering investment in strategic sectors, like semiconductors. FDI flows are increasingly concentrated among countries that are geopolitically aligned. The role of geopolitical alignment in driving the geographic footprint of FDI is particularly relevant for emerging market and developing economies and has increased since 2018, with the resurgence of trade tensions between the US and China. Thus, if geopolitical tensions were to increase and countries were to move farther apart along geopolitical fault lines, FDI is likely to become more concentrated within blocs of aligned countries. Efforts to preserve a multilateral dialogue are needed to keep FDI fragmentation from increasing.

- Analysis from a multidimensional index of vulnerability to FDI relocation suggests that, on average, emerging market and developing economies are more vulnerable to such relocation than advanced economies. This is mostly because of emerging market and developing economies' reliance on FDI from countries with which they are relatively unaligned geopolitically. Several large emerging markets, across different regions, show high vulnerabilities to relocation of FDI, indicating that the fragmentation scenario is not a risk only for a few countries. As better regulatory quality is associated with lower vulnerability, countries could mitigate their exposure to FDI relocation by introducing policies and regulations to promote private sector development.

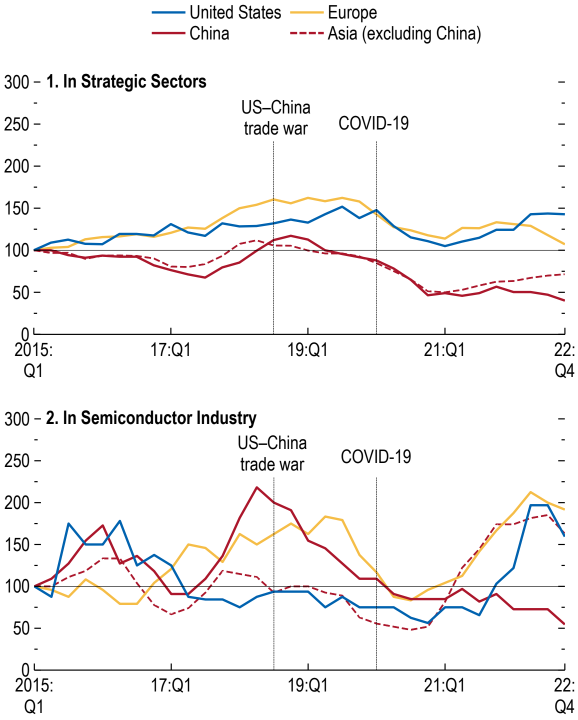
- A further contraction in FDI and a shift in its geographic distribution would likely have large negative effects on host countries, through lower capital accumulation and technological deepening. The chapter finds that vertical FDI, more likely to be targeted by policies aimed at friend-shoring investment in strategic sectors, is associated with economic growth, not least because of its knowledge-intensive nature. The entry of multinational corporations also directly benefits domestic firms. In advanced economies, increased competition from foreign firms pushes domestic firms to become more productive. In emerging market and developing economies, domestic suppliers benefit from technology transfers and increased local demand for inputs from foreign firms in downstream sectors.

- Illustrative model-based scenarios suggest that FDI fragmentation—modeled as a permanent rise in cross-bloc barriers to importing investment inputs—could substantially reduce global output, by about 2 percent in the long term. Simulations of various hypothetical scenarios suggest that the losses are likely to be unevenly distributed, with emerging market and developing economies with reduced access to advanced economies particularly affected, through both lower capital formation and reduced productivity gains. While the diversion of investment inputs could allow some economies to gain, such benefits could be significantly offset by spillovers from lower external demand. Alternate scenarios are used to highlight that nonaligned regions could have some negotiating power vis-à-vis the geopolitical blocs. However, uncertainty regarding their alignment could restrict their ability to attract investment. The estimated output losses highlight the importance of carefully balancing the strategic motivations behind reshoring and friend-shoring against economic costs to the countries themselves and to third parties, including through multilateral consultations to reduce uncertainty for bystanders.

Figure 4.4. Foreign Direct Investment Fragmentation

(Number of investments, four-quarter moving average, 2015:Q1 = 100)

Foreign direct investment flows to different regions are diverging, with China losing market shares.



Sources: fDi Markets; and IMF staff calculations.
Note: Vertical lines indicate the start of US–China trade war and the start of COVID-19 pandemic, respectively.

Early Signs of FDI Fragmentation

Recent trends point to the emergence of FDI fragmentation. This chapter relies on investment-level data on new (greenfield) FDI from fDi Markets, which provides data on about 300,000 investments from the first quarter of 2003 to the fourth quarter of 2022. The richness of the data—which include information on the source and host countries and on the sector and purpose of the investment—allows for zooming in on specific regions, country pairs, and industries.[5] It also permits classification of certain sectors as "strategic": those for which policymakers may be

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[5] As the data do not show divestment, the chapter studies the geographic footprint of new direct investments. Once aggregated at the host country–year level, the investment-level data are highly correlated with gross FDI inflows, and the distributions of the two show a large degree of overlap, as also shown by Toews and Vézina (2022). As data on mergers and acquisitions are not available from the same data source, the analysis is based exclusively on greenfield investments. New (greenfield) investments are more numerous than mergers and acquisitions, especially in emerging market and developing economies; are more highly correlated with aggregate data on FDI; and are less frequently concentrated in tax havens. To mitigate the risk that findings are affected by phantom FDI (Damgaard, Elkjaer, and Johannesen 2019), the robustness of the analysis is tested excluding FDI from and to offshore financial centers and tax havens. More details are discussed in Online Annex 4.1. All online annexes are available at www.imf.org/en/Publications/WEO.

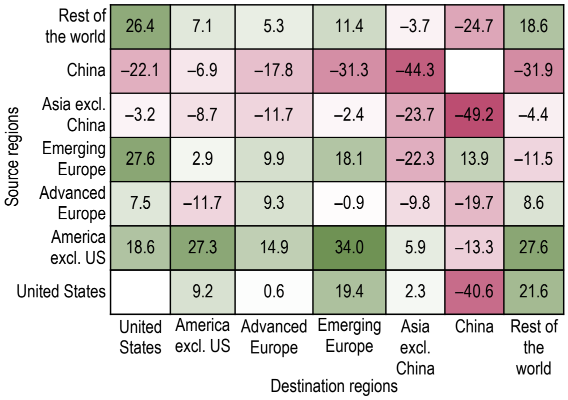
particularly interested in relocation due to national and economic security interests.[6] Throughout the chapter, the number of greenfield foreign direct investments is used as the measure of FDI.[7]

Many factors likely contributed to the slowdown in FDI before the pandemic, such as increasing automation and other technological changes (Alonso and others 2022). Yet some recent patterns point to increased FDI fragmentation as geopolitical tensions and inward-looking policies have gained importance. The flow of strategic FDI to Asian countries started to decline in 2019 and has recovered only mildly in recent quarters. By contrast, flows of strategic investments to the US and Europe have proved more resilient. As a result, by the fourth quarter of 2022, a significant gap emerged between new investment directed to these regions, with strategic FDI to Europe about twice that going to Asian countries (Figure 4.4, panel 1). Fragmentation—and specifically the lack of recovery of FDI to China—is even more apparent for foreign investment in R&D and in specific strategic industries, such as the semiconductor industry (panel 2), which both the U.S. and the European Union have targeted with policies directed at strengthening domestic production and reducing the vulnerability from unaligned foreign suppliers.

Figure 4.5. Foreign Direct Investment Reallocation across Regions, 2020:Q2–22:Q4 versus 2015:Q1–20:Q1

(Percentage point deviation from aggregate change)

The regional shift in foreign direct investment flows shows winners and losers.



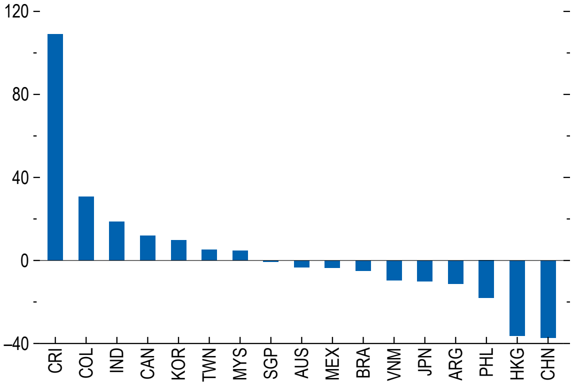
	United States	America excl. US	Advanced Europe	Emerging Europe	Asia excl. China	China	Rest of the world
Rest of the world	26.4	7.1	5.3	11.4	–3.7	–24.7	18.6
China	–22.1	–6.9	–17.8	–31.3	–44.3		–31.9
Asia excl. China	–3.2	–8.7	–11.7	–2.4	–23.7	–49.2	–4.4
Emerging Europe	27.6	2.9	9.9	18.1	–22.3	13.9	–11.5
Advanced Europe	7.5	–11.7	9.3	–0.9	–9.8	–19.7	8.6
America excl. US	18.6	27.3	14.9	34.0	5.9	–13.3	27.6
United States		9.2	0.6	19.4	2.3	–40.6	21.6

Sources: fDi Markets; and IMF staff calculations.
Note: Figure shows deviation of regional foreign direct investment change from aggregate change (19.5 percent decline). Changes are computed using the number of greenfield foreign direct investment in 2020:Q2–22:Q4 and average number in 2015:Q1–20:Q1. Green (red) shading denotes positive (negative) numbers.

Figure 4.6. Change in Outward US Foreign Direct Investment, 2020:Q2–22:Q4 versus 2015:Q1–20:Q1

(Percentage point deviation from aggregate change)

US foreign direct investment partly shifted from less to more aligned countries.



Sources: fDi Markets; and IMF staff calculations.
Notes: Figure shows the deviation of outward US foreign direct investment change by destination from aggregate change (24 percent decline). Changes are computed using the number of greenfield foreign direct investment from the United States to Europe and Asia in 2020:Q4–22:Q2 and average number in 2015:Q1–20:Q1. Economy labels on the *x*-axis uses International Organization for Standardization (ISO) country codes. "TWN" refers to "Taiwan Province of China."

These patterns are indicative of a more general process of reallocation of FDI flows across countries. FDI declined in the post-pandemic period from the second quarter of 2020 to the fourth quarter of 2022 by almost 20 percent compared to the post–global financial crisis pre-pandemic average. But this decline has been extremely uneven across regions, with the emergence of relative winners and losers as both source and host of FDI (Figure 4.5). Asia became less relevant both as a source and host, losing market

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[6] The chapter defines strategic sectors at the three-digit industry level. More details are discussed in Online Annex 4.1.

[7] As investment values in the fDi Markets data set are often estimated the chapter's main analysis relies on the number of investments; in the chapter, a change in FDI refers to a change in the number of greenfield foreign direct investments. Online Annex 4.1 shows that the main results are robust to the use of investment values.

share vis-à-vis almost all other regions. Notably, FDI to and from China declined by even more than the Asian average, although the persistent effect of the pandemic and prolonged lockdowns could also have contributed to the fall in foreign investment. In other regions, such as the US and emerging Europe, greenfield FDI declined less and, in some cases, even increased (for example, inflows to emerging Europe).

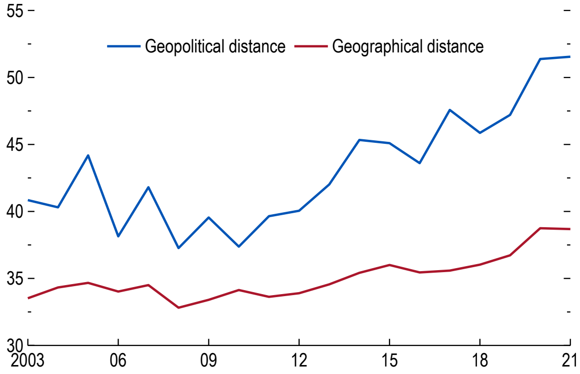
In regard to outward FDI from the US, the bottom row of Figure 4.5 shows that US FDI to China declined by much more than the average global decline. At the same time, US FDI to other regions—and particularly to emerging Europe—was more resilient. This shift in the composition of outward US FDI can be analyzed in detail, looking at differences between host countries (Figure 4.6). Among major Asian and European recipients of US FDI, some of the relative winners (for example, Canada, Korea) are politically closer to the US than the relative losers (for example, China, Vietnam). This suggests that geopolitical factors have driven part of the shift in FDI flows in recent years. The next section investigates this issue in detail.

FDI Is Becoming More Responsive to Geopolitical Factors

Rising geopolitical tensions are a key driver of FDI fragmentation, as bilateral FDI is increasingly concentrated among countries that share similar geopolitical views (Figure 4.7). This chapter measures geopolitical alignment between countries using the "ideal point distance" proposed by Bailey, Strezhnev, and Voeten (2017), which is based on the similarity of voting patterns at the United Nations General Assembly.[8] As transportation costs and geographic frictions also influence FDI decisions (Alfaro and Chen 2018; Ramondo, Rodríguez-Clare, and Tintelnot 2015), it is informative to compare their roles with that of geopolitical alignment. The share of FDI among countries that are geopolitically aligned is larger than the share going to countries geographically close, suggesting that geopolitical preferences play a key role as a driver of FDI. In addition, the importance of geopolitical alignment has increased over the last decade, and increased more steeply than the importance of geographic distance, especially for FDI in strategic sectors.

Figure 4.7. Foreign Direct Investment between Geographically and Geopolitically Close Countries
(Percent)

The importance of geopolitical distance for foreign direct investment has increased.



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); Centre d'études prospectives et d'informations internationales, Gravity database; fDi Markets; NL Analytics; and IMF staff calculations.
Note: Figure shows the annual share of total foreign direct investments between country pairs that are similarly distant (that is, in same quintile of distance distribution), geopolitically and geographically, from the United States.

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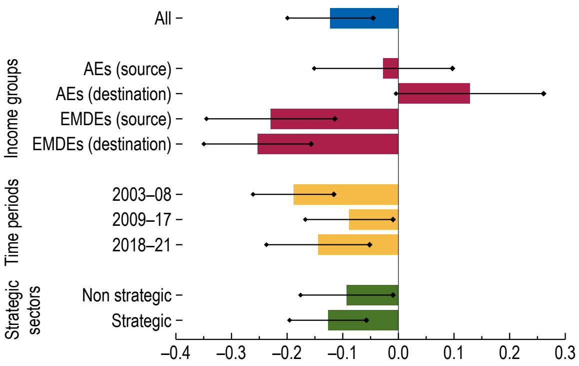
[8] Recent analysis of geoeconomic fragmentation looks at recent votes, such as the UN General Assembly vote on Resolution ES-11/1 on aggression against Ukraine on March 2, 2022 (October 2022 *Regional Economic Outlook: Asia and Pacific,* Chapter 3; Javorcik and others 2022). However, this chapter looks at the role of geopolitical alignment over a longer period: the last 20 years. In this respect, the ideal point distance has the advantage of being comparable over time. Although the ideal point distance is widely used in political science and in economics, scholars have proposed alternative measures. The findings of the chapter are robust to the use of the *S* score used in the April 2023 *Global Financial Stability Report* and proposed by Signorino and Ritter (1999), who assign numeric values to voting behavior in the UN General Assembly and calculate the degree of disagreement between two countries by computing the sum of squared differences of these values.

The role of geopolitical alignment is significant and economically relevant, particularly for emerging market and developing economies, in a gravity model that controls for other potential drivers of FDI flows. In the baseline specification, an increase in the ideal point distance from the first to the third quartile of its distribution (equivalent to moving the distance from that between Canada and Japan to that between Canada and Jordan) is associated with a decline in FDI between countries of about 17 percent. This average effect is much stronger when emerging market and developing economies are either a source or a host country. Moreover, since 2018, coincident with increasing trade tensions between China and the US, geopolitical factors have become more relevant to FDI flows. Finally, the analysis suggests that these factors matter more in regard to investments in strategic sectors (Figure 4.8). Thus, if countries move farther apart along geopolitical fault lines, FDI is likely to become more concentrated within blocs of geopolitically aligned countries. Moreover, fragmentation risks are not confined to FDI flows. Zooming in on non-FDI flows points out a sharp increase in countries' exposure to financial fragmentation risk, which could trigger a significant global reallocation of capital in response to a rise in geopolitical tensions (Box 4.2). Such tensions matter significantly for cross-border portfolio allocation and could cause a sudden reversal of cross-border capital flows, especially in emerging market and developing economies (see the April 2023 *Global Financial Stability Report*).

Figure 4.8. Gravity Model for Ideal Point Distance and Foreign Direct Investment
(Semielasticities)

Greater geopolitical distance is associated with less foreign direct investment, especially in EMDEs, in recent years, and in strategic sectors.



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); Centre d'études prospectives et d'informations internationales, Gravity database; fDi Markets; NL Analytics; and IMF staff calculations.
Note: Coefficients of ideal point distance are estimated from gravity model for number of foreign direct investments. See Online Annex 4.1 for details. AEs = advanced economies; EMDEs = emerging market and developing economies.

The findings reported in Figure 4.8 are based on a gravity model that takes bilateral FDI as the dependent variable and controls for standard push-and-pull factors, including a set of time-varying fixed effects for source and host countries (Kox and Rojas-Romagosa 2020).[9] To minimize the possibility that the coefficient on the index of geopolitical distance captures the role of other factors that could drive FDI, the model is augmented to include measures of geographic, cultural, and institutional distance and a historical measure of colonial ties. As expected, the inclusion of these variables—which are indeed associated with bilateral FDI flows—reduces the size of the coefficient of the ideal point distance, which however remains statistically and economically significant. The findings are also robust to considering FDI in manufacturing or services separately; excluding financial centers or China; controlling for the announcement and implementation of

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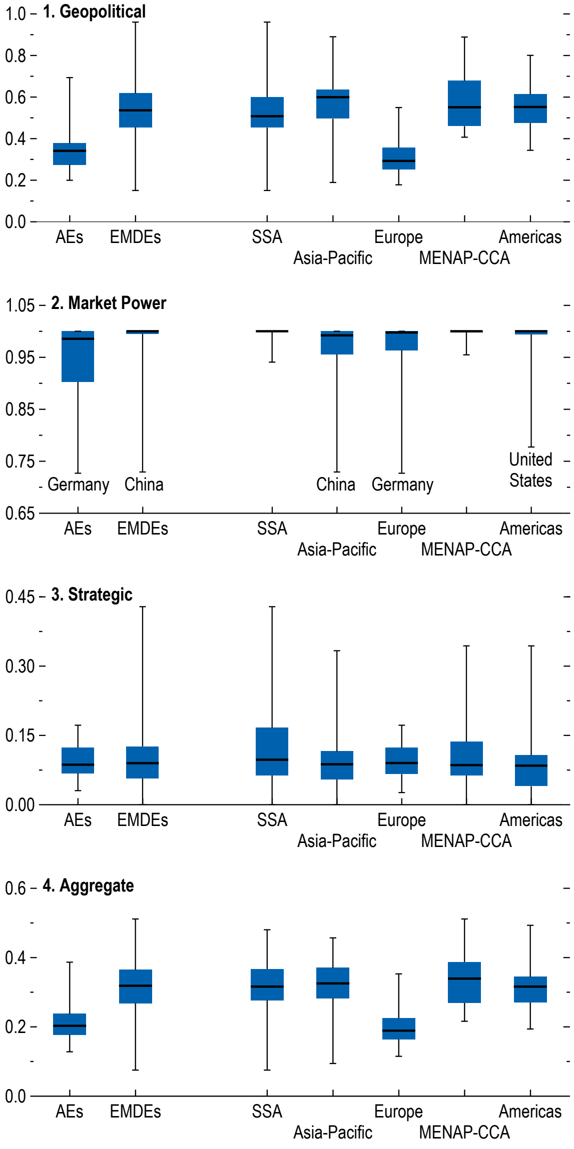
[9] The analysis is based on estimating the following specification: $= f(\alpha IPD_{sdt-1} + \beta Distance_{sd} + \tau_{st} + \upsilon_{dt}, \varepsilon_{sdt})$, where bilateral FDI flows (measured by the number of investments) from the source country *s* to the host country *d* in year *t* is a function of the lagged value of *IPD* [the ideal point distance] between countries *d* and *s*. As is standard in gravity models, the specification controls for the geographic distance between source and host countries and absorbs any time-varying unobservable push-and-pull factors, adding source country × year and host country × year fixed effects. These fixed effects would capture, for instance, business cycle dynamics that could push FDI outflows from a source country and attract inflows into a host country. As, by construction, most of the FDI_{sdt} cells are 0, the model is estimated using Poisson pseudo-maximum likelihood (Santos Silva and Tenreyro 2006). Standard errors are clustered at the country-pair level.

bilateral trade barriers, for the volume of bilateral trade, and for exchange rate effects; measuring FDI by its size rather than the number of investments; and considering cross-border mergers and acquisitions rather than greenfield FDI. The methodology and the results are described in Online Annex 4.1.

