CHAPTER 4

GLOBAL TRADE AND VALUE CHAINS DURING THE PANDEMIC

When COVID-19 hit, the combined supply and demand shock was expected to lead to a dramatic collapse in trade. However, although trade in services remains sluggish, trade in goods bounced back surprisingly quickly. This chapter finds that factors specific to the pandemic played a key role in the rotation of trade from services to goods, above and beyond the impact on demand. Imports of goods fell by less and imports of services by more than can be explained by demand and relative prices. The pattern was more pronounced in countries where the pandemic—and associated containment policies—were more severe. Further, an examination of granular bilateral trade data reveals that international spillovers from lockdown-induced supply disruptions were a key driver of the decline in trade early in the pandemic. These negative spillover effects tended to be short-lived and were mitigated to the extent that telework was possible. Moreover, the spillover effects diminished over subsequent waves of the pandemic, suggesting adaptability and resilience in global value chains (GVCs). Indeed, with differences in the timing of pandemic outbreaks and containment policies across different regions, some regions with significant participation in GVCs were able to increase their share in the imports of other regions, but these changes also appear to be unwinding over time. In view of the overall resilience of global trade and value chains during the pandemic, this chapter argues that policies such as reshoring are likely misguided. Instead, supply chain resilience to shocks is better built by increasing diversification away from domestic sourcing of inputs and greater substitutability in input sourcing (easier switching of input supplies between countries). Increasing supply chain resilience is important for dealing with not only health emergencies like the pandemic, but also other types of shocks such as the war in Ukraine, cyberattacks, and extreme weather events related to climate change. While much of the work of building resilience must be undertaken by firms (as private sector actors), governments can still play a useful role by filling information gaps in supply chains, investing in trade and digital infrastructure, reducing trade costs, and minimizing policy uncertainty. Widespread vaccination will be crucial to mitigating spillovers from future shocks related to the spread of COVID-19.

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Introduction

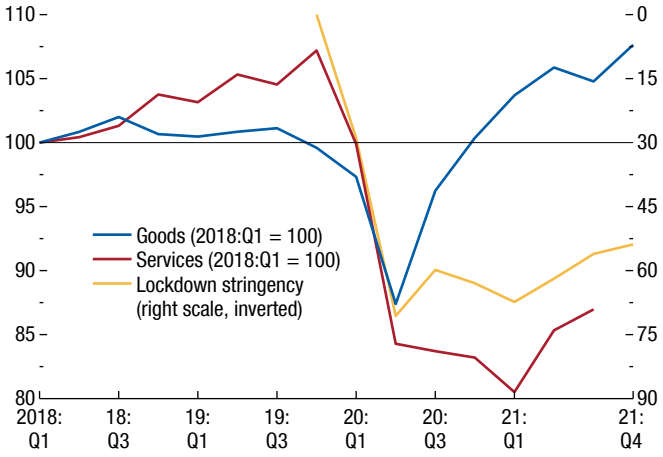
With the onset of the COVID-19 pandemic, trade collapsed in a dramatic fashion. At its trough in the second quarter of 2020, the volume of global trade in goods fell 12.2 percent, and trade in services fell even more sharply, by 21.4 percent, compared with the last quarter of 2019 (Figure 4.1). However, the recovery in trade was also surprisingly quick, compared with the much more protracted recoveries after other global recessions (Figure 4.2) (Baldwin 2020). Trade in goods had recovered to pre-pandemic levels by October 2021—a very rapid rebound compared, for example, with that from the global financial crisis. However, the aggregate trends mask considerable heterogeneity, and further disruptions are likely, owing to the war in Ukraine.[1]

- Trade in services remains sluggish, driven mainly by the collapse of travel. Transport services appear to be recovering, although disruptions in seaborne trade remain elevated (see Komaromi, Cerdeiro, and Liu, 2022, on the evolution of delays in shipping). Trade in other services has been more robust (Figure 4.3), notably telecommunication services.
- Trade in goods that rely heavily on global value chains (GVC-intensive goods) was more volatile than that in other goods (Figure 4.4). Between January and April 2020, exports of GVC-intensive goods fell 30 percent, while exports of other goods fell by

[1]The analysis presented in this chapter was concluded in early 2022, prior to the outbreak of the war in Ukraine, and does not focus on it's implications for global trade and value chains.