Which Host Countries Are More Vulnerable to FDI Relocation?

Figure 4.9. Vulnerability Index

Emerging market and developing economies tend to be more vulnerable to relocation of foreign direct investment than advanced economies.



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); fDi Markets; NL Analytics; Trade Data Monitor; and IMF staff calculations.
Note: Figure shows distribution of vulnerability index by income and regional groups, based on post-2009 foreign direct investment flows. AEs = advanced economies; EMDEs = emerging market and developing economies; MENAP-CCA = Middle East, North Africa, Afghanistan, Pakistan, Caucasus, and Central Asia; SSA = sub-Saharan Africa.

To assess the exposure of the stock of FDI hosted by an economy to geoeconomic fragmentation, the chapter develops a multidimensional index of vulnerability. It combines three subindices, based on three dimensions relevant to geoeconomic fragmentation: (1) the geopolitical distance between source and host countries, (2) the degree of market power that host countries have in each industry in which they receive FDI, and (3) the strategic component of the stock of FDI.

- The geopolitical index captures the idea that the greater the geopolitical distance between source and host countries, the greater the vulnerability to friend-shoring. The index is calculated for each host country by multiplying the share of investment from each source country by the geopolitical distance between host and source countries. Given that most countries receive much of their FDI from advanced economies and given that those economies are geopolitically closer to one another than to emerging market and developing economies, these economies are more geopolitically vulnerable than advanced economies (Figure 4.9, panel 1).

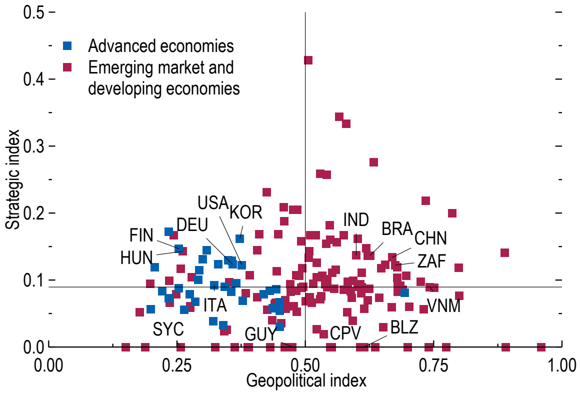
- Countries with high market shares in trade of a given product may be less vulnerable to relocation pressures in that sector, as foreign investors may have fewer options for relocating investment. The index of market power captures this dimension by treating FDI in a particular sector as less vulnerable if the host country is among the top 10 exporters in that sector. By contrast, FDI in host countries that are not among the top 10 exporters in that sector are treated as fully vulnerable. Though the vast majority of economies show low levels of protection from market power, some large economies (for example, China, Germany, US) do enjoy some level of protection, being large exporters in many sectors (Figure 4.9, panel 2).

- The strategic index measures the share of inward FDI in strategic sectors. This dimension of vulnerability shows substantial overlap between advanced and emerging market and developing economies (Figure 4.9, panel 3).

The geopolitical and strategic dimensions of vulnerability are broadly uncorrelated and capture distinct aspects of countries' vulnerability to geoeconomic fragmentation (Figure 4.10). Whereas geopolitical vulnerability is concentrated among emerging market and developing economies—as shown by the disproportionate share of red squares in the figure to the right of the vertical line denoting the median geopolitical index—many large advanced economies, including the US, Germany, and Korea, are in the top half of the distribution of strategic vulnerability. The cluster of countries particularly vulnerable along both dimensions includes some large emerging market economies, such as Brazil, China, and India, but also several other emerging market economies, suggesting that FDI fragmentation is likely to be an issue for a large set of countries.

Figure 4.10. Geopolitical Index and Strategic Index

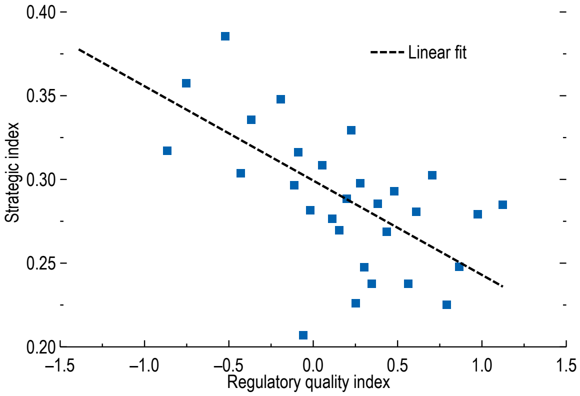
Strategic and geopolitical indices capture distinct vulnerabilities.



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); fDi Markets; NL Analytics; Trade Data Monitor; and IMF staff calculations.
Note: Data are based on post-2009 foreign direct investment flows. Horizontal line indicates the median value of strategic index, 0.09, and vertical line indicates the median value of geopolitical index, 0.5. Economy labels in the figure use International Organization for Standardization (ISO) country codes.

Figure 4.11. Vulnerability Index and Regulatory Quality

Higher regulatory quality is associated with lower vulnerabilities.



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); fDi Markets; NL Analytics; Trade Data Monitor; World Bank, World Governance Indicators; and IMF staff calculations.
Note: Sample includes a cross section of 128 countries. The binned scatterplots are obtained from a regression of the aggregate vulnerability index against the regulatory quality index, controlling for the logarithm of real GDP, trade (percent of GDP) and foreign direct investment inflows (percent of GDP). All variables are averaged over 2010–19. The regressions give a coefficient of the regulatory quality index equal to –0.057 (*p*-value of 0.000).

The three subindices are combined to construct an aggregate index. The aggregate index adds the strategic and geopolitical dimensions, with the latter multiplied by the market power index. Multiplying the geopolitical dimension by the market power index—buonded between 0 and 1—allows for a dampening of the geopolitical vulnerability component. This captures the idea that multinationals that would like to move their investments out of geopolitically distant countries will find it more difficult to do so if the host country is a key player in the global market in that sector. The strategic dimension is added to the combined geopolitical and market power component, as it reflects the heightened vulnerability of investments in specific sectors in all host countries, not only those that are geopolitically distant, and such sectors are more likely to be targeted with reshoring policies, offsetting any protection from market power.[10] Overall, emerging market and developing economies are more vulnerable to FDI fragmentation than advanced economies, even if there is large variation in the distribution of the index and some overlap between advanced and emerging market economies (for instance, 14 percent of emerging market and developing economies have a vulnerability index lower than the median for advanced economies). The distribution across regions shows the better position of Europe, while all other regions show higher and similar levels of vulnerability (Figure 4.9, panel 4).

While the aggregate vulnerability index is intended to describe exposures of existing stocks to relocation as they stand, policy measures could help reduce future vulnerabilities. Beyond multilateral efforts to preserve cooperation, domestic policies could also help, allowing economies to mitigate some risks even in a geopolitically tense world. Figure 4.11 suggests that stronger regulatory quality tends to be associated with lower aggregate vulnerability to relocation of FDI. Improved regulatory quality tends also to be associated with higher exports, which could offer protection against relocation pressures.

FDI Spillovers to Host Countries

Besides direct effects on job creation and capital formation, inward FDI could have spillover effects on domestic firms through technology diffusion, backward and forward linkages, and productivity gains from increased competition.[11] When it comes to empiric results, however, the effects are mixed (Görg and Greenaway 2004; Bénétrix, Pallan, and Panizza 2022). Cross-country studies reveal that the effect of inward FDI is uneven and depends on host countries' human capital (Borensztein, De Gregorio, and Lee 1998), institutional quality (Kose and others 2009), and financial development (Alfaro and others 2004). The lack of consistent findings may stem from FDI heterogeneity along the mode of entry, the type of investment, and the relationship between foreign and domestic firms. The evidence is generally more informative for specific types of FDI and spillovers along the value chain (Harrison and Rodríguez-Clare 2010). Hence, the analysis here explores two important dimensions: the distinction between horizontal and vertical FDI and differences in spillovers within and across industries.[12]

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[10] Rather than simply combining a host country's scores for the three subindices, the aggregate index is built up from the sector–source country level, such that market power offsets geopolitical distance only for sectors in which the host economy is among the top 10 exporters. The methodology for constructing the vulnerability indices is discussed in Online Annex 4.2.

[11] Formal descriptions of each channel are developed in Rodríguez-Clare (1996) for backward and forward linkages, Glass and Saggi (1998) for the technology spillover effect, and Barba Navaretti and Venables (2004) for the pro-competitive effect. For a more skeptical view on the gains from financial integration, see Gourinchas and Jeanne (2006).

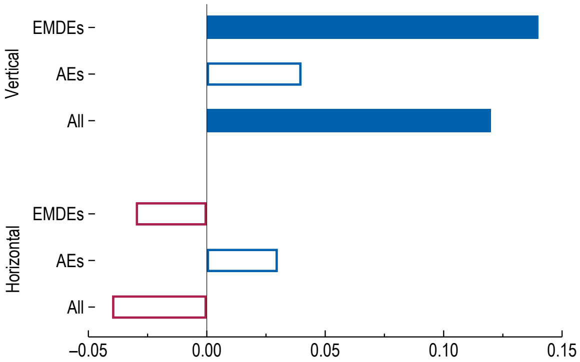
[12] The interpretation of the results should take into account the potential endogeneity of FDI, which is in part addressed by using lagged values of FDI and including fixed effects (especially in the firm-level analysis).

Horizontal versus Vertical FDI

Horizontal FDI refers to foreign firms entering a country to directly serve local markets. By contrast, vertical FDI takes place when foreign firms enter a country to produce inputs that will be supplied to affiliated firms.[13] This distinction is particularly relevant in the context of geoeconomic fragmentation, given that vertical FDI is likely more exposed to FDI fragmentation risk than horizontal FDI. Higher trade barriers, for instance, would make horizontal FDI more attractive—as it could be a substitute for trade (Brainard 1997)—while making vertical FDI less attractive. Moreover, vertical FDI is often centered on advanced technology embodied in input production and thus is more likely to be the target of policies aimed at reshoring strategic production.

Figure 4.12. Foreign Direct Investment and Growth: Horizontal versus Vertical
(Standardized coefficients)

Vertical foreign direct investments are associated with higher GDP growth in emerging market and developing economies.



Sources: Export-Import Bank of Korea; and IMF staff calculations.
Note: Figure reports the standardized coefficients obtained from cross-country growth regression estimated separately for countries with horizontal foreign direct investment and those with vertical. Solid bars indicate statistical significance at 1 percent level. See Online Annex 4.3 for details. AEs = advanced economies; EMDEs = emerging market and developing economies.

Vertical FDI is positively associated with economic growth, as it is concentrated among intermediate-goods producers that adopt more sophisticated (and skill-intensive) technology (Atalay and others 2014; Ramondo, Rappoport, and Ruhl 2016). This is not the case for horizontal FDI, more likely to be found among final-goods producers, which tend to transfer simple (and labor-intensive) assembly technology to host countries (Figure 4.12). These findings are obtained from cross-country growth regressions, which are estimated separately for countries more likely to receive vertical or horizontal FDI.[14]

Spillovers within and across Industries

The effects of the entry of a multinational corporation on domestic firms could be different depending on whether those firms are in the same sector or in other sectors—either upstream or downstream along the value chain. For instance, consider Toshiba setting up a chip-making plant in China. The Chinese chipmakers are directly affected by the entry of Toshiba (within-industry spillovers), as the increased competition can either provide local firms with a greater incentive to innovate, and thus to become more productive, or crowd out local firms by stealing market share (Markusen and Venables 1999). At the same time, there are spillovers to other industries (cross-industry spillovers): Chinese silicon producers are also affected as they are big suppliers to the chip-

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[13] The Samsung Electronics smartphone factory in India is an example of horizontal FDI, as most of its products are sold to Indian customers, whereas its semiconductor factory in Vietnam is an example of vertical FDI, as its products are sold mainly to Samsung's own affiliates worldwide. Other relatively minor types of FDI include export-platform FDI (for example, Volkswagen's plant in Mexico, which sells mostly to the US), and export-supporting FDI (for example, Toyota Financial Services USA, which offers US consumers financing options to facilitate export sales from Japan).

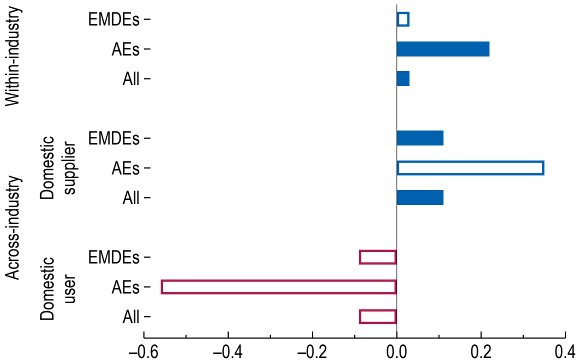
[14] This classification is based on detailed foreign subsidiary–level sales information from the Export-Import Bank of Korea. The estimation results are robust to alternative classifications based on parent and subsidiary firms' sector affiliations from Orbis. The methodology and the results are described in more detail in Online Annex 4.3.

making industry (backward linkages). Moreover, Chinese firms in the automobile industry will be also affected as they are heavy users of semiconductor chips (forward linkages).

Results based on a large sample of firm-level data from the World Bank Enterprise Surveys covering over 120,000 firms in 150 countries from 2006 to 2021 show positive spillovers to domestic firms in the same industry (Figure 4.13, top graph). Positive within-industry spillovers to firm's labor productivity are confined to advanced economies, where firms react to fiercer competition from multinational corporations by becoming more productive. In the case of cross-industry spillovers, domestic suppliers benefit from the entry of foreign firms in downstream sectors, as the latter may source inputs locally and increase local demand for inputs produced by domestic firms. Local suppliers may also benefit from learning by doing via direct contact with foreign buyers with better technology. These positive spillovers to domestic suppliers are driven by FDI in emerging market and developing economies.[15] By contrast, there is no evidence of spillovers to domestic users, even in emerging market and developing economies. This could be because foreign firms in upstream sectors mostly sell abroad, implying limited scope for positive technology spillovers via direct contact with local buyers (Figure 4.13, bottom two graphs).

Figure 4.13. Firm-Level Foreign Direct Investment Spillover: Within-Industry versus Across-Industry
(Standardized coefficients)

Foreign direct investment spillovers take place within industry in advanced economies, while domestic suppliers benefit from foreign direct investment in emerging market and developing economies.



Sources: Eora Global Supply Chain Database; fDi Markets; World Bank Enterprise Survey; and IMF staff calculations.
Note: Figure reports the standardized coefficients obtained from firm-level regression of labor productivity growth as a function of foreign direct investment within and across industries. Solid bars indicate statistical significance at 1 percent level. See Online Annex 4.3 for details. AEs = advanced economies; EMDEs = emerging market and developing economies.

A Model-Based Quantification of the Costs of FDI Fragmentation

To investigate the long-term implications of potential FDI fragmentation, this section uses a multiregion DSGE model to explore possible scenarios.[16] The simulations focus on fragmentation of investment flows arising from permanent barriers between geopolitical blocs, as well as heightened uncertainty about the geopolitical alignment of different regions. The analysis, and the various hypothetical scenarios, are intended to illustrate some of the key economic mechanisms likely to be at play and to provide a sense of overall output losses and the distribution of costs and benefits across economies, including those from spillovers through external demand and the reallocation of production capacity. The geopolitical coalitions considered are for analytical purposes only and are not intended to indicate alignment choices countries are likely to make.

The analysis focuses on two key roles of FDI: its contribution to capital formation in host economies and the transmission of technologies and productivity-enhancing management practices

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[15] These findings are consistent with those of Mercer-Blackman, Xiang, and Khan (2021) on a smaller sample covering mostly Asian countries.

[16] The analysis uses the IMF's Global Integrated Monetary and Fiscal model, further elaborated in Online Annex 4.4. A detailed exposition of the model and its properties may be found in Kumhof and others (2010) and Anderson and others (2013).

from advanced to emerging market and developing economies. The model does not have explicit foreign ownership of productive capital, and thus there is no direct mapping to FDI.[17] The bilateral cross-border flow of inputs into investment is instead used as a proxy, since similarly to reductions in FDI, barriers to the flow of such inputs directly reduce capital formation. The scenarios illustrate a 50 percent reduction of such flows. Alongside, empirical estimates of the correlation between FDI flows and labor productivity are used to discipline the associated productivity losses from a reduction in such flows. The analysis complements the literature, which has focused on the impact of fragmentation through trade and associated knowledge spillovers (Cerdeiro and others 2021; Eppinger and others 2021; Góes and Bekkers 2022; Javorcik and others 2022), although a full analysis of the interaction between different aspects of geoeconomic fragmentation is beyond the scope of this chapter. Box 4.3 discusses new evidence suggesting that the fragmentation of international trade as a result of geopolitical tensions could lead to lower output in most countries, with emerging market and developing economies more adversely affected than other country groups.

The simulations center on decoupling between the two largest economies—China and the US—which is likely to be the most economically consequential form of fragmentation. Although how other countries and regions might align themselves in such a decoupling remains unclear and will depend on a multitude of factors (for example, strength of existing trade and financial links and national security considerations), scenario analysis is used to highlight the implications of different geopolitical-alignment choices for economic outcomes.

The model allows for up to eight regions. China, the EU+ (that is, the EU and Switzerland), and the US are assigned their own regions, as the policy choices of these economies are likely to shape global fragmentation scenarios. To illustrate the interaction between alignment choices and economic outcomes for emerging market and developing economies, including through investment diversion, a region is assigned to Latin America and the Caribbean and another to India and Indonesia, two representative Asian emerging market and developing economies with relatively neutral measures of geopolitcal distance from the US and China. The remaining three regions comprise the rest of southeast Asia, other advanced economies (for example, Australia, Canada, Japan, UK), and the rest of the world (for example, central Asia, Middle East, Russia, sub-Saharan Africa).

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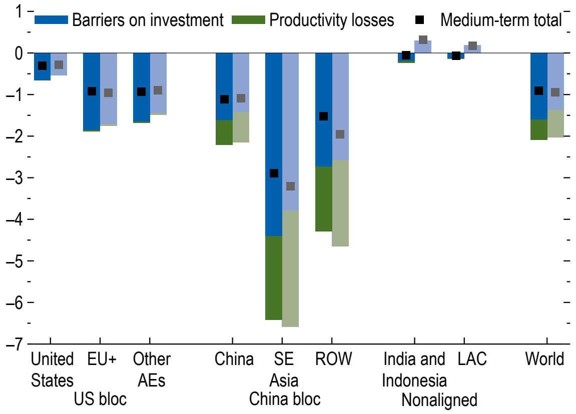
[17] With a few exceptions (Arkolakis and others 2018; Reyes-Heroles, Traiberman, and Van Leemput 2020), multicountry trade models used in the literature tend to abstract from investment.

While geopolitical-alignment choices are highly uncertain, to discipline the analysis, the chapter constructs a baseline hypothetical scenario for alignments using the ideal point distance. Relative distances from either the US or China, based on the latest ideal point distance data, are used to assign regions to geopolitical blocs aligned with either the US or China, or as nonaligned. Additional scenarios, focusing on different alignment choices for the EU+, India and Indonesia, and Latin America and the Caribbean, explore the interaction between geopolitical alignment and economic outcomes (Table 4.1). In reality, geopolitical alignments are not givens and likely require the balancing of multiple considerations (beyond the scope of this chapter) under frictions and uncertainty.

In the first scenario, in which the world splinters into a US-centered bloc and a China-centered bloc, and with both India and Indonesia and Latin America and the Caribbean remaining nonaligned, global output is about 1 percent lower after five years (relative to the no-fragmentation scenario). Global output losses increase as the impact on capital stocks and productivity from lower investment input flows cumulate, with long-term output lower by 2 percent (Figure 4.14). Output losses are generally larger in the emerging-market-dominated China bloc, as these regions face heightened barriers to the major sources of investments, namely, advanced economies. The losses are also nonnegligible for the US bloc, however, driven by some members’ strong links to

Figure 4.14. Impact of Investment Flow Barriers on GDP
(Percent deviation from no-fragmentation scenario)

Fragmentation could lower global output by up to 2 percent.



Source: IMF staff calculations.
Note: Baseline fragmentation scenario represents 50 percent decline in investment input flows between China and US blocs; and two nonaligned regions India and Indonesia, and Latin America and the Caribbean). Darker bars denote scenario with lower elasticity of substitution (1.5) between foreign sources of investment inputs. Lighter bars denote scenario with higher elasticity of substitution (3.0) between foreign sources of investment inputs and thus a greater role for diversion. AEs = advanced economies; EU+ = European Union and Switzerland; LAC = Latin America and the Caribbean; ROW = rest of the world; SE = Southeast.

Table 4.1. Modeled Fragmentation Scenarios

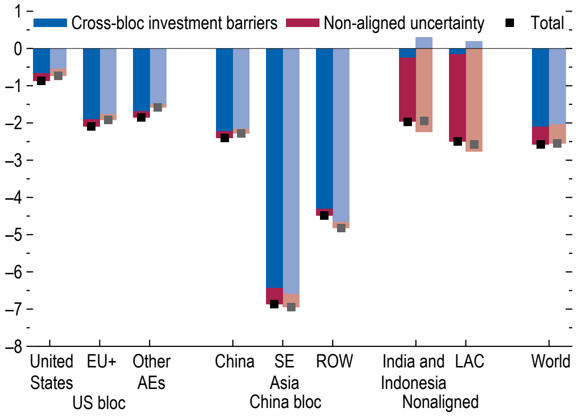
🟦 US bloc 🟩 China bloc ⬜ Nonaligned

Model region	GDP share (percent)	Two blocs + Nonaligned EMDE	Nonaligned EU+	Nonaligned EMDEs join China bloc	Nonaligned EMDEs join US bloc
United States	16.0	🟦	🟦	🟦	🟦
China	17.5	🟩	🟩	🟩	🟩
EU+	15.6	🟦	⬜	🟦	🟦
Other AEs	13.8	🟦	🟦	🟦	🟦
IND and IDN	9.6	⬜	⬜	🟩	🟦
Southeast Asia	4.0	🟩	🟩	🟩	🟩
LAC	6.5	⬜	⬜	🟩	🟦
ROW	17.0	🟩	🟩	🟩	🟩

Source: IMF staff compilation.
Note: AEs = advanced economies; EMDEs = emerging market and developing economies; EU+ = European Union and Switzerland; IND and IDN = India and Indonesia; LAC = Latin America and the Caribbean; ROW = rest of the world.

Figure 4.15. Long-Term GDP Losses, with Uncertainty for Nonaligned
(Percent deviation from no-fragmentation scenario)

Policy uncertainty could amplify losses for nonaligned economies.



Source: IMF staff calculations.
Note: Darker bars denote scenario with lower elasticity of substitution (1.5) between foreign sources of investment inputs. Lighter bars denote scenario with higher elasticity of substitution (3.0) between foreign sources of investment inputs and thus a greater role for diversion. AEs = advanced economies; EU+ = European Union and Switzerland; LAC = Latin America and the Caribbean; ROW = rest of the world; SE = Southeast.

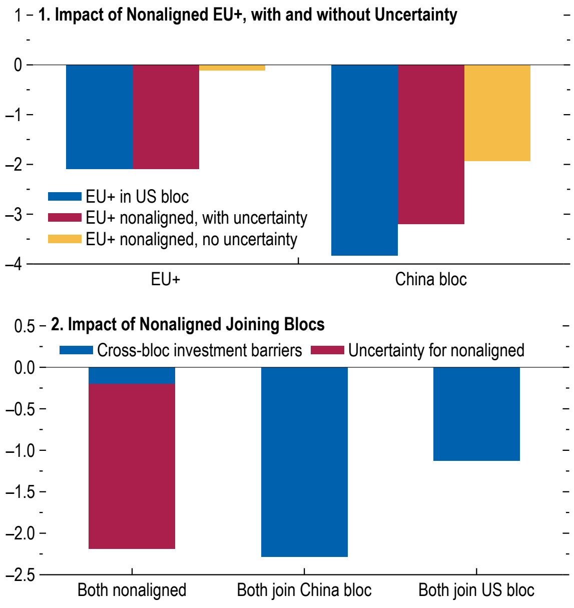
China (such as Japan and Korea in the other advanced economies region and Germany in the EU+ region).

For the nonaligned economies, the impact depends on the outcome of two competing channels. On the one hand, the substantial reduction in global activity reduces external demand, weighing on net exports and investment. On the other hand, these regions also benefit from the diversion of investment flows, which—if sufficiently large—could boost investment and output. The importance of the second channel increases with the ease with which investment goods from different regions can be substituted for one another by the importing region. In the benchmark assumption for the elasticity of substitution across source regions of investment inputs, the first channel dominates, and the nonaligned regions experience a small drop in output (Figure 4.15, darker bars). Alongside the benchmark case, an alternative case uses a higher elasticity of substitution (double in value). In the alternative case, higher diversion yields a small net increase in investment and output (Figure 4.15, lighter bars).[18]

Figure 4.16. Impact on GDP for Bloc Members: Tripolar World and Nonaligned Joining Blocs

(Percent deviation from no-fragmentation scenario)

Remaining nonaligned with certainty tends to limit losses.



Source: IMF staff calculations.
Note: EU+ = European Union and Switzerland.

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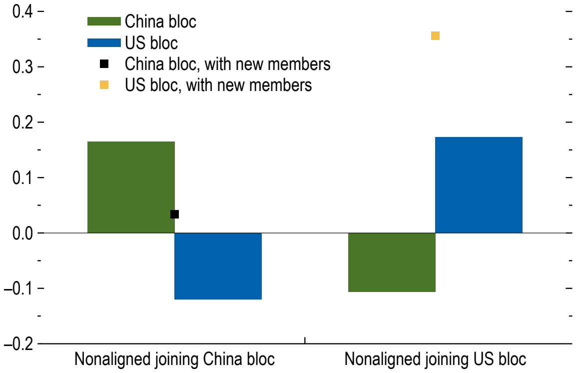
[18] Similar to the cases of India and Indonesia and Latin America and the Caribbean, losses are significantly lower for other regions, such as southeast Asia, if they are also nonaligned, as shown in additional simulations in Online Annex 4.4.

In reality, a geoeconomically fragmented world might entail substantial policy uncertainty for economies that try to remain open to both geopolitical blocs. Rather than having their nonaligned status accepted, these economies may need to walk a narrow path amid pressures from both sides, with the attendant risk of falling out with one bloc or the other. This type of policy uncertainty, in which investors perceive a risk that current policy stances toward that economy could shift radically in the future, can act as an economically meaningful barrier to trade and investment, as documented in the literature (for example, Handley and Limão 2022). While the exact degree of such uncertainty in a hypothetical fragmented future is impossible to pin down, a case involving a high level of uncertainty—in which investors in both blocs perceive a 50 percent chance that the nonaligned region will fall in with the opposing bloc over the long term—is a natural analytical complement to the baseline no-uncertainty scenario already discussed.[19] Specifically, investors behave as if investment input flows to (from) these regions face half the barriers faced by regions in the opposing bloc. As shown in Figure 4.15, losses are significantly amplified for nonaligned regions under such uncertainty, as they face reduced inflows from both blocs, with some negative spillovers to other regions as well.

Figure 4.17. Impact on GDP for Bloc Members: Nonaligned Joining Blocs

(Percent deviation from nonaligned scenario with uncertainty)

Blocs have incentives to attract nonaligned regions and discourage nonaligned joining the opposing bloc.



Source: IMF staff calculations.
Note: The nonaligned include India and Indonesia, and Latin America and the Caribbean.

Alternative alignment choices highlight their significant impact on outcomes. For example, a world in which the EU+ remains nonaligned entails significantly lower costs for both itself and the China bloc economies. However, the EU+ might face heavy costs if such a policy approach significantly raises the possibility of barriers between itself and the US—due to greater uncertainty about its future alignment (Figure 4.16, panel 1). Under the baseline, the two nonaligned regions generally tend to be worse off when aligning with either bloc, as opposed to remaining open to both. However, given that the advanced economy–dominated US bloc is the major source of investment flows, they are better off joining this bloc if forced to choose, especially if they were to face uncertainty otherwise (Figure 4.16, panel 2).

Blocs' incentive to attract emerging market and developing economies might give nonaligned regions some bargaining power but could also generate the type of damaging uncertainty that reduces investment (Figure 4.17). Unsurprisingly, existing bloc members would gain when their bloc attracts the nonaligned regions and lose when nonaligned regions join the opposing bloc. The gain to the existing bloc members could outweigh the losses to the joining regions, suggesting some scope for transfers to implement such an outcome. Potential transfers could take several forms, including favorable trade and investment treatment or fiscal measures to encourage friend-shoring

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[19] The scenario illustrates the case with India and Indonesia and the Latin America and Caribbean regions remaining nonaligned indefinitely, but with investors perceiving a risk they will pick a side in the future (and therefore face the associated barriers). Alongside the 50-50 scenario presented here, Online Annex 4.4 discusses a range of possible levels of uncertainty.

to target economies.[20] The opposing bloc would likely want to avoid such an outcome. In reality, alignment choices are likely to be dependent on multiple considerations and subject to coordination frictions, further underscoring the uncertainty that could itself weigh on investment.

Policy Implications

The findings of this chapter contribute to understanding how fragmentation pressures may already be affecting investment flows across economies, as well as the long-term implications for the global economy if such pressures lead to a substantial relocation of FDI. Vulnerabilities to FDI fragmentation are broadly shared across many emerging market and developing economies, and advanced economies are not immune, particularly those with significant FDI stocks in strategic sectors. As vulnerabilities can also extend to non-FDI flows (see the April 2023 *Global Financial Stability Report*), a rise in political tensions could trigger large reallocation of capital flows at the global level, with effects particularly pronounced for emerging market and developing economies. The chapter's analysis suggests that a fragmented global economy is likely to be a poorer one. While there may be relative—and possibly absolute—winners from diversion, such gains are subject to substantial uncertainty.

The chapter does not attempt to measure the success of the policies driving geoeconomic fragmentation in meeting the objectives often ascribed to them, such as enhancing national security or maintaining a technological advantage over rival countries, especially in strategic sectors. Instead, its analysis highlights that the pursuit of these objectives entails large economic costs, not just for a country's rivals and (possibly) other nonaligned countries, but also for the country itself and countries aligned with it. These costs need to be considered carefully.

In regard to policies, the large and widespread economic costs from strategic decoupling provide a rationale for a robust defense of global integration, at a time when several actors are advocating more barriers and inward-looking policies. For instance, increasing diversification in international sourcing of inputs away from domestic sources can make supply chains more resilient to shocks (see Chapter 2 of the April 2022 *World Economic Outlook*), without imposing costs on the world economy. At the same time, the current rules-based multilateral system must adapt to the changing world economy and should be complemented by credible "guardrails" to mitigate global spillovers and by domestic policies targeted at those adversely affected by global integration (Aiyar and others 2023).

As policy uncertainty amplifies losses from fragmentation, especially for nonaligned countries, effort should be devoted to minimizing such uncertainty. Improving information sharing through multilateral dialogue would support this goal. In particular, the development of a framework for international consultations—for instance, on the use of subsidies to provide incentives for reshoring or friend-shoring of FDI—could help identify unintended consequences. It could also mitigate cross-border spillovers by reducing uncertainty and promoting transparency on policy options.

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[20] For example, see the announcement that the US will support investment in India by the largest US solar manufacturer (Sharma 2022).

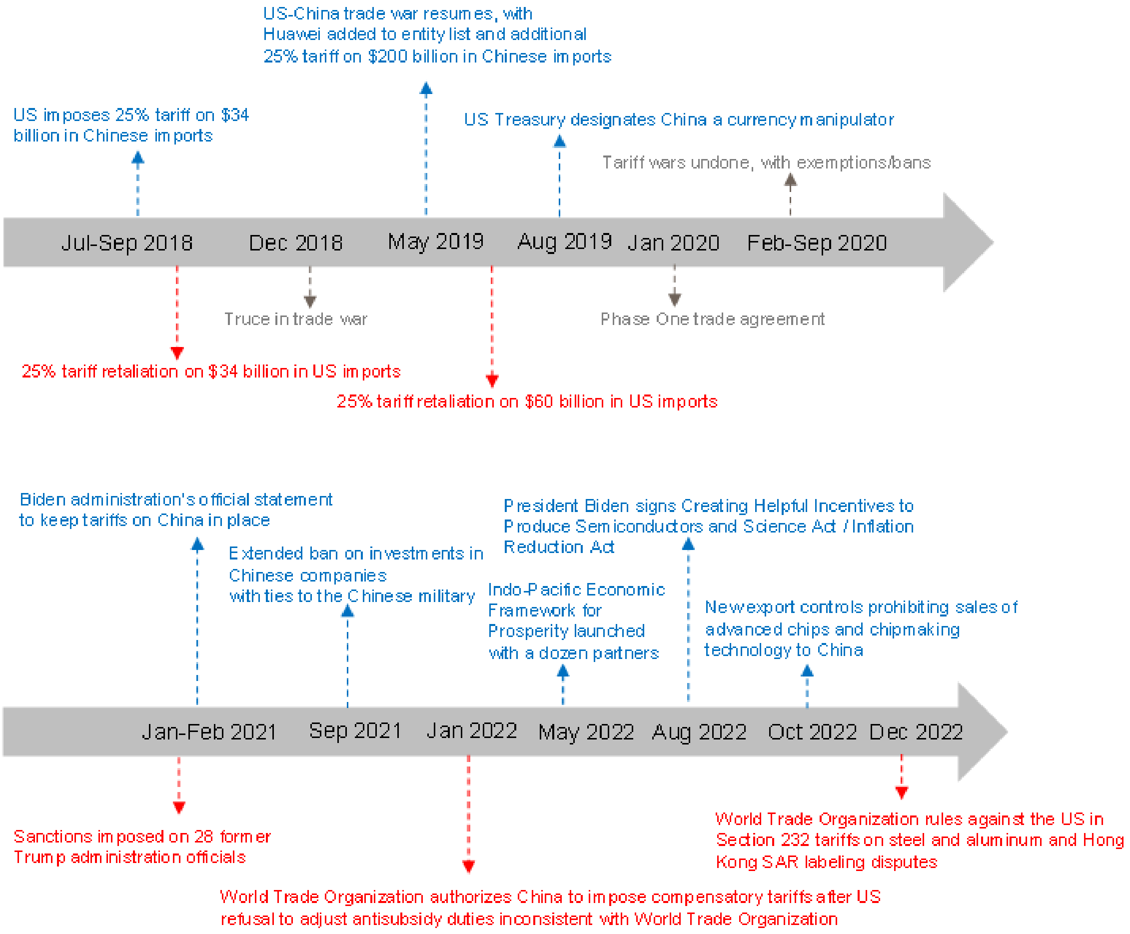
Finally, in a more geopolitically tense world, countries can reduce their vulnerability to FDI relocation by implementing policies and regulations to promote private sector development. Moreover, a more fragmented world in which large economies implement policies to promote friend-shoring of FDI could be an opportunity for some countries to benefit from diversion of investment flows by attracting new FDI. Measures that can increase countries' attractiveness as investment destinations include undertaking structural reforms (Campos and Kinoshita 2010), establishing investment promotion agencies to reduce information asymmetries and ease bureaucratic procedures (Harding and Javorcik 2011; Crescenzi, Di Cataldo, and Giua 2021), and improving infrastructure (Chen and Lin 2020).

Box 4.1. Rising Trade Tensions[21]

This box provides a summary and timeline of recent events behind US-China trade tensions, one of the major drivers behind the rising risk of geoeconomic fragmentation.

China's accession to the World Trade Organization (WTO) in 2001, following its ambitious economic reforms of the 1990s, was a pivotal milestone, with world trade volumes almost doubling since then and China becoming the world's top exporter and second-largest economy. However, trade tensions have been growing over the subsequent years as China's rapid export growth has affected segments of European and US industry. As China's economic reforms slowed and even reversed, major trading partners became increasingly concerned by the economic role of the state in domestic and export markets, including technology transfer practices and the footprint of state-owned enterprises with an international presence. The inability of WTO members to agree on reforms in these and other sensitive areas has exacerbated trade tensions (Aiyar and others 2023).

Figure 4.1.1. A Timeline of US-China Trade Tensions



Sources: China and U.S. authorities; World Trade Organization; and IMF staff compilation.

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[21] The author of this box is JaeBin Ahn.