Figure 4.1. Global Import Volume and Lockdown Stringency
(Index)

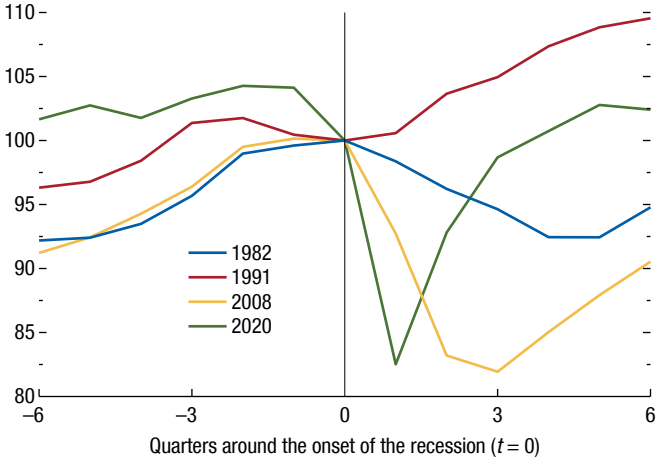
Goods trade recovered rapidly, although services trade remains sluggish.



Sources: CPB World Trade Monitor; Hale and others (2021); and IMF staff calculations.
Note: The lockdown stringency index is the world import-weighted average of the Oxford COVID-19 Government Response Stringency Index.

Figure 4.2. Trade Patterns around Global Recessions: Goods and Services Import Volume
(Index)

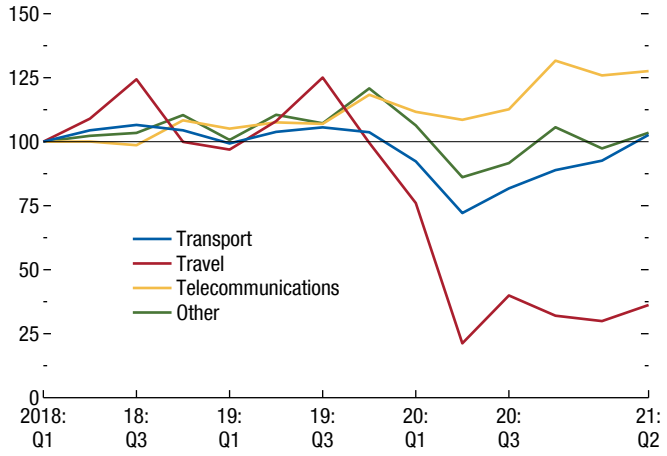
The recovery in goods trade was more rapid than in previous recessions.



Sources: Kose, Sugawara, and Terrones (2020); and IMF staff calculations.
Note: The goods and services import volume index is normalized to 100 at the onset of the recession ($t = 0$).

Figure 4.3. Imports of Commercial Services by Main Sectors
(Index, 2018:Q1 = 100)

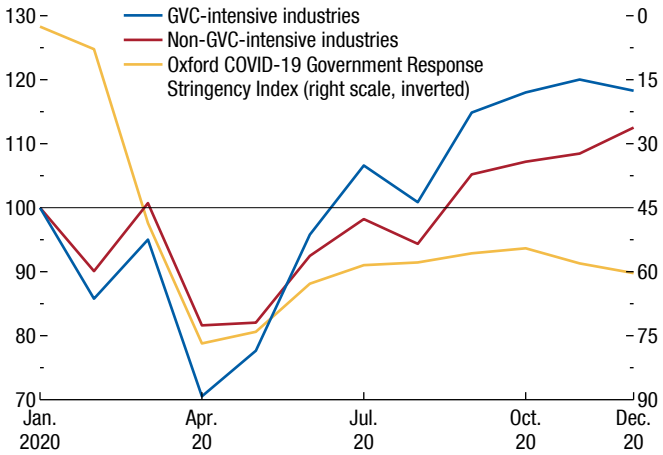
The decline in services trade has mainly been due to that in travel services.



Sources: World Trade Organization; and IMF staff calculations.
Note: "Telecommunications" comprises telecommunications, computer, and information services. "Other" comprises commercial, goods-related, construction, financial, insurance and pension, intellectual property, other business, personal, cultural, and recreational services.