The US imposition of tariffs against China in July 2018 triggered an immediate Chinese response and was followed by rounds of back-and-forth escalations (Figure 4.1.1). The Phase One trade agreement between the two countries, signed in early 2020, helped avert further escalation but did little to reverse the increase in trade restrictions. Tensions have subsequently widened to a new technological front, with the US explicitly aiming to hinder China's advancement in sectors such as semiconductors and green-energy equipment. For example, the US has imposed export controls to restrict China's access to advanced computing and semiconductor items. The Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act and the Inflation Reduction Act (IRA) aim to advance US global leadership in key technologies by imposing high domestic-content requirements. Meanwhile, because of the ongoing US blockage of WTO Appellate Body appointments, most disputes are being left unresolved, undercutting the value of trade rules.

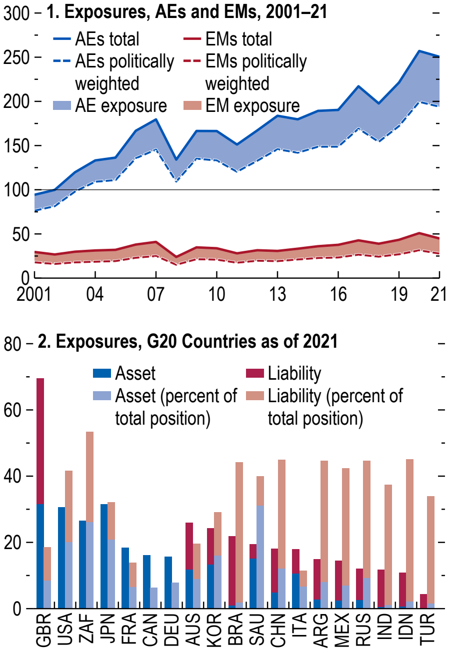
Recent initiatives, and the uncertainties surrounding them, have the potential to reshape global value chains along geopolitical lines and have already begun to affect production and sourcing strategies. For example, the proposed US Chip 4 alliance with three key Asian countries seeks to set up a semiconductor industry supply chain independent of China. Other major economies are also reacting as the case for more active, inward-looking regional industrial policies gains prominence. For example, the EU's proposed European Chips Act aims to boost the bloc's semiconductor industry to 20 percent of global production capacity by 2030, with more than €43 billion in investments.

Box 4.2. Balance Sheet Exposure to Fragmentation Risk[22]

This box complements the analysis in the chapter by constructing a new measure of financial exposure to fragmentation risk, defined as the stock of non–foreign direct investment (FDI) foreign assets (liabilities) invested in (borrowed from) countries with diverging geopolitical views, for major advanced and emerging market economies.

Figure 4.2.1. Gross Exposures to Fragmentation, Assets and Liabilities

(Percent of GDP, unless noted otherwise)



1. Exposures, AEs and EMs, 2001–21

2. Exposures, G20 Countries as of 2021

Sources: Bailey, Strezhnev, and Voeten (2017); Bank for International Settlements; and IMF staff calculations.

Note: Gross positions are aggregated by country group and divided by sum of each group's respective GDP. See Online Annex 4.5 for details on country group composition. Economy labels in the figure use International Organization for Standardization (ISO) country codes. AEs = advanced economies; EMs = emerging market economies.

Cross-border non-FDI financial linkages are constructed using IMF Coordinated Portfolio Investment Survey statistics (CPIS) and Bank for International Settlements Locational Banking Statistics. Since a large share of positions in the CPIS are booked to financial centers, bilateral portfolio holdings are first reallocated to their proper source and host countries following Coppola and others (2021). Bank and portfolio investments are then aggregated to derive bilateral foreign assets and liabilities for 38 countries during 2001–21, whose GDP accounts for 86 percent of world GDP. These positions are combined with bilateral measures of political proximity as captured by the ideal point distance, normalized into a continuous variable that takes the value 1 for the politically closest country and 0 for the most distant country. Bilateral holdings are then weighted by the political proximity index to generate a politically discounted measure of foreign assets and liabilities. The exposure to fragmentation is defined as the difference between undiscounted positions and their politically weighted counterparts and captures the stock of assets (or liabilities) that could be at risk in a fragmentation scenario.

Exposures are large and have roughly doubled over the past 20 years. While gross foreign investment positions (assets plus liabilities) as a share of GDP have more than doubled since 2001, politically weighted positions have not grown as fast, suggesting that capital has been increasingly invested in (borrowed from) countries with political views that are further apart (Figure 4.2.1, panel 1). This is particularly the case for advanced economies, but it is also the case for emerging markets. Exposures vary significantly across the Group of Twenty (G20) (Figure 4.2.1, panel 2). They are concentrated on the asset side in advanced economies and on the liability side in emerging markets. In aggregate, exposures have now reached 42 percent of GDP, or 24 percent of all non-FDI cross-border holdings. Therefore, a rise in political tensions could trigger a significant reallocation of capital at the global level, although exposures vary significantly across the G20 (see Online Annex 4.5).

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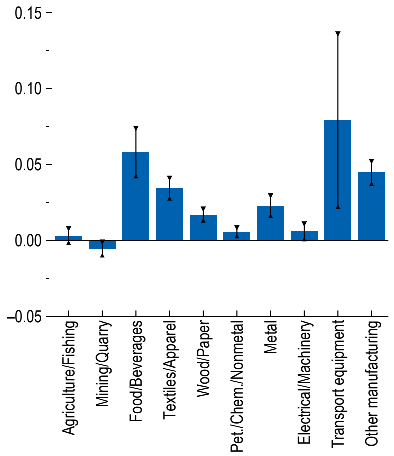
[22] The authors of this box are Ariadne Checo de Los Santos, Rui Mano, and Damien Puy, with assistance from Fujie Wang. Online Annex 4.5 reports details about the empirical analysis, additional results, and robustness checks.

Box 4.3. Geopolitical Tensions, Supply Chains, and Trade[23]

This box presents new evidence that trade fragmentation could lower output for most countries, especially for emerging market and developing economies. To assess countries' exposure to geoeconomic fragmentation in trade, the box estimates the impact of geopolitical alignment on sector-level bilateral trade data for 189 countries (in 10 broad manufacturing sectors) using structural gravity regressions. These estimates show that divergences in individual countries' geopolitical alignment act as a barrier to trade. This effect is concentrated in some sectors, notably food, but also transportation equipment and other manufacturing, which account for a large share of FDI-intensive global value chain trade (Figure 4.3.1).

These estimates are used to calibrate a multicountry, multisector general equilibrium trade model to gauge the macroeconomic impact of a fragmentation scenario defined as an increase in alignment among countries within the US, China, and nonaligned blocs, which reduces the alignment across the blocs, and a doubling of the estimated sensitivity of trade barriers to geopolitical alignment. Countries are assigned to blocs based on whether their current geopolitical treaties are stronger with the US, stronger with China, or equally strong with both.[24] Three main factors drive countries' exposure to geoeconomic fragmentation: (1) *economy size:* a given rise in trade barriers is more damaging to smaller economies (in terms of population and GDP), which tend to rely more on international trade; (2) *comparative advantage:* fragmentation has a greater effect on countries that import in sectors with trade barriers more sensitive to geopolitical alignment; and (3) *geoeconomic alignment:* fragmentation is more damaging, for a given bloc membership, to countries that are not closely aligned with either of the world's two major economies.

Figure 4.3.1. Impact of One-Standard-Deviation Decrease in Geopolitical Alignment on Tariff-Equivalent Trade Barrier
(Log change)



Sources: Alliance Treaty Obligations and Provisions Project (ATOP); Caliendo and Parro (2015); Eora Global Supply Chain Database; and IMF staff calculations.
Note: Bars show estimates from sector-level gravity regressions on 2017–19 average trade values, with importer and exporter fixed effects, geography, cultural ties, and economic agreements controlled for. Geopolitical alignment is measured by the foreign-treaty *s*-score from ATOP (Leeds and others, 2002). A one-standard-deviation decrease, in geopolitical alignment, corresponds roughly to the difference between two average North Atlantic Treaty Organization members and two average nonmembers.
Pet./Chem./Nonmetal = Petroleum, chemical, and nonmetal minerals.

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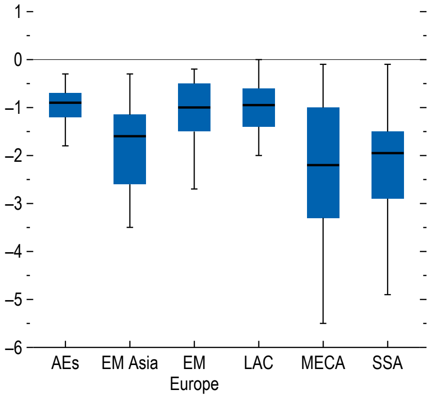
[23] The authors of this box are Shushanik Hakobyan, Sergii Meleshchuk, and Robert Zymek. For details on data, estimation methodology, and modeling, see Hakobyan and others (2023).

[24] Unlike in this box, the nonaligned regions in the chapter text do not face increasing barriers with respect to the two blocs, particularly in the case in which there is no uncertainty regarding their alignment.

While geoeconomic fragmentation leads to income losses for most countries, it hurts emerging market and developing economies more than advanced economies. For the median emerging market economy in Africa and central Asia, real income losses due to geoeconomic fragmentation are more than twice as large as for the median advanced economy (Figure 4.3.2). This is primarily because these regions comprise many emerging market and developing economies that are small in economic size and relatively unaligned with major geopolitical blocs.

Figure 4.3.2. Change in Real Per Capita Income Due to Fragmentation
(Percent)



Source: IMF staff calculations.
Note: The figure shows the distribution of outcomes based on baseline fragmentation scenario in Hakobyan and others (2023), where the horizontal lines stand for the medians, the box represents the 25th and 75th percentiles, and the whiskers represent the extremes, excluding outliers. AEs = advanced economies; EM = emerging and developing; LAC = Latin America and the Caribbean; MECA = Middle East and Central Asia; SSA = sub-Saharan Africa.

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CHAPTER 4

GEOECONOMIC FRAGMENTATION AND FOREIGN DIRECT INVESTMENT

ONLINE ANNEX

Online Annex 4.1. Geopolitical Alignment and FDI

This annex provides the details behind the non-parametric and parametric evidence that foreign direct investment (FDI) is more likely to take place between countries that are geopolitically close. The annex also provides additional exhibits that complement those in the main text.

Methodology

The analysis relies on two different approaches to get at non-parametric evidence that the association between geopolitical alignment and FDI grew overtime, and parametric results that quantify in a controlled setting such relationship.

The non-parametric evidence is based on the following steps. First, countries are ranked based on their distance from the U.S. (similar results hold if another large country of reference like China if chosen). Then, countries are split in five groups $G \in \{1,2..5\}$ based on their ranking—very close, close, at medium distance, far, vary far. A function from the set of countries C to the set of groups $\{1,2..5\}$ $g(.): C \rightarrow \{1,2..5\}$ is such that if a country i belongs to group G then $g(i) = G$. Then, for each year in the sample FDI taking place between countries in the same group is counted. Finally, this number is divided by the total number of FDI observed in the year. Thus, the measure of FDI geopolitical concentration in year *t* ($FDIGC_t$) is obtained as:

$$FDIGC_t = \frac{\sum_{G=1}^{5} \sum_{g(i)=g(j)} FDI_{ij}}{\sum_j \sum_i FDI_{ij}}$$

As there are 25 combinations of groups from $\{1,2..5\} \times \{1,2..5\}$, while only the FDI taking place between countries belonging to the same group are counted in the numerator in the expression for $FDIGC_t$, if geopolitical distance did not matter, $FDIGC_t$ would equal 0.2, that is one in five FDI would take place between geopolitically close (aligned) countries. Upwards deviation from this number is taken as evidence that geopolitical distance matters for FDI.

The parametric evidence relies on a regression framework based on a standard gravity model, which controls for many bilateral variables and country specific time varying factors. Namely, the following equation is estimated:

$$FDI_{sdt} = f(\alpha Geopolitical\ Distance_{sdt-1} + \beta Gravity_{sd} + \tau_{st} + v_{dt}, \varepsilon_{sdt}) \qquad (1),$$

Where bilateral FDI flows (measured in USD volumes or by the number of projects) from the source country *s* to the destination country *d,* in year *t* is a function of the lagged value of a measure of geopolitical distance between countries *d* and *s*. As standard in gravity models, the specification controls for the geographical distance between source and destination countries (which could be correlated with the geopolitical distance), other standard gravity factors (common legal origins, common language, colonial or dependency relationship), and absorb any time varying push and pull unobservable factor adding source country x year and destination country x year fixed effects. These fixed effects would absorb, for instance, business cycle dynamics which could push FDI outflows from the source country and attract inflows into the destination country. Equation (1) would capture mostly cross section differences in geopolitical proximity. In other words, for the FDI from a given source country s, the coefficient α would inform how the difference in the geopolitical distance between two destination countries and the source country s affects FDI flows from country s to the two destination countries. However, the coefficient α could pick up the effect of other factors which are specific of the country-pair and are potentially correlated with the geopolitical distance and are not captured by the gravity variables. Equation (1) is then augmented to include measure of cultural and institutional distance and a historical measure of colonial ties. However, as long as these measures are time invariant, equation (1) could be fully saturated by including the country-pair fixed effects (ψ_{sd}) which would absorb all these sources of heterogeneity:

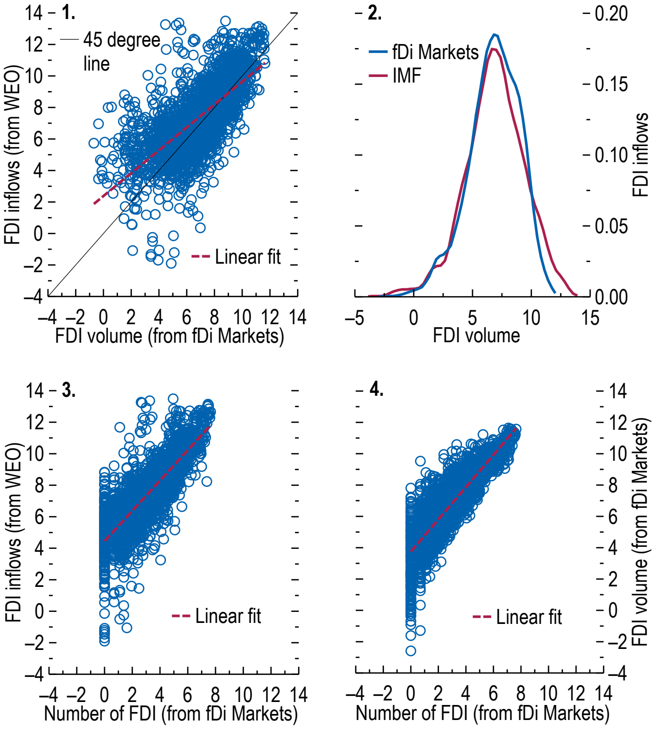
$$FDI_{sdt} = f(\alpha Geopolitical\ distance_{sdt-1} + \psi_{sd} + \tau_{st} + \upsilon_{dt}, \varepsilon_{sdt}) \qquad (2),$$

In this case, the interpretation of the coefficient α is more restrictive and within country-pair. This means that that the coefficient α picks up the effect of a deviation in political proximity between the source and the destination country on FDI flows.

As most of the FDI_{sdt} cells are zeros, the model is estimated by Poisson pseudo-maximum likelihood (PPML, Santos Silva and Tenreyro 2006). Standard errors are clustered at the country-pair level.

Online Annex Figure 4.1.1. fDi Markets versus World Economic Outlook Data, 2003–21

(Log)



Sources: fDi Markets; and IMF staff calculations.

Note: Panels 1, 2, and 3 report FDI inflows at the country-year level from the WEO database and from fDi Market database between 2003 and 2021, both in volumes (panels 1 and 2) and in number of investments (panel 3). Panel 4 plots FDI inflows at the country-year level only from fDi Market between 2003 and 2021, comparing flows in volumes and in number of investments. FDI = foreign direct investment; WEO = *World Economic Outlook*.

Data Sources

The data on bilateral greenfield FDI comes from fDi Markets, a service from the Financial Times which tracks new physical project or expansion of an existing investment which creates new jobs and capital investment.[1] The data are collected primarily from publicly available sources (e.g., media sources, industry organizations, investment promotion agencies newswires) and report investment-level information for over 300,000 FDI between January 2003 and December 2022. For each investment, the dataset reports the source and destination countries, as well as the sector, activity

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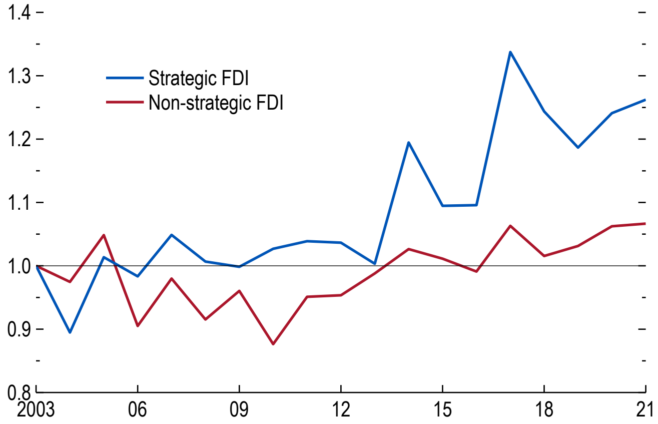
[1] fDi Markets does not track mergers and acquisitions and other international equity investments, investment projects that do not create new jobs, companies which establish a foreign subsidiary without a physical company presence.

(e.g., business services, sales, R&D), type (new investment or expansion), volume (in USD) and number of jobs created. The volume of the capital investment and the associated jobs are often estimated. The reliability of these data is tested by aggregating the volumes at the destination country-year level and contrasting them with gross FDI inflows as published in the World Economic Outlook (WEO). Online Annex Figure 4.1.1 shows that the two sets of data are highly correlated, and the two distributions show a large degree of overlap. In addition, the number and value of bilateral investment are highly correlated. Both variables, once aggregated at the source-destination-year level, are top-winsorised with a threshold corresponding to the 0.01 percent of the observations.

Online Annex Figure 4.1.2. Geopolitics Became More Relevant for Strategic FDI

(Probability ratios, 2003 = 1)



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); Centre d'études prospectives et d'informations internationales; fDi Markets; NL Analytics; and IMF staff calculations.
Note: Figure shows probability ratio of strategic FDI and non-strategic FDI taking place between country pairs geopolitically close (that is, in the same quintile of the distribution of the ideal point distance). FDI = foreign direct investment.

The measure of geopolitical distance used in the analysis is the Ideal Point Distance (IPD) constructed by Bailey and others (2017). It is based on the votes at the United Nation General Assembly between 1946 and 2021. The measure is built by first estimating an ordered logit over the three voting choices (yea, abstain, nay), where the choice depends on the parameters of the model combined with a latent vote specific preference of each country in a given year. The latent process is estimated imposing a Bayesian prior on the preferences and employing a Metropolis-Hastings/Gibbs sampler algorithm to infer the parameters of the logit model and then the posterior distribution of the latent preferences parameters. The distance between two countries in each year is then computed as the absolute value of the difference between the inferred vote specific preference parameter. More details on the measurement and the estimation are provided in Bailey and others (2017).[2]

The CEPII gravity dataset provides standard gravity variables including geographical distance, common language, legal framework and colonial ties.

Data on earnings calls from NL Analytics (Hassan and others 2019) and a study from the Atlantic Council are combined to obtain the definition of strategic sectors. Specifically, the chapter defines strategic sectors at the 3-digit industry level, based on the following approach. First, a list proposed by the Atlantic Council is used to identify as strategic these sectors: semiconductors, telecommunications and 5G infrastructure, equipment needed for green transition, pharmaceutical ingredients, and strategic and critical minerals.[3] These sectors are

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[2] The distance is not estimated but taken directly as available from this link: https://dataverse.harvard.edu/dataverse/Voeten which provides the most updated version of the distance for all the country pairs.

[3] See: https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/our-guide-to-friend-shoring-sectors-to-watch/

mapped into the 3-digit industry classification based on ISIC Revision 4. Second, amongst manufacturing and mining sectors, the 3-digit industry groups which fall in the top-3 deciles of mentions of reshoring-related terms in companies earnings calls between 2017-2022 are added to the list. The manufacture of textiles, which also falls in the top-3 deciles of reshoring terms mentions, is excluded. The final list of strategic sectors is reported in Online Annex Table 4.1.5.

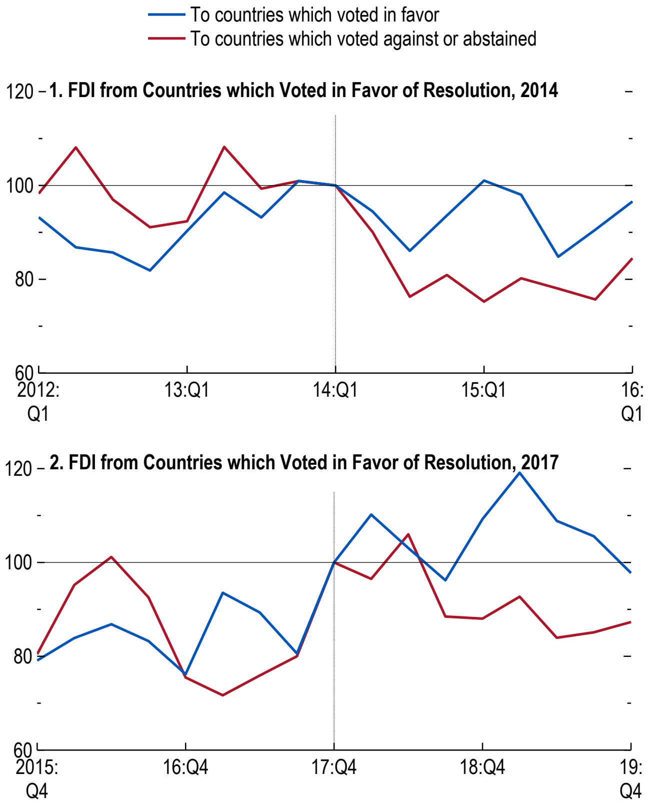
The list of 162 source countries and 180 destination countries for which we have complete data and at least one FDI sourced or received is reported in Online Annex Table 4.1.5.

Non-Parametric Results

Figure 4.7 in the main text shows that our measure $FDIGC_t$ is greater than 0.2 and it is in fact well above 0.35 throughout the sample. Second, it has increased to more than 0.5 in 2021. To interpret the size of $FDIGC_t$, an analogous measure based on geographical distance is plotted in red in the same figure. The line shows that FDI takes place more frequently between geographically close countries than between countries further apart, but the red line is consistently below the blue line suggesting that geopolitical distance is relatively more important. A ratio between the two lines summarizes this relative importance. Such ratio has increased from 1.2 in 2003 (the first year of data) to 1.3 in 2021.

Online Annex Figure 4.1.3. Event Studies around United Nations Resolutions

(Index, quarter of the vote = 100)



Sources: fDi Markets and IMF staff calculations.
Note: The charts plot the number of greenfield FDI in each quarter from countries which approved the United Nations General Assembly resolution to that from countries which either voted against or abstained. The series are normalized to 100 in the quarter of the vote. Panel 1 refers to resolution 68/262 (March 2014) about the territorial integrity of Ukraine. Panel 2 refers to resolution 72/191 (December 2017) on human rights in Syria. FDI = foreign direct investment.

To gauge a sense of the different importance of geopolitical distance for different types of sectors, the same exercise is repeated focusing the count on strategic sectors and other sectors. Measures of FDI concentration are built based on geopolitical and geographic distance, and their year-by-year ratio is then normalized to one in 2003. The normalized series for the two groups of sectors is reported in Online Annex Figure 4.1.2. The chart shows that the increase in geopolitical importance for FDI decisions was markedly higher in strategic sectors (+26 percent) than for other sectors (+6 percent).

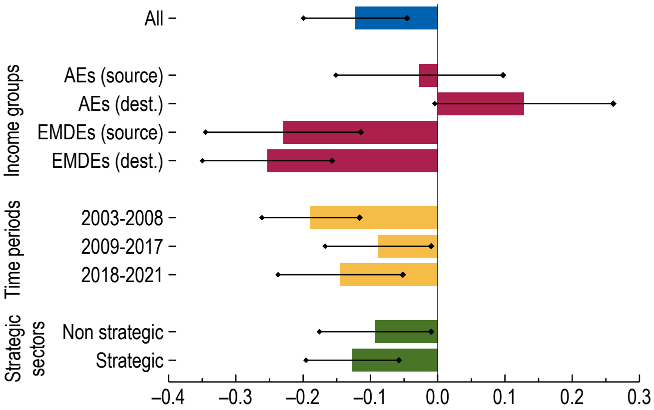
Before turning to the parametric evidence, also looking at the behavior of FDI flows around key UN resolutions suggests that indeed geopolitics matters for the allocation of FDI. The evidence is gathered by focusing on the patterns of FDI flows from countries which approved the resolution to host countries which either voted against or abstained in the 16 quarters around two resolutions.[4] Online Annex Figure 4.1.3 shows that the two series of FDI diverge after both resolutions, with investments to opposing countries being much lower than those to countries which approved the resolutions. This evidence, while purely descriptive, suggests that geopolitical factors affect MNCs' investment decisions.

Parametric Results

Baseline Findings

The results of the estimation of the gravity model are shown in Online Annex Table 4.1.1, where columns 1-3 take the number of projects as dependent variable and columns 4-6consider their volume (in USD). The estimates show that a higher IPD is associated with lower FDI, regardless of how FDI is measured. As expected, the estimated coefficient becomes smaller when controlling for geographical distance—which is also associated with lower FDI (columns 2 and 5)—and when augmenting the model with controls for common legal origins, common language, and the presence of a colonial relationship (columns 3 and 6). While these variables are generally associated with more FDI, the coefficient on IPD remains negative and statistically significant. A quantitative interpretation of the coefficient in column 3 suggests that as the IPD measure raises from the 25th to the 75th percentile (equivalent to moving the distance from that between South Korea and Japan to that between the UK and Russia), the number of FDI between countries declines by about 15 percent.

Online Annex Figure 4.1.4. Heterogeneity Analysis
(Semielasticities)



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); Centre d'études prospectives et d'informations internationales, Gravity database; fDi Markets; NL Analytics; and IMF staff calculations.
Note: Coefficients are estimated from a gravity model for foreign direct investment estimated with Pseudo-Poisson Maximum Likelihood. The reported coefficients refer to the ideal point distance measure from Bailey, Strezhnev, and Voeten (2017).

To explore how the importance of IPD for FDI changes across samples, time and types of FDI, the main specification (Online Annex Table 4.1.1, column 3) is re-estimated by interacting the coefficient on IPD with various dummies or restricting the sample appropriately. FDI responds to IPD especially when a EMDE country is involved on the source or destination end. The relevance of geopolitical distance for FDI was declining up to 2017 but started increasing again after then. Finally, the coefficient of the ideal point distance is larger for FDI in strategic

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[4] First, the resolution 68/262 about the territorial integrity of Ukraine, which was adopted on 27 March 2014 in response to the Russian annexation of Crimea. The resolution defends the territorial integrity of Ukraine within its internationally recognized borders and underscores the invalidity of the 2014 Crimean referendum. Second, the resolution 72/191, adopted on 19 December 2017 on the situation of human rights in Syria. This resolution strongly condemns the grave deterioration of the human rights situation in Syria, the indiscriminate killing and deliberate targeting of civilians as such, including those involving the continued indiscriminate use of heavy weapons and aerial bombardments.

sectors than in other sectors. These results are reported in Online Annex Figure 4.1.4. The blue bars in the chart show that the negative relationship between FDI and IPD is non significantly different from zero if the source of destination country is an advanced economy (AE), while it is larger than average (approximately twice as large) if the destination or source country is an emerging market and developing economy (EMDE). Further analysis reveals that the impact of IPD on FDI flows is especially driven by South-South flows, that is in cases when both the source and the destination country is an EMDE. The red bars show that the importance of IPD for FDI has changed over time. The U-shaped of the negative coefficients captures the fact that the negative relation between IPD and FDI was declining between the beginning of the sample (2003, soon after China joined the WTO) and 2017, while it increased after 2018 and until 2021, coincidentally with the resurgence of tensions between China and the U.S. Importantly, the difference in the semielasticities between the 2009-17 and 2018-21 periods is statistically significant. Finally, the green bars report the coefficient on IPD from two different regressions: one in which only FDI that are classified as strategic are included in the sample, and one in which only FDI in other sectors are included. The results show that the importance of IPD for FDI is larger for strategic sectors than for other sectors.

Robustness and Extensions

The main results are robust to alternative samples, alternative measures of geopolitical distance, and to the inclusion of additional control variables.

As shown in Online Annex Table 4.1.2, the main findings hold when restricting the sample to only manufacturing (column 1) or services (column 2) FDI, and they remain valid when excluding country pairs that never registered a FDI during the sample period (column 3). The results are also robust to excluding financial centers,[5] or China (columns 4 and 5).

Results are similar if the IPD measure is replaced with the rank of the destination country with respect to the source country in the IPD distribution, or with alternative indicators of geopolitical distance, such as the *S* score or the *Pi* (π) scores proposed by Signorino and Ritter (1999) and Häge (2011)—which are used in Chapter 3 of the April 2023 *Global Financial Stability Report* (Online Annex Table 4.1.2, columns 1-3).

Columns 4 to 7 in Online Annex Table 4.1.2 address the concern that geopolitical distance could pick up other factors which could vary across country pair and affect FDI flows. Results are also robust to the inclusion of: (1) the announcement and implementation of bilateral trade barriers, as measured by Global Trade Alerts (column 4); (2) the intensity of trade flows, measured by bilateral imports (column 5); and (3) the yearly change in the bilateral exchange rate (column 6). In column 7 the model is saturated with country-pair fixed effects. In that specification, which is very restrictive and only exploits the variation in IPD within country pairs, the coefficient of the

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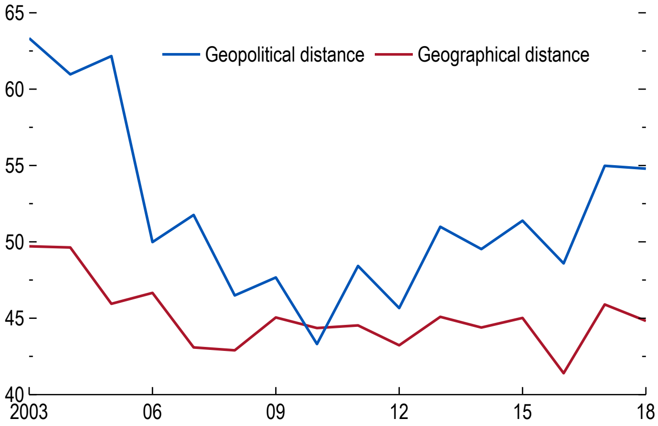
[5] Singapore, Luxembourg, The Netherlands and Ireland, as classified by Daamgard and others (2019), with the addition of Bahamas, Malta and Cyprus, see column 4. The other countries classified as offshore financial centers by Daamgard and coauthors 2019 are also excluded from our baseline sample as other variables included in the specification are not available for those countries

IDP variable becomes smaller in size and loses significance when FDI is measured by the number of projects (top panel), but not when FDI is measured in value (bottom panel).[6]

Finally, although the chapter focuses exclusively on greenfield FDI, key findings from the chapter hold for brownfield FDI (i.e., cross-border M&As). Specifically, replacing country-year level greenfield FDI measures with corresponding brownfield FDI measures up to 2018 from the SDC Platinum database, Online Annex Figure 4.1.5 confirms the robustness of the results reported in Figure 4.7 in the main text, and Online Annex Table 4.1.4 show qualitatively identical results to Online Annex Table 4.1.1.

Online Annex Figure 4.1.5. Foreign Direct Investment between Geographically and Geopolitically Close Countries: Brownfield FDI (Merge and Acquisition)
(Percent)



Sources: Atlantic Council; Bailey, Strezhnev, and Voeten (2017); Centre d'études prospectives et d'informations internationales; SDC Platinum database; and IMF staff calculations.
Note: Figure shows the annual share of strategic brownfield foreign direct investments (merge and acquisition) between country pairs that are similarly distant (that is, in same quintile of distance distribution), geopolitically and geographically, from the United States.

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[6] However, restricting the sample to EMDE destination countries shows that an increase in geopolitical distance is associated with a subsequent decline in FDI, regardless of measuring in value of by the number of projects. Quantitatively, in the baseline specification in the EMDEs-destination-countries sample moving the IPD measure from the 25th to the 75th percentiles is associated with a decline of about 30 percent in the number of FDI, and this is reduced to 15 percent in the model saturated with country pairs fixed effects.

Online Annex Table 4.1.1. Main Results

Dependent Variable:	**cross-border M&As (number of deals)**			**cross-border M&As (USD million)**		
	(1)	(2)	(3)	(4)	(5)	(6)
Ideal point distance, lagged	-0.3570***	-0.1448***	-0.1162***	-0.4563***	-0.2610***	-0.2162***
	(0.042)	(0.040)	(0.039)	(0.035)	(0.034)	(0.033)
Geographic distance		-0.6266***	-0.5694***		-0.6168***	-0.5720***
		(0.035)	(0.037)		(0.035)	(0.035)
Common legal origins			0.1541***			0.0503
			(0.048)			(0.051)
Common language			0.4768***			0.5446***
			(0.079)			(0.077)
Colonial or dependency relationship			0.4135***			0.4052***
			(0.083)			(0.085)
Observations	320,025	320,025	320,025	320,025	320,025	320,025
Source country x year FE	Y	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y	Y

Sources: United Nations (Bailey et al. 2017), CEPII, fDi Markets, and IMF staff calculations.

Notes: Standard errors are clustered at the country-pair level. Period 2003-2021.

Online Annex Table 4.1.2. Robustness on Alternative Samples

	Dependent Variable: cross-border M&As (number of deals)				
	(1)	(2)	(3)	(4)	(5)
Ideal point distance, lagged	-0.1310***	-0.1157***	-0.1259***	-0.1229***	-0.1566***
	(0.034)	(0.043)	(0.038)	(0.039)	(0.041)
Geographic distance	-0.5102***	-0.6447***	-0.5368***	-0.5931***	-0.6135***
	(0.037)	(0.039)	(0.035)	(0.040)	(0.039)
Common legal origins	0.1389***	0.1537***	0.1652***	0.1590***	0.1578***
	(0.048)	(0.046)	(0.047)	(0.052)	(0.043)
Common language	0.3911***	0.5482***	0.4296***	0.4665***	0.4667***
	(0.078)	(0.080)	(0.076)	(0.084)	(0.081)
Colonial or dependency relationship	0.2805***	0.5056***	0.3950***	0.4266***	0.4196***
	(0.074)	(0.090)	(0.080)	(0.087)	(0.088)
Observations	229,262	269,436	115,659	291,547	312,830
Source country x year FE	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y
Country pair FE	N	N	N	N	N
Sample	Manufacturing	Services	Restricted	No fin. centers	Drop China
	Dependent Variable: cross-border M&As (USD million)				
Ideal point distance, lagged	-0.1999***	-0.2352***	-0.2346***	-0.2106***	-0.2192***
	(0.032)	(0.038)	(0.032)	(0.033)	(0.036)
Geographic distance	-0.5743***	-0.5941***	-0.5331***	-0.6023***	-0.6105***
	(0.036)	(0.034)	(0.033)	(0.038)	(0.039)
Common legal origins	0.0478	0.1195**	0.0727	0.0643	0.0745
	(0.056)	(0.048)	(0.050)	(0.055)	(0.050)
Common language	0.5039***	0.6108***	0.4795***	0.5400***	0.5353***
	(0.084)	(0.076)	(0.075)	(0.079)	(0.081)
Colonial or dependency relationship	0.3320***	0.4889***	0.3845***	0.4160***	0.4030***
	(0.085)	(0.094)	(0.082)	(0.090)	(0.089)
Observations	229,262	269,436	115,659	291,547	312,830
Source country x year FE	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y
Country pair FE	N	N	N	N	N
Sample	Manufacturing	Services	Restricted	No fin. centers	Drop China

Sources: United Nations (Bailey et al. 2017), CEPII, fDi Markets, and IMF staff calculations.

Notes: Standard errors are clustered at the country-pair level. Period 2003-2021.

Online Annex Table 4.1.3. Robustness to Alternative Measures of Geopolitical Distance and Additional Controls

	Dependent Variable: FDI (number of projects)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ideal point distance, lagged				-0.1028**	-0.1182***	-0.1151***	0.0075
				(0.041)	(0.038)	(0.039)	(0.028)
Geographic distance	-0.5661***	-0.5747***	-0.5530***	-0.5604***	-0.3565***	-0.5680***	
	(0.036)	(0.036)	(0.036)	(0.038)	(0.040)	(0.037)	
Common legal origins	0.1538***	0.1494***	0.1533***	0.1546***	0.1102**	0.1544***	
	(0.048)	(0.048)	(0.047)	(0.049)	(0.048)	(0.048)	
Common language	0.4760***	0.4823***	0.4736***	0.4795***	0.4262***	0.4749***	
	(0.079)	(0.079)	(0.079)	(0.080)	(0.076)	(0.079)	
Colonial or dependency relationship	0.4106***	0.4148***	0.4263***	0.3976***	0.3923***	0.4149***	
	(0.084)	(0.081)	(0.082)	(0.087)	(0.078)	(0.083)	
Ideal point distance rank, lagged	-0.3281***						
	(0.094)						
S measure of distance, lagged		-0.2946***					
		(0.113)					
Pi measure of distance, lagged			-0.2809***				
			(0.067)				
Trade barriers, starting				-0.0010			
				(0.003)			
Trade barriers, announced				0.0020			
				(0.004)			
Imports					0.2012***		
					(0.018)		
Exchange rate (yearly change)						-2.4574***	
						(0.933)	
Observations	320,025	319,987	319,987	252,172	257,077	317,770	115,637
Source country x year FE	Y	Y	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y	Y	Y
Country pair FE	N	N	N	N	N	N	Y
	Dependent Variable: FDI (USD Million)						
Ideal point distance, lagged				-0.1854***	-0.2204***	-0.2157***	-0.1198**
				(0.035)	(0.032)	(0.033)	(0.055)
Geographic distance	-0.5717***	-0.5769***	-0.5478***	-0.5838***	-0.4082***	-0.5698***	
	(0.035)	(0.034)	(0.035)	(0.036)	(0.040)	(0.035)	
Common legal origins	0.0485	0.0405	0.0557	0.0648	0.0220	0.0501	
	(0.051)	(0.051)	(0.050)	(0.052)	(0.050)	(0.051)	
Common language	0.5508***	0.5500***	0.5389***	0.5176***	0.4989***	0.5434***	
	(0.078)	(0.078)	(0.076)	(0.079)	(0.074)	(0.077)	
Colonial or dependency relationship	0.3955***	0.4146***	0.4207***	0.3981***	0.3861***	0.4072***	
	(0.085)	(0.083)	(0.085)	(0.087)	(0.080)	(0.085)	
Ideal point distance rank, lagged	-0.5503***						
	(0.081)						
S measure of distance, lagged		-0.6239***					
		(0.099)					
Pi measure of distance, lagged			-0.4870***				
			(0.062)				
Trade barriers, starting				0.0012			
				(0.004)			
Trade barriers, announced				-0.0013			
				(0.004)			
Imports					0.1608***		
					(0.020)		
Exchange rate (yearly change)						-4.3679***	
						(1.076)	
Observations	320,025	319,987	319,987	252,172	257,077	317,770	115,637
Source country x year FE	Y	Y	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y	Y	Y
Country pair FE	N	N	N	N	N	N	Y

Sources: IMF *World Economic Outlook* , Global Trade Alert, Signorino and Ritter (1999), and Hage (2011).