Figure 4.4. Volatility of Trade in GVC-Intensive Industries versus Non-GVC-Intensive Industries Early in the Pandemic
(Index)

Trade in GVC-intensive industries was relatively more volatile than trade in non-GVC intensive industries.



Sources: Hale and others (2021); Trade Data Monitor; and IMF staff calculations.
Note: GVC = global value chain.

about 18 percent.[2] The recovery in GVC-intensive goods was also more rapid. The initial drop, however, was relatively more severe in some industries like automobiles, amid disruptions to key inputs such as semiconductors (see Box 4.1 for further details on the evolution of supply disruptions, including in automobile and semiconductor trade). Amid the volatility in trade among GVC-intensive goods, calls to explore policy options to increase GVC resilience to shocks have gained prominence.

Against this backdrop, this chapter first formally examines potential explanations for observed patterns in trade during the pandemic. In particular it asks three questions: (1) How well can trade patterns be accounted for by a standard model of demand and prices, compared with previous large recessions?; (2) What factors specific to the pandemic were important in determining the trade patterns?; and (3) What international spillover effects were generated by the mobility restrictions in response to the pandemic? These questions are investigated using an empirical framework based on standard models from the trade literature and relying on granular bilateral trade data at monthly frequency to examine spillovers.

The second set of questions in this chapter probes developments in GVCs and examines how to build up GVCs' resilience. It is difficult to paint a precise picture of changes in the structure of GVCs through the pandemic, given lags in high-frequency input–output data. Hence, the chapter tracks GVC developments as inferred from trade data. And in response to concerns about how well GVCs can weather global shocks, it examines options for increasing the resilience of the world economy in a modeling framework. Using a model that spans multiple sectors and countries, it examines the gains in resilience from (1) increasing the geographic diversification of input sourcing across countries and (2) increasing the substitutability of inputs across sources in different countries.

[2]GVCs are internationally distributed activities, such as design, production, and distribution, involved in bringing a product or service from conception to end use (Ponte, Gereffi, and Raj-Reichert 2019). Operationally, GVC trade has been defined to include trade in goods that cross at least two international borders (Hummels, Ishii, and Yi 2001). In this chapter, GVC-intensive goods are defined to include inputs and finished goods in the following industries: automobiles, electronics, textiles and garments, and medical goods. Together these goods account for about a quarter of global goods trade (in 2019), and are typically considered to be at the forefront of GVCs (Sturgeon and Memedovic 2010).

The main conclusions of the chapter are as follows:

- Factors specific to the pandemic had an important role in determining trade patterns. Goods imports were larger, and services imports were smaller, in 2020 than would be predicted by a model of import demand. Moreover, the deviations in actual trade from model predictions were much larger than in previous recessions. The "excess" goods imports were larger in countries with more severe pandemic outbreaks, more stringent containment policies, and larger declines in mobility. On the other hand, "deficit" services imports were larger where the pandemic was more severe.
- Lockdown policies to contain the pandemic had substantial—if unintended—international spillovers. Lockdowns in a country's trade partners on average accounted for up to 60 percent of the observed decline in imports in the first half of 2020. International spillovers were larger in GVC-intensive industries than in non-GVC-intensive industries, and they were larger in downstream (close to final user) industries than in upstream (input) industries. However, the ability to work from home (teleworkability) in partner countries mitigated the spillovers from lockdowns, and the effects also diminished over time. These findings on spillovers suggest two things. First, containing the pandemic domestically is important not just for domestic activity, but also because future outbreaks leading to lockdowns could have negative spillovers onto trade partners. Second, the reduction of spillovers over time, including for GVC-intensive goods, suggests that global supply chains were able to adjust. This should sound a cautionary note regarding policies seeking to effect permanent changes in the structure of global production and trade.
- GVCs were able to adjust to the asynchronous development of the pandemic, as reflected in changes in market shares among GVC regions during the pandemic. To further build resilience in GVCs, there is potentially substantial room to diversify away from domestic inputs. The chapter shows that resilience to shocks may be gained by further diversification of inputs across countries and by making inputs from different countries more substitutable. Diversification substantially reduces global GDP losses in response to shocks in key upstream suppliers. It also reduces GDP volatility following productivity shocks to multiple countries that are correlated, in line with what is observed in historical productivity data over the past 25 years. Reducing diversification, on the other hand, increases volatility. Greater input substitutability across

source countries reduces GDP losses from shocks in individual countries. Thus, it is important to find avenues to expand trade opportunities, which can boost resilience in the world economy in the face of a variety of shocks.