Notes: Standard errors are clustered at the country-pair level. Period 2003-2021.

Online Annex Table 4.1.4. Robustness to Brownfield FDI (M&A) Measures

Dependent Variable:	**FDI (number of projects)**			**FDI (USD million)**		
	(1)	(2)	(3)	(4)	(5)	(6)
Ideal point distance, lagged	-0.5453***	-0.2660***	-0.1919***	-0.5087***	-0.3819***	-0.3270***
	(0.053)	(0.048)	(0.041)	(0.046)	(0.043)	(0.045)
Geographic distance		-0.8341***	-0.7798***		-0.5348***	-0.5058***
		(0.034)	(0.030)		(0.044)	(0.045)
Common legal origins			0.1924***			0.2568***
			(0.064)			(0.084)
Common language			0.5524***			0.1556
			(0.092)			(0.123)
Colonial or dependency relationship			0.2224**			0.1292
			(0.090)			(0.123)
Observations	150,811	150,811	150,811	150,811	150,811	150,811
Source country x year FE	Y	Y	Y	Y	Y	Y
Destination country x year FE	Y	Y	Y	Y	Y	Y
Country pair FE	N	N	N	N	N	N
Sample	All	All	All	All	All	All

Sources: United Nations (Bailey et al. 2017), CEPII, SDC Platinum database, and IMF staff calculations.

Notes: Standard errors are clustered at the country-pair level. Period 2003-2018.

Online Annex Table 4.1.5. List of Strategic Sectors and Countries Included in the Main Regression Analysis

Strategic Sectors
As described in SEC 3 definitions: Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms -- Manufacture of batteries and accumulators -- Manufacture of coke oven products -- Manufacture of consumer electronics -- Manufacture of domestic appliances -- Manufacture of electronic components and boards -- Manufacture of general-purpose machinery -- Manufacture of measuring, testing, navigating and control equipment; watches and clocks -- Manufacture of motor vehicles -- Manufacture of non-metallic mineral products n.e.c. -- Manufacture of pharmaceuticals, medicinal chemical and botanical products -- Mining of non-ferrous metal ores -- Support activities for petroleum and natural gas extraction. And following subsectors of ISIC code 20 (Manufacture of Chemicals and Chemical Products) for which there is not precise mapping into SEC classification: Biological products (except diagnostic) -- In-Vitro diagnostic substances -- Other (Biotechnology) -- Pesticide, fertilizers & other agricultural chemicals.
Source countries included in main regression:
Afghanistan; Albania; Algeria; Andorra; Angola; Antigua and Barbuda; Argentina; Armenia; Australia; Austria; Azerbaijan; Bahamas, The; Bahrain; Bangladesh; Barbados; Belarus; Belgium; Belize; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Burundi; Cambodia; Cameroon; Canada; Chile; China; Colombia; Congo, Republic of; Costa Rica; Croatia; Cyprus; Czech Republic; Côte d'Ivoire; Democratic Republic of the Congo; Denmark; Djibouti; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Estonia; Ethiopia; Fiji; Finland; France; Gabon; Gambia, The; Georgia; Germany; Ghana; Greece; Guatemala; Guyana; Haiti; Honduras; Hungary; Iceland; India; Indonesia; Iran; Iraq; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Kiribati; Korea; Kuwait; Kyrgyz Republic; Lao P.D.R.; Latvia; Lebanon; Libya; Lithuania; Luxembourg; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta; Mauritius; Mexico; Micronesia, Fed. States of; Moldova; Mongolia; Montenegro, Rep. of; Morocco; Mozambique; Myanmar; Namibia; Nepal; Netherlands; New Zealand; Nicaragua; Nigeria; North Macedonia; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Qatar; Romania; Russia; Rwanda; Samoa; San Marino; Saudi Arabia; Senegal; Seychelles; Sierra Leone; Singapore; Slovak Republic; Slovenia; Solomon Islands; South Africa; Spain; Sri Lanka; St. Kitts and Nevis; St. Lucia; Sudan; Sweden; Switzerland; Syria; Tajikistan; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Türkiye; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Vanuatu; Venezuela; Vietnam; Yemen; Zambia; and Zimbabwe.
Destination countries included in main regression:
Afghanistan; Albania; Algeria; Andorra; Angola; Antigua and Barbuda; Argentina; Armenia; Australia; Austria; Azerbaijan; Bahamas, The; Bahrain; Bangladesh; Barbados; Belarus; Belgium; Belize; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Canada; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo, Republic of; Costa Rica; Croatia; Cyprus; Czech Republic; Côte d'Ivoire; Democratic Republic of the Congo; Denmark; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Estonia; Eswatini; Ethiopia; Fiji; Finland; France; Gabon; Gambia, The; Georgia; Germany; Ghana; Greece; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hungary; Iceland; India; Indonesia; Iran; Iraq; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Kiribati; Korea; Kuwait; Kyrgyz Republic; Lao P.D.R.; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Luxembourg; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta; Mauritania; Mauritius; Mexico; Micronesia, Fed. States of; Moldova; Mongolia; Montenegro, Rep. of; Morocco; Mozambique; Myanmar; Namibia; Nepal; Netherlands; New Zealand; Nicaragua; Niger; Nigeria; North Macedonia; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Qatar; Romania; Russia; Rwanda; Samoa; Saudi Arabia; Senegal; Seychelles; Sierra Leone; Singapore; Slovak Republic; Slovenia; Solomon Islands; Somalia; South Africa; Spain; Sri Lanka; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Sudan; Suriname; Sweden; Switzerland; Syria; São Tomé and Príncipe; Tajikistan; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Türkiye; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Vanuatu; Venezuela; Vietnam; Yemen; Zambia; and Zimbabwe.

Online Annex 4.2. A Multidimensional Index of Vulnerability

This annex describes the construction of the aggregate vulnerability index and the following three sub-indices.

1. Geopolitical index, which captures the idea that the vulnerability of an investment project to being relocated should increase with the geo-political distance between the host country and the source country. Therefore, a host country is more vulnerable the greater is the share of the FDI stock sourced from geo-politically distant countries. The index is defined as follows:

$$v_i^{geo} = \sum_j share_{ij}^{FDI} * \gamma^{geo}(i,j) \text{ ,} where\ \gamma^{geo}(i,j) = \frac{percentile\big(IPD(i,j)\big)}{100}$$

In the above, i denotes the host-country, j denotes the source-country, v_i^{geo} denotes the country-level geopolitical vulnerability measure, $share_{ij}^{FDI}$ denotes the estimated share of FDI stock in host-country i from source-country j, and function $\gamma^{geo}(i,j)$ is a measure of a geopolitical distance between the host and source. The index is bounded between 0 and 1, with higher values indicating greater vulnerability. The $share_{ij}^{FDI}$ is estimated by counting the number of greenfield FDI from j into i, after the GFC and before COVID (2010-2019), and dividing by the number of investments in country i over the same period from all source countries. The function $\gamma^{geo}(i,j)$ is the percentile of the bilateral IPD amongst all bilateral IPDs across all years. A lower percentile indicates closer geopolitical alignment between the source and host.

2. Market power index, which captures the idea that it may be harder to relocate projects out a sector in a host country if that host country is a major player in that sector. Therefore, host countries that have market power in many of the sectors where they host FDI are less vulnerable. The index is defined as follows:

$$v_i^{mkt} = \sum_s share_{i,s}^{FDI} * \gamma^{mkt}(i;s) \text{ ,} where\ \gamma^{mkt}(i;s)$$

$$= \begin{cases} 0.5\ if\ country\ i\ is\ a\ top - 10\ exporter\ in\ sector\ s \\ \qquad\qquad 1\ if\ otherwise \end{cases}$$

The $share_{i,s}^{FDI}$ denotes the estimated share of FDI stock in country i and sector s, from all source countries over the period 2010-2019. The function $\gamma^{mkt}(i;s)$ treats FDI in sector s, country i, as partly vulnerable if the country is amongst the top-10 exporters in that sector, and fully vulnerable if otherwise. A significant share of FDI in many host-countries are in non-tradeable sectors (e.g., retail, finance). These investments are treated as fully vulnerable in all countries in the baseline calculation. As robustness, an alternate calculation using tradeable sectors only yields similar results.

3. Strategic index, which captures the idea that source-countries may be particularly interested in re-locating investments in strategic sectors for national or economic security reasons. Both geo-politically close and distant host economies may be vulnerable along this dimension. The index is defined as follows:

$$v_i^{strat} = \sum_s share_{i,s}^{FDI} * \gamma^{strat}(s) \ \ , where\ \gamma^{strat}(s) = \begin{cases} 1\ if\ sector\ is\ strategic \\ 0\ if\ sector\ is\ non-strategic \end{cases}$$

Aggregate index. For each host country, an aggregate index of vulnerability is constructed by combining the three indices at the sector-source country level. The following equation defines the aggregate index:

$$v_i^{agg} = \frac{1}{2}\sum_j \sum_s share_{ij,s}^{FDI} * \left(\gamma^{geo}(i,j) * \gamma^{mkt}(i;s) + \gamma^{strat}(s)\right)$$

The $share_{ij,s}^{FDI}$ denotes the estimated share of FDI stock in country i – sector s and from source-country j, amongst the total FDI stock in that country. Market power in a sector is considered to ameliorate geopolitical vulnerability from the source country, and therefore $\gamma^{mkt}(i;s)$ and $\gamma^{geo}(i,j)$ are multiplied together. This market-power adjusted geopolitical vulnerability is added to $\gamma^{strat}(s)$, as the strategic dimension is considered to capture a separate aspect of GEF. The weighted average—summed across all sectors and source countries, is then divided by 2 so that the aggregate index is between 0 and 1.

Data. As elsewhere in the chapter, the distribution of FDI stocks in each host, by sector and by source, is proxied for by counting the number of greenfield investment projects—from fDi Markets—since the Global Financial Crisis, and prior to the outbreak of COVID-19 (2010-2019). Bilateral geopolitical distance is measured using the ideal point distance (Bailey et al. 2017). Alongside, export market shares are calculated based on bilateral exports flows from Trade Monitor Data for 2019.

Baseline assumptions. Hong Kong SAR and Macao SAR are merged with mainland China, while Taiwan Province of China is dropped. Financial centers are included.

Robustness. Several alternative thresholds and functional forms are considered to check the robustness of the indices. As well, the following alternate approaches are considered for calculating the index. The baseline index is broadly correlated with these alternate methods, and the findings of the chapter are robust to these alternate methods.

- Estimating FDI stocks starting from 2003 (first available year in fDi Markets) rather than 2010.
- Dropping mining sectors from strategic industries when calculating strategic vulnerability.
- Calculating each index using only sectors with non-zero exports.
- Estimating FDI stocks using value of projects, or the number of jobs created.
- Dropping Hong Kong and Macao SARs rather than merging with China.
- Dropping countries that are financial centers.

Online Annex 4.3. Empirical Evidence on FDI Spillovers to Host Countries

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

Country-Level Evidence

Background

Not all FDI is alike and gains from FDI may differ by FDI types. To the extent that the composition of inward FDI types is also different across countries, the relationship between FDI and growth could vary across countries. A case in point is the distinctive nature of two major types of FDI: horizontal and vertical FDI. This has become more relevant as the degree of exposure to geoeconomic fragmentation risk is likely to vary across FDI types.[7]

Against the background, this section compares the relationship between FDI and growth across host countries classified into a group of horizontal or vertical countries.

Data and Methods

Previous studies proposed novel approaches to identifying horizontal and vertical FDI. Ramondo and others (2016) explore the U.S. BEA data that provide a detailed breakdown of sales by foreign subsidiaries into geographical and customer-type dimensions: inter-firm or intrafirm local sales; inter-firm or intra-firm exports to other countries. The idea is that, since horizontal (vertical) FDI firms tend to sell their products mainly to local unaffiliated (affiliated) customers, subsidiaries with a high share of local inter-firm sales (total intra-firm sales) in total sales can be classified as horizontal (vertical) FDI firms.

Alternatively, Alfaro and Charlton (2009) propose to use information on parent and subsidiary firms' sector affiliations to distinguish different types of FDI. Specifically, a parent and subsidiary pair that belongs to the same sector is likely to be horizontal FDI, while a pair that belongs to different sectors is likely to be vertical FDI.

Following these approaches, the chapter constructs two different country-level proxy measures on the prevalence of horizontal FDI as opposed to vertical FDI. First, aggregating respective sales data in a given country by Korean foreign subsidiaries, a country with more than 50 percent of local unaffiliated sales in total sales is classified as a horizontal FDI country, while the other countries are classified as vertical FDI countries.[8] A limitation of this approach is that it is strictly based on Korean MNCs' perspectives.

Hence, the chapter consider an alternative approach, by exploring the ownership structure information in the Orbis database employed in Ando and Wang (2020). A case in which a

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[7] Vertical FDI is likely to be more exposed to risks from rising protectionism as higher tariffs, for example, would make horizontal FDI more attractive while making vertical FDI less attractive. Moreover, a risk of geoeconomic fragmentation, particularly in the current form of tech wars, is expected to hurt vertical FDI more as it is centered around advanced technology embodied in input production where vertical FDI tends to prevail.

[8] Foreign subsidiary-level data from the Export-Import Bank of Korea are comparable to the U.S. BEA data. See Ahn and Park (2022) for more details.

subsidiary belongs to the same 2-digit industry as the parent firm is identified as horizontal FDI, while a case in which a subsidiary belongs to a different 2-digit sector from their parents' is categorized as a vertical FDI. Aggregating up the total number of horizontal and vertical FDI firms, if a country's share of horizontal FDI firms in total foreign owned firms is above 20 percent is classified as a horizontal FDI country, while a country below the same threshold value is classified as a vertical FDI country. One limitation of this proxy variable is that, in several countries, the coverage of foreign owned firms in the Orbis database is limited.

The relationship between FDI and growth Is then assessed in a parsimonious specification, with a particular focus on the difference between horizontal and vertical FDI countries, as defined above:

$$Y_{it} = \beta_1 FDI_{it-1} + \gamma X_{it} + \epsilon_{it},$$

where Y_{it} is real GDP growth in country *i* at time *t*, FDI_{it-1} is lagged FDI over GDP and the controls in X_{it} include lagged log-GDP, all of which are taken from the IMF World Economic Outlook database. Country and time fixed effects are also included, and standard errors are clustered at the country level. The baseline sample covers 160 countries between 1981 and 2021.

Estimation Results

Columns 1-3 in Online Annex Table 4.3.1 summarize the baseline estimation results on the full set of countries, regardless their horizontal/vertical FDI classification. There is a strong positive correlation between FDI and growth, especially strong among EMDEs.

Employing the first country-level proxy variable, based on subsidiary-level sales information, column 1 in Online Annex Table 4.3.2 reports the estimation results for all horizontal FDI countries, which are further broken down into AEs and EMDEs (columns 2 and 3). Similarly, columns 4-6 show estimation results for all vertical FDI countries, AE vertical FDI countries, and EMDE vertical FDI countries, respectively. Overall, there is a strong positive correlation

Online Annex Table 4.3.1 Country-Level Estimation Results: Baseline

By income levels	All	AEs	EMDEs
By FDI types	All	All	All
	(1)	(2)	(3)
	unstandardized coefficients		
Lagged FDI over GDP	0.165***	0.0291**	0.233***
	(0.0595)	(0.0129)	(0.0820)
Lagged Log of real GDP	-4.679***	-5.051***	-4.589***
	(0.603)	(0.682)	(0.683)
	standardized coefficients		
Lagged FDI over GDP	0.159***	0.067**	0.180***
	(0.0595)	(0.0129)	(0.0820)
Lagged Log of real GDP	-0.985***	-0.575***	-0.763***
	(0.603)	(0.682)	(0.683)
Observations	5274	1103	4171
Adj-R2	0.253	0.602	0.239

Source: IMF staff calcualtions.

Note: All specifications include country and year fixed effects. Columns (1)-(3) consider all countries, advanced economies, emerging and developing market economies, respectively. Standard errors are clustered at the country level. ***p<0.01, **p<0.05, *p<0.1.

between FDI and growth for vertical FDI countries, but this relationship does not hold for horizontal FDI countries. Looking at the results by income levels makes it clear that the strong positive correlation among vertical FDI countries is driven entirely by EMDEs. Online Annex Table 4.3.3 confirms these findings relying on the proxy variable based on sector affiliation information. Qualitative results are very close, except that a positive relationship between FDI and growth is also found for horizontal FDI in AEs.

These findings reflect the distinctive nature of horizontal and vertical FDI; horizontal FDI are more frequent among final goods producers that tend to bring simple (and labor intensive) assembly technology to host countries. By contrast, vertical FDI tends to be concentrated among intermediate goods producers, which are more likely to employ more sophisticated (and skill intensive) technology.

Online Annex Table 4.3.2 Country-Level Estimation Results: Sales Information-Based Classification

By income levels	All	AEs	EMDEs	All	AEs	EMDEs
By FDI types	Horizontal	Horizontal	Horizontal	Vertical	Vertical	Vertical
	(1)	(2)	(3)	(4)	(5)	(6)
			unstandardized coefficients			
Lagged FDI over GDP	-0.0302	0.0116	-0.0535	0.0840	0.0152	0.186***
	(0.0235)	(0.0132)	(0.164)	(0.040	(0.0215)	(0.0666)
Lagged Log of real GDP	-4.230***	-7.570***	-4.575***	-3.008	-3.715**	-3.489***
	(1.488)	(1.981)	(1.409)	(0.794	(1.647)	(0.995)
			standardized coefficients			
Lagged FDI over GDP	-0.040	0.033	-0.028	0.109*	0.037	0.138***
	(0.0235)	(0.0132)	(0.164)	(0.040	(0.0215)	(0.0666)
Lagged Log of real GDP	-1.203***	-0.976***	-0.997***	-0.795	-0.391**	-0.680***
	(1.488)	(1.981)	(1.409)	(0.794	(1.647)	(0.995)
Observations	948	410	538	1475	491	984
Adj-R2	0.344	0.678	0.282	0.425	0.589	0.417

Source: IMF staff calcualtions.

Note: All specifications include country and year fixed effects. Columns (1)-(3) consider horizontal FDI countries only. Columns (4)-(6) consider vertical FDI countries only. Standard errors are clustered at the country level. ***p<0.01, **p<0.05, *p<0.1.

Online Annex Table 4.3.3 Country-Level Estimation Results: Industry Information-Based Classification

By income levels	All	AEs	EMDEs	All	AEs	EMDEs
By FDI types	Horizontal	Horizontal	Horizontal	Vertical	Vertical	Vertical
	(1)	(2)	(3)	(4)	(5)	(6)
			unstandardized coefficients			
Lagged FDI over GDP	0.0946	0.172***	0.0774	0.112*	0.00639	0.218***
	(0.0615)	(0.0199)	(0.0857)	(0.045	(0.0118)	(0.0797)
Lagged Log of real GDP	-3.847***	-5.683***	-3.172***	-4.312	-2.387	-4.869***
	(0.938)	(0.431)	(0.838)	(0.869	(2.302)	(0.980)
			standardized coefficients			
Lagged FDI over GDP	0.063	0.174***	0.047	0.146*	0.017	0.197***
	(0.0615)	(0.0199)	(0.0857)	(0.045	(0.0118)	(0.0797)
Lagged Log of real GDP	-0.951***	-0.701***	-0.702***	-1.019	-0.255	-0.861***
	(0.938)	(0.431)	(0.838)	(0.869	(2.302)	(0.980)
Observations	1554	244	1310	2651	859	1792
Adj-R2	0.315	0.685	0.305	0.288	0.589	0.260

Source: IMF staff calcualtions.

Note: All specifications include country and year fixed effects. Columns (1)-(3) consider horizontal FDI countries only. Columns (4)-(6) consider vertical FDI countries only. Standard errors are clustered at the country level. ***p<0.01, **p<0.05, *p<0.1.

Firm-Level Evidence

Background

Foreign entry may have different impacts depending on whether it mostly affects intra-industry domestic competitor firms as opposed to inter-industry domestic suppliers/buyers.[9] Previous firm-level studies focusing on one country find mixed evidence on this.[10] To better understand potential costs of FDI deterred by geo-economic fragmentation, it is important to identify specific sources of spillover effects from inward FDI in host countries. This part of the analysis evaluates firm-level FDI spillovers by exploring cross-country sector-level variation in FDI.[11]

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[9] In a nutshell, intra-industry spillover refers to the case in which FDI in any given sector potentially benefit sales and innovation by local firms in the same sector. Backward (forward) linkages refer to the case in which an upstream (downstream) domestic firm could benefit from FDI in downstream (upstream) sectors.

[10] For intra-industry spillover effects, Aitken and Harrison (1999) find a negative spillover effect in Venezuela, which is attributed to the market-stealing effect caused by entering foreign firms, whereas Haskel and others (2007) and Keller and Yeaple (2009) report positive spillover effects in the United Kingdom and United States, respectively. By contrast, inter-industry spillover effects tend to be found mostly positive for backward linkages (Harrison and Rodriguez-Clare, 2010). Javorcik (2004) explore Lithuanian firm-level data to separately estimate intra-industry and inter-industry spillover effects where the latter is further broken down into backward and forward linkages. The estimation results support the strong presence of backward linkages: positive productivity spillovers from FDI take place mostly through contacts between foreign firms and their local suppliers in upstream sectors. Blalock and Gertler (2008) confirm technological spillovers from FDI via backward linkages among Indonesian firms. Jiang and others (2018) find both backward and intra-industry spillover effects from international joint ventures in China. Jude (2016) and Newman and others (2015) confirm positive backward spillover effects and negative forward spillover effects in Romania and Vietnam, respectively.

[11] In line with the literature, this chapter only considers spillovers from manufacturing sector FDI.

Data and Methods

The fDi Markets Database is matched with the World Bank Enterprise Surveys (WBES), which provide a rich set of standardized firm-level information in a repeated cross-sectional design (with different countries surveyed in different years) for more than 180,000 firms in over 150 countries between 2006 and 2022. Firm-level performance measures in the standardized WBES dataset includes employment, sales, investment, and R&D expenditures. The current analysis aims to separately estimate inter-industry and intra-industry spillover effects on firm-level labor productivity, and thus is close to the approach taken in Mercer-Blackman and others (2021).

To measure inter-industry linkages, the global input-output matrix from the EORA database is used to construct the weighted sum of FDIs across input or output sectors for a given country-sector, where weights are calculated from a share of input from (or output to) respective sector in total inputs (or outputs). Specifically, these are expressed as:

$$FDI_{cjt}^{user} = \sum\nolimits_{s\neq abroad}\left[\left(\frac{\alpha_{cjs}}{\sum_s \alpha_{cjs}}\right)\times FDI_{cst}\right]$$

$$FDI_{cjt}^{supplier} = \sum\nolimits_{u\neq abroad}\left[\left(\frac{\alpha_{cuj}}{\sum_u \alpha_{cuj}}\right)\times FDI_{cut}\right]$$

where α_{cus} is total input supplied by sector *s* to produce output in sector *u*, taken from the EORA database for each country *c*; FDI_{cj} is country-sector level inward FDI measured as the number of new greenfield FDI in the fDi Markets database, which effectively serves as a measure for intra-industry spillover effects and thus is also denoted as FDI_{cj}^{within}).[12]

The baseline regression is specified as:

$$\Delta\ln LP_{icjt} = \beta_1 \ln\left(FDI_{cjt-3}^{within}\right) + \beta_2 \ln\left(FDI_{cjt-3}^{supplier}\right) + \beta_3 \ln\left(FDI_{cjt-3}^{user}\right) + FE_{cj} + FE_{ct} + FE_{jt} + \varepsilon_{icjt}$$

for estimating both intra-industry and inter-industry spillover effects at the same time, where $\Delta\ln LP_{icjt}$ denotes a firm *i*'s labor productivity growth over the previous three years.[13] Using the lagged values of FDI and including fixed effects FE_{cj}, FE_{ct}, and FE_{jt} that captures country-sector, country-year, and sector-year fixed effects, respectively, might partly mitigate the concerns for the most obvious sources of endogeneity. Standard errors are clustered in multiple dimensions at the country-sector and country-year level.

Estimation Results

Columns 1-3 in Online Annex Table 4.3.4 summarize the baseline estimation results from the analysis of both inter-industry and intra-industry spillover effects when FDI from all source countries is considered. Intra-industry spillover effects are positive and statistically significant only for AEs. Backward spillover effects are positive and statistically significant, particularly in EMDEs. Forward spillover effects are negative, but not statistically significant.

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[12] 1 is added to FDI measures to include observations in those country-sectors without new FDI in given year.

[13] The questionnaire includes total sales and number of workers in the last fiscal year and three fiscal years ago so that labor productivity growth over the period can be calculated.

Online Annex Table 4.3.4 Firm-Level Estimation Results

Sample (host country)	All	AEs	EMDEs	All	AEs	EMDEs	All	AEs	EMDEs
Source country	All	All	All	AEs	AEs	AEs	EMDEs	EMDEs	EMDEs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					unstandardized coefficients				
Intra-industry spillover	0.159*	0.890**	0.141	0.139	0.768*	0.125	0.0909	1.009	0.0776
	(0.0899)	(0.394)	(0.0922)	(0.100)	(0.438)	(0.103)	(0.192)	(1.007)	(0.196)
Backward spillover	0.340**	0.759	0.372**	0.293*	0.758	0.285*	0.256	0.527	0.451*
	(0.144)	(0.931)	(0.148)	(0.149)	(1.124)	(0.151)	(0.240)	(1.529)	(0.251)
Forward spillover	-0.277	-1.298	-0.288	-0.285*	-0.734	-0.273	-0.185	-1.663	-0.339
	(0.181)	(0.999)	(0.181)	(0.168)	(1.015)	(0.171)	(0.320)	(1.989)	(0.329)
					standardized coefficients				
Intra-industry spillover	0.028*	0.217**	0.025	0.024	0.177*	0.021	0.005	0.084	0.004
	(0.0899)	(0.394)	(0.0922)	(0.100)	(0.438)	(0.103)	(0.192)	(1.007)	(0.196)
Backward spillover	0.107**	0.349	0.114**	0.091*	0.333	0.086*	0.027	0.103	0.044*
	(0.144)	(0.931)	(0.148)	(0.149)	(1.124)	(0.151)	(0.240)	(1.529)	(0.251)
Forward spillover	-0.085	-0.557	-0.086	-0.085*	-0.299	-0.080	-0.020	-0.296	-0.035
	(0.181)	(0.999)	(0.181)	(0.168)	(1.015)	(0.171)	(0.320)	(1.989)	(0.329)
Observations	129557	16316	113114	129557	16316	113114	129557	16316	113114
Adj-R2	0.178	0.159	0.178	0.178	0.159	0.177	0.178	0.159	0.177

Source: IMF staff calcualtions.

Note: All specifications include country-sector, country-year and sector-year fixed effects. Columns (1)-(3) consider FDI from all source countries; Columns (4)-(6) consider FDI from AEs only. Columns (7)-(9) consider FDI from EMDEs only. Standard errors are clustered at the country-sector and country-year level. ***p<0.01, **p<0.05, *p<0.1.

These results are consistent with the previous literature that finds that pro-competitive effects and market stealing effects operate within an industry in the opposite direction; the former may dominate in AEs, while the latter may prevail in EMDEs (e.g., Aitken and Harrison, 1999). As for inter-industry spillovers, positive productivity spillovers from FDI take place mainly through contacts between foreign affiliates and local suppliers in upstream sectors rather than through contacts between foreign affiliates and local buyers in downstream sectors (e.g., Javorcik 2004).

Columns 4-6 and columns 7-9 in Online Annex Table 4.3.4. report extended results, breaking down FDI source countries into AEs and EMDEs, respectively. The results are consistent with the notion that FDI from AEs tend to embody more advanced technology than FDI from EMDEs: positive intra-industry spillover effects in AEs are driven mainly by FDI from AEs. Moreover, positive backward spillover effects in EMDEs stem from FDI originating in both AEs and EMDEs, while standardized coefficients suggest that FDI from AEs yields two times stronger effects than FDI from EMDEs.

Online Annex 4.4. Modeling FDI Fragmentation

This annex provides a summary of key elements of the IMF's Global Integrated Monetary and Fiscal model (GIMF) and its calibration; the assignment of regions into geo-political blocs; and the calibration of productivity losses for EMDE regions; a scenario where only China and the U.S. impose barriers on one another; and different assumptions around uncertainty for the non-aligned regions.

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 8 regions: the United States, EU+, other advanced economies, China, Southeast Asia, India and Indonesia, Latin America and the Caribbean, and the rest of the world.[14] 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) and Anderson and others (2013).

Some households are modeled as non-Ricardian, finitely lived, overlapping generations, as found, for example, in Blanchard (1985). These saving households choose consumption, savings, and labor supply. The remaining households are liquidity constrained, consume all their income every period and set their labor supply in proportional to that of the saving households and reinforce 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 Database (OECD 2021; presented in Online Annex Table 4.4.1).

Firms in every sector choose investment to maximize their net present value. Investment requires inputs sourced both domestically and from foreign regions. Inputs sourced from various regions are not perfectly substitutable. The analysis in the chapter puts barriers on the

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[14] 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 refers to Mainland China and Hong Kong SAR; Southeast Asia is Brunei, Cambodia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam; Latin America is Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, and Peru; India and Indonesia are a region; and the rest of the world includes Russia, South Africa, and Türkiye plus the regions of Africa, the Caribbean, Central Asia, other Latin America, the Middle East, and Oceania, and any other EMDEs not accounted for elsewhere.

Online Annex Table 4.4.1. 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

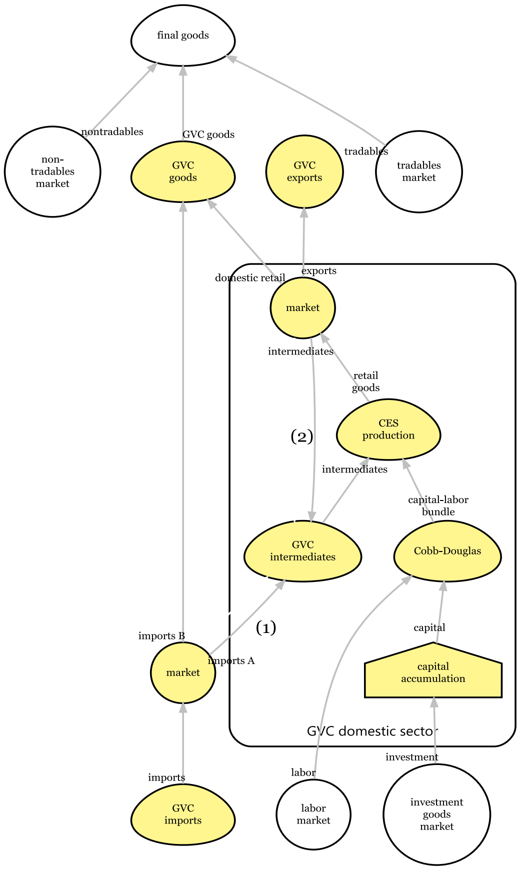
Sources: OECD (2021); and IMF staff calculations.

import of these inputs from opposing bloc regions. The GVC sector is added to the model, as FDI can play an important role in developing country's links to global value chains, though FDI contributes to productive capacity in other sectors as well.

Non-tradable goods and domestically produced tradable goods are produced using some combination of labor and capital.

The GVC sector is more complex than the other two sectors, as seen in Online Annex Figure 4.4.1, as GVC goods are used both in final goods and as inputs in the production of other GVC goods. 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 capital and labor (bundled using a Cobb-Douglas function) 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 cycled back as inputs into the production of other GVC goods, both domestically and abroad.

Online Annex Figure 4.4.1 The Global Value Chain Sector in GIMF



Regions trade final goods (consumption and investment), and tradable and GVC 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.

The model captures barriers to trade using "non-tariff barriers" (NTBs), which affects the model's importers and exporters in ways similar to tariffs but does not generate fiscal revenues. NTBs in GIMF can take two forms, and they have identical economic impacts. The more standard first form is where country A imposes an NTB on imports from country B, which country B's exporters partially pass on to country A's importers through higher prices. The second form is where country B imposes the NTB on its exports to country A. This also results in country B's exporters passing on the cost as much as possible to country A's importers. This second form of NTB is used in the chapter, reflecting that source countries are trying to restrict flows of investment inputs to destinations in the opposing bloc.

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 Database for 2018 (OECD 2021), drawing on its national accounts and fiscal ratios. National accounts ratios are summarized in Online Annex Table 4.4.2. 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 remaining regions. Regions with high shares of liquidity constrained households have more volatility in GDP, as they are less able to smooth their consumption under temporary shocks or implement gradual adjustments under permanent shocks.

Online Annex Table 4.4.2. Domestic Sector Calibration

(perent of region's GDP, unless noted otherwise)

	United States	EU+	Other Advanced Economies	China	South-east Asia	Rest of the World	India and Indonesia	Latin America
Share of Global GDP (%, US$)	24.4	18.9	16.5	16.7	2.3	11.6	4.5	5.1
Domestic Demand								
Household Consumption	65.4	54.9	56.3	51.7	58.8	58.7	56.4	63.0
Private Investment	17.1	32.2	17.5	22.5	24.3	22.2	27.7	16.0
Trade								
Aggregate Exports	11.5	20.1	23.5	17.4	61.7	24.9	19.9	21.0
Consumption	*3.5*	*6.4*	*5.4*	*5.0*	*20.9*	*6.0*	*6.3*	*5.5*
Investment	*1.6*	*3.2*	*3.6*	*3.1*	*6.9*	*0.9*	*2.8*	*2.3*
Intermediate	*2.5*	*3.5*	*3.9*	*1.8*	*10.8*	*3.4*	*2.7*	*4.0*
GVC	*3.8*	*7.1*	*10.5*	*7.5*	*23.2*	*14.6*	*8.2*	*9.3*
Goods Imports	11.5	20.1	23.5	17.4	61.7	24.9	19.9	21.0
Investment	*1.4*	*2.8*	*2.4*	*1.6*	*8.7*	*5.6*	*2.4*	*2.6*
Intermediate	*1.7*	*3.8*	*4.1*	*2.6*	*11.3*	*3.2*	*2.9*	*3.2*
GVC	*5.4*	*7.0*	*9.8*	*9.2*	*29.5*	*7.3*	*11.7*	*9.2*

Sources: OECD (2021); and IMF staff calculations.

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 how activity in the rest of the world will spill over onto it, and how that region influences the rest of the world.

Online Annex Table 4.4.3. 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*
Tradables	-	1.5	1.5
GVC Goods	0.3	0.6^	0.5

Source: IMF staff calculations.

* Alternative value of 3.0 used when exploring trade diversion.

^ Elasticity between domestic and imported when using GVC goods in the production of final goods or of other GVC goods.

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).

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 4.4.3). A key parameter is the elasticity of substitution for investment inputs sourced from different foreign regions, which influences the role of diversion of investment input flows in a fragmented world. The benchmark elasticity of 1.5 and a higher value of 3 are considered. Demand for goods in the GVC sector are assumed to be relatively inelastic (all well under 1), compared to other elasticities of demand and trade, which are usually elastic at around 1.5. Final goods are a combination of nontradable goods and a tradable goods bundle, with an elasticity of 0.5. The tradable goods bundle is assembled from tradable intermediate goods and GVC goods with an elasticity of 0.95.

Construction of Geo-Political Blocs

This section outlines the assignment of model regions into geo-political blocs, based on the bilateral IPD scores averaged over 2017-2021. First, every country is ranked based on its closeness to the two pole countries: China and the US. These rankings are used to calculate six statistics for each country, equal 1 if true for that country and 0 if otherwise. The six statistics are (i) is relatively closer to China than the US; (ii) is relatively closer to the US than China; (iii) in the closest quartile to China; (iv) in the closest quartile to the US; (v) in the closest quartile to neither; and (vi) in the closest quartile to both.

Second, the six statistics for countries are aggregated up to the regional level, with countries weighted by GDP in PPP terms. Online Annex Table 4.4.4 summarizes the regional averages.

Online Annex Table 4.4.4. Geopolitical Alignment Statistics by Region

Region	Region's share of global GDP (PPP)	Closer to China	Closer to U.S.	Closest quartile of China	Closest quartile of U.S.	Closest quartile of neither	Closest quartile of both
1.United States	16.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%
2. China	18.9%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%
3. EU+	15.6%	0.0%	100.0%	0.0%	99.8%	0.2%	0.0%
4. Other AEs	11.2%	0.0%	100.0%	0.0%	65.1%	34.9%	0.0%
5. India and Indonesia	9.6%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%
6. Southeast Asia	3.8%	100.0%	0.0%	54.3%	0.0%	45.7%	0.0%
7. LAC	6.3%	12.2%	87.8%	5.8%	0.0%	94.2%	0.0%
8. ROW	18.7%	83.5%	16.5%	42.5%	3.2%	54.4%	0.0%

Sources: Bailey and others (2017); IMF *World Economic Outlook*.
Note: IMF staff calculations.

Third, the relative leans towards China and the US, based on statistics (i) and (ii), are used to sort regions into a group closer to China (Southeast Asia, India and Indonesia, rest of the world) and a group closer to the US (EU+, other AEs, Latin America and the Caribbean). From each group, the region with the least intense affiliation, as measured by statistic (v)—in the closest quartile to neither China nor the US, are assigned as non-aligned regions in the baseline fragmentation scenario. The remaining regions in each group form the two geopolitical blocs.

Calibrating Productivity Losses Associated with Lower FDI Flows

The conditional correlation between FDI inflows-to-GDP and labor productivity is estimated using the following equation separately for EMDE and AE recipients, using a cross-country panel between 1980-2021.

$$logLP_{i,t} = \beta_0 + \beta_1 logLP_{i,t-1} + \beta_2 \left(\frac{FDI}{GDP}\right)_{i,t-1} + \delta_t + \gamma_i + \epsilon_{i,t} \quad (1)$$

In equation (1), $(logLP_{i,t})$ denotes the logarithm of labor productivity, $(logLP_{i,t-1})$ is the lagged value of the logarithm of labor productivity, and $\left(\frac{FDI}{GDP}\right)_{i,t-1}$ is the lagged ratio of FDI inflows to GDP. Time and country fixed effects are included. The estimates, reported in Online Annex Table 4.4.5, suggest an economically and statistically significant conditional correlation between lagged FDI to GDP and log labor productivity in EMDEs. The coefficient of 0.00147 implies that a 10 percentage point increase in FDI inflows to GDP is associated 1.47 percent increase in labor productivity levels. The corresponding coefficient is small and insignificant for AEs.

To map these estimates into the model, first define (i) $\left\{\left(\frac{\widetilde{FDI}}{GDP}\right)_{i,t-j+1}\right\}_{j=0}^{\infty}$ as the sequence of FDI inflows to GDP in region *i* in a fragmentation scenario, with barriers rising starting in year *t*, and define (ii) $\left\{\left(\frac{\widehat{FDI}}{GDP}\right)_{i,t-j+1}\right\}_{j=0}^{\infty}$ as the corresponding sequence in the no-fragmentation scenario.

The permanent nature of the shock leads to permanent differences between sequences (i) and (ii), with the differenc es in labor productivity levels between the fragmentation and no-fragmentation economies cumulating over time. Equation (1) is used to obtain the difference in labor productivity between the two economies, s periods after the beginning of the shock, as shown in equation (2).

$$\left[\log\left(\widetilde{LP}\right)_{i,t+s} - \log\left(\widehat{LP}\right)_{i,t+s}\right] = \beta_2 \sum_{j=0}^{s} \beta_1 \left[\left(\frac{\widetilde{FDI}}{GDP}\right)_{i,t+j-1} - \left(\frac{\widehat{FDI}}{GDP}\right)_{i,t+j-1}\right] \qquad (2)$$

As the model does not have a variable mapping directly to FDI, the import of investment inputs is used as a proxy on the right-hand side of equation (2).

Online Annex Table 4.4.5 Estimated Conditional Correlations between FDI/GDP and Labor Productivity

	Dependent Variable: Labor Productivity	
	(1)	(2)
Lagged FDI over GDP	-0.00399	0.147**
	(0.00801)	(0.0586)
Labor prductivity (lagged)	0.960***	0.963***
	(0.00521)	(0.00678)
Constant	0.464***	0.366***
	(0.0586)	(0.0647)
Observations	1262	4313
Rsquared	0.997	0.998
Period	1980-2021	1980-2021
Sample	AEs	EMDEs

Source: IMF staff calculations.

First, the model is run to obtain the sequence of each EMDE regions' import of investment inputs from AE regions, in the no-fragmentation and fragmentation scenarios. These are then used to calculate labor productivity changes for EMDE regions using equation (2), with s = 10 (i.e., losses cumulated for ten years). Second, these estimated labor productivity losses are fed back into the model to obtain the overall impact of fragmentation.

Losses mainly arise for EMDE regions in the China bloc, while non-aligned or US bloc EMDE regions may see some increase in flows due to diversion. The labor productivity changes are cumulated for ten years rather than indefinitely, to capture the idea that China itself is becoming a technological leader in many areas and can partly substitute as a source of knowledge transfer for its bloc members over time.

Fragmentation Scenario with Barriers Between the U.S. and China Only

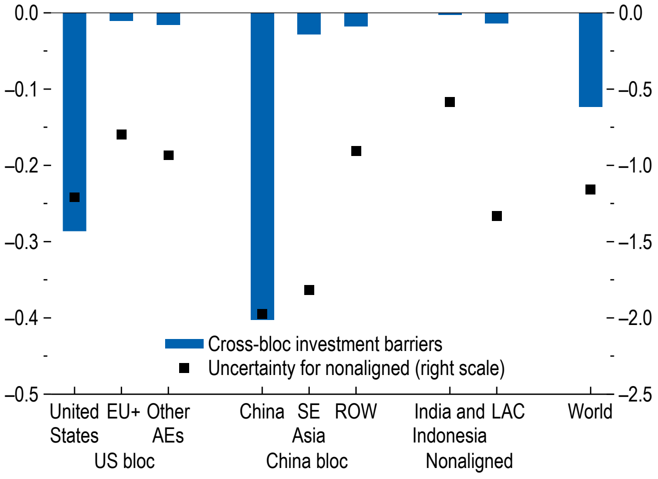
A scenario in which the US and China impose barriers on each other, while the six other regions all remain non-aligned, is considered. In line with the results presented in the main text, regions can significantly mitigate their losses if they are able to remain non-aligned, with no barriers to investment flows with either bloc, and do so with certainty (Online Annex Figure 4.4.2). Under the benchmark elasticity of substitution between investment inputs sourced from different regions (1.5), any gains from the diversion of investment flows to non-aligned regions is dominated by the negative impact of reduced external demand, such that the non-aligned experience small output losses.

Alternative Assumptions for Policy Uncertainty

Regions can be in one of three policy regimes in a fragmented world: part of the US bloc, part of the China bloc, or non-aligned (i.e., non-aligned regions). This chapter considers two possibilities regarding investors' expectations about the future alignment of non-aligned regions: investors either expect the regions will remain non-aligned permanently (certainty case), or that there is some positive probability of these regions joining one bloc or the other (uncertainty case). This type of policy uncertainty can persist indefinitely, and as discussed in the literature, significantly weigh on trade and investment. Policy uncertainty can effectively raise the bar for market entry or investment, affecting economic decisions similarly to formal barriers (Handley and Limao, 2022). The analysis of uncertainty in this chapter exploits this relationship, imposing partial barriers to capture the implied impact on investment flows from uncertainty.

Online Annex Figure 4.4.2. Long-Term GDP Losses, Barriers between China and the United States Only

(Percent deviation from no-fragmentation scenario)



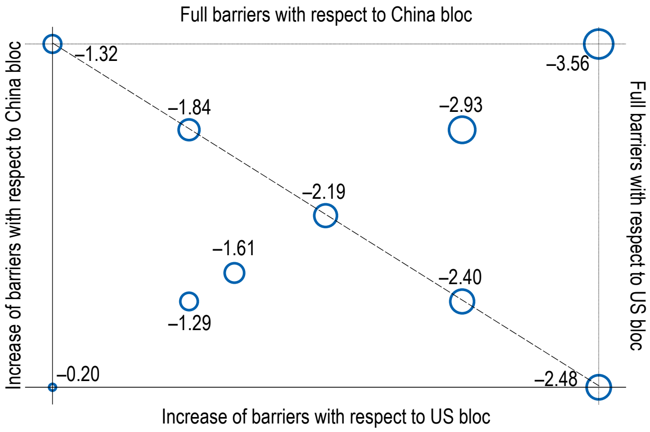
Source: IMF staff calculations.

Note: Scenario reflects explicit barriers to reduce investment input flows by 50 percent between China and the United States only, while all other regions remain nonaligned. AEs = advanced economies; EU+ = European Union and Switzerland; LAC = Latin America and the Caribbean; ROW = rest of the world; SE Asia = Southeast Asia.

As investors' perceived expectations regarding non-aligned regions in a hypothetical fragmentation scenario are impossible to pin down, the main text considers an illustrative case where such uncertainty translates into implicit barriers equal to half those faced by regions in the two blocs. Online Annex Figure 4.4.3 presents several other possibilities, using alternate combinations correspond to the non-aligned with certainty scenario as discussed in the main text, while the top-left and top-right corners correspond to the non-aligned joining the US bloc and the China bloc respectively. Smaller degrees of uncertainty (e.g., 25 percent implied barriers with either bloc) is associated with smaller losses. Facing smaller barriers with respect to the US bloc leads to smaller losses in general, given the relative importance of that bloc as a source of investment flows.

Online Annex Figure 4.4.3. Impact on Nonaligned GDP, Various Uncertainty Assumptions

(Percent deviation from no-fragmentation scenario)



Source: IMF staff calculations.

Note: Nonaligned regions are India and Indonesia, and Latin America and the Caribbean. Full barriers refer to nonaligned regions facing same level of investment input import barriers as regions in the opposing bloc.

Online Annex 4.5. Balance Sheet Exposure to Fragmentation Risk

This annex complements Box 2 on “Balance Sheet Exposure to Fragmentation Risk” by providing further details about the data and methodology. Robustness checks as well as additional results not reported in the box are also provided.

Data Sources and Methodology

Bilateral cross-border financial linkages across countries are constructed using (1) bilateral portfolio equity and debt investments taken from the IMF Coordinated Portfolio Investments Statistics Survey (CPIS) and (2) bilateral cross-border loans to non-banks, taken from the BIS International Locational Banking Statistics and reported on a residency basis. The total stock of non-FDI assets and liabilities for each country vis-a-vis the rest of the world is the sum of both components and captures the amount of capital invested in (and borrowed from) each partner country (in US dollars).

Small adjustments to the latest vintage of BIS data were made to ensure maximum country coverage. For India and Indonesia, BIS cross-border bank loans to non-banks were imputed after 2015 and 2016, respectively, assuming that (i) the bilateral distribution of bank loans to non-banks remained constant and (ii) loan volumes grew in line with the total amount of cross border loans (to both bank and non-bank borrowers) reported by the BIS for each country. For Germany and Japan, BIS cross-border bank loans to non-banks were estimated assuming they were in line with the bilateral distribution of total cross-border bank investments (both loans and debt securities) reported by the BIS. For China, estimates of cross-border bank loans were taken directly from Horn and others (2021). For Argentina, Russia and Saudi Arabia, BIS data on cross-border bank loans were not available and no substitute could be found in the literature. As a result, the stock of non-FDI assets and liabilities for these countries only captures CPIS portfolio investment data and exposures should be interpreted as a lower bound on the “true” exposure.

Since a large share of portfolio investments are booked in financial centers which are simply conduits for other countries’ investments, CPIS positions are first reallocated to their parent country using matrices based on fund holdings from Coppola and others (2021) and transformed into a nationality-based bilateral position. The reallocation matrices used are available from 2007-2021. Between 2001 and 2007, positions are reallocated using the 2007 reallocation matrix.

Political proximity data is taken from Bailey and others (2017). For every country, the Ideal Point Distance (IPD) variable is averaged between 2002 and 2021 and then normalized into a political proximity index, γ, with values ranging from [0,1] where a value of 0 (1) represents the most (least) politically distant country. All IPDs are rebased to ensure that the average IPD across countries when the destination is the US equals the average IPD across all destinations excluding the US. This is done to avoid unduly inflating exposures, as the IPD suggests the US is very politically distant from all countries and positions vis-à-vis the US are very large.

The (gross) balance sheet exposure to fragmentation risk for country i at time t is defined as:

$$fragmentation\_exposure_{i,t} = \frac{\sum_j (p_{i,j,t} - \gamma_{i,j} p_{i,j,t})}{X_{i,t}}$$

where $p_{i,j,t}$ is the bilateral non-FDI cross-border position (assets plus liabilities) for country i and counterpart country j at time t; $\gamma_{i,j} p_{i,j,t}$ is the politically-weighted version of the same position, and $X_{i,t}$ represents a country specific variable used to normalize exposures and express it as a share. This share captures the percentage of assets and liabilities at risk in a fragmentation scenario. In the main text, both nominal Gross Domestic Product in US dollars ($GDP_{i,t}$) and total cross-border positions for country i ($\sum_j p_{i,j,t}$) are used. GDP data is taken from the WEO database.

Online Annex Table 4.5.1 Composition of Country Groups in the Sample

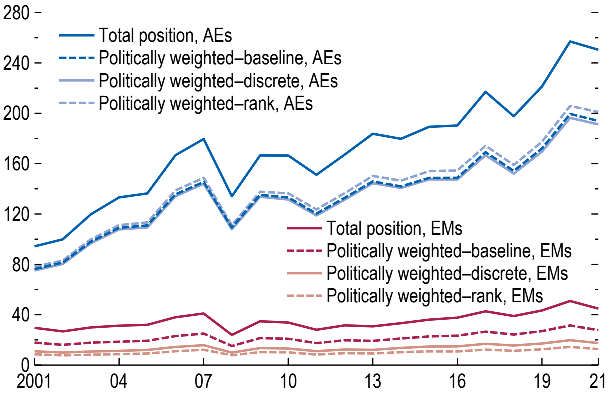
Advanced economies		Emerging Economies
Australia	Portugal	Argentina
Austria	Singapore	Bahrain
Belgium	South Korea	The Bahamas
Canada	Spain	Brazil
Cyprus	Sweden	Chile
Denmark	Switzerland	China
Finland	United Kingdom	India
France	United States	Indonesia
Germany		Mexico
Greece		Panama
Ireland		Philippines
Italy		Russia
Japan		Saudi Arabia
Luxembourg		Türkiye
Netherlands		South Africa

The final sample covers 38 countries (23 AE and 15 EM) accounting for 86 percent of world GDP. Online Annex Table 4.5.1 shows the composition of each country group. Compared to International Investment Position data from Lane and Milesi-Ferretti (2018), cross-border positions constructed in this Appendix represent 70.8% of total external assets and 59.3% of total external liabilities among the countries in the sample.

Robustness Exercises

Key findings presented in the box are robust to (i) alternative normalizations of the IPD variable and (ii) using an alternative measure of political proximity. Online Annex Figure 4.5.1 shows how gross exposures vary with two alternative transformations of the IPD variable, namely (i) a discrete measure, where countries with a proximity index below the first quartile are all assigned a weight of 0, those between the first and third quartiles are assigned a weight of 0.5, and those above the third quartile are all assigned a weight of 1; (ii) a continuous "rank" measure, which computes the ranking of each country based on the IPD and is normalized to be expressed in a range of [0,1]. Online Annex Figure 4.5.1 shows that the baseline measure of political proximity delivers more conservative results (i.e., less exposures to fragmentation risks). Similarly, using a political proximity measure based on Häge (2011)—as done in Chapter 3 of the April 2023 *Global Financial Stability Report*—generates qualitatively similar results, but tends to increase estimated exposures relative to those presented in the box by a factor of 1.5 for AE and roughly 2 for EM in 2021. Overall, those results suggest that exposures presented in the box should be interpreted as conservative estimates.

Online Annex Figure 4.5.1. Gross Exposures, Assets and Liabilities, 2001–21
(Percent of GDP)



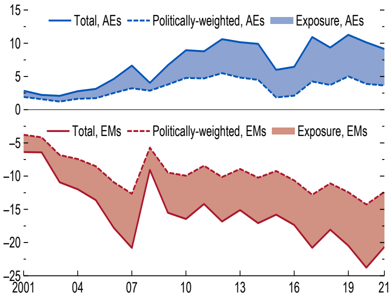
Sources: Bailey, Strezhnev, and Voeten (2017); Bank for International Settlements; and IMF staff calculations.
Note: The figure shows total and politically weighted positions based on 1) the baseline; 2) a discrete version of the ideal point distance variable; and 3) a continuous (rank) version of the ideal point distance variable for both AEs and EMs. AEs = advanced economies; EMs = emerging market economies.

Additional Results

Online Annex Figure 4.5.2 reports a net measure (asset minus liabilities) of exposures to fragmentation by country group. Over the last 20 years, AE have accumulated a large and positive net exposure to fragmentation risks (6 percent of GDP in 2021), whereas EM have become increasingly liable to politically distant creditors (-8 percent of GDP). A concentration analysis also reveals that emerging markets are more exposed to concentration risks, especially on the liability side: Online Annex Figure 4.5.3 shows that the 5 percent most politically distant countries in EM currently account for 20 percent of their gross mismatch (against 1 percent for AE). Finally, as of 2021, assets exposures represented 9 percent of the financial system's total assets in G20 countries (on average), while liabilities exposures accounted for 8% of the total credit going to the non-financial sector (Online Annex Figure 4.5.4).

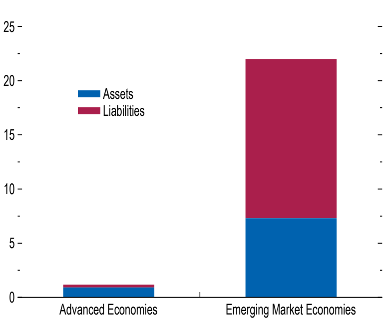
Online Annex Figure 4.5.2. Net Exposures, 2001–21

(Percent of GDP)



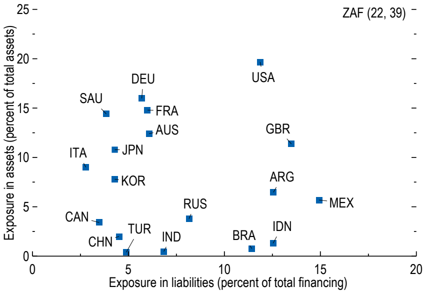
Sources: Bailey, Strezhnev, and Voeten (2017); Bank for International Settlements; and IMF staff calculations.
Note: Shaded areas represent the net exposure to fragmentation as the difference between total assets-liabilities and politically weighted assets-liabilities as percent of GDP. AEs = advanced economies; EMs = emerging market economies.

Online Annex Figure 4.5.3. Contribution of the Bottom Fifth Percentile of Political Proximity Countries to Gross Exposures, 2021



Note: The plot shows the share of gross exposures accounted for by the 5-percent most politically distant countries, by assets and liabilities.

Online Annex Figure 4.5.4. G20 Assets and Liabilities Exposures, 2021



Sources: Bank of International Settlement; Central Bank of Argentina; IMF, Monetary and Financial Statistics; Organisation for Economic Co-operation and Development; Saudi Central Bank; and IMF staff calculations.
Note: *Y*-axis shows the gross exposures on the asset side as a ratio of the total assets of the financial system. *X*-axis shows the gross exposure on the liability side as a ratio of the total credit of the non-financial sector.

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