Drivers of Trade during the Pandemic

Demand and Relative Prices Alone Do Not Explain Pandemic Trade Patterns

Unlike previous global recessions such as that during the global financial crisis, changes in services and goods trade growth early in the pandemic are poorly explained by a model including conventional factors (domestic demand and relative prices) alone. Such a model performs well in explaining total trade but produces large forecast errors for goods and services import growth in 2020 when goods and services are considered separately. Moreover, these forecast errors are significantly correlated with pandemic-specific factors, pointing to the unique nature of this trade shock.

Here, a standard import demand model is used to estimate the historical relationship between demand and import growth. The model links real import growth of goods and services to growth in demand and the relative price of imports for a sample of 127 countries over 1985–2019.[3] Consistent with economic intuition and previous studies (see, for example, Chapter 2 of the October 2016 *World Economic Outlook*), the estimated coefficients on the measure of import-adjusted demand (a combination of demand components weighted by their import content, as in Bussière and others 2013) are positive for most countries and greater than 1. The coefficients on relative price are mostly negative and average between –0.2 and –0.3 (Online Annex 4.1).

Combining the estimates from the regressions—using world import shares as weights—yields good predictions of import growth up to 2019. Yet for 2020, the model underpredicts the large observed decline in services trade (the model predicts a growth rate of about –8 percent, while trade in 2020 actually fell by 25 percent). It overpredicts the fall in goods trade (predicting a 10 percent decline, against the 6 percent observed fall) (Figure 4.5).[4] The forecast errors are unprecedented in size; by contrast, the global financial crisis and the global recession of the early 1990s are much better explained by standard factors.

Figure 4.5. Average Forecast Errors of the Growth in Imports from the Import Demand Model
(Log points)

The large errors for 2020 show that conventional factors alone cannot explain the changes in goods and services imports.

Sources: Eora Global Supply Chain Database; IMF, *Balance of Payments Statistics*; and IMF staff estimates.

Pandemic Intensity and Containment Policies Were Key Drivers of Trade Patterns in This Crisis

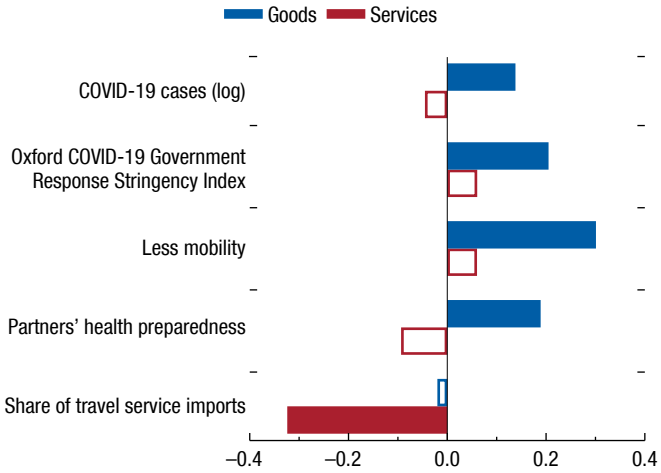
Several features of—and policy responses to—the pandemic are key to explaining the discrepancies between predicted and actual import growth. Relating the forecast errors to country-specific factors suggests that countries whose experience of the pandemic was more severe (more COVID-19 cases, more stringent containment measures, or less mobility) showed "excess import demand" for goods—that is, the fall in goods imports was smaller than predicted by the model (Figure 4.6). The forecast error for goods

[3]As explained in Bussière and others (2013), an import demand equation, which relates growth in real imports to changes in absorption and relative price levels, can be derived from virtually any international real business cycle model. In this chapter, the following empirical specification, $\Delta \ln M_{i,t} = \pi_i + \beta_{D,i} \Delta \ln D_{i,t} + \beta_{Pi} \Delta \ln P_{i,t} + \varepsilon_{i,t}$, in which $M_{i,t}$, $D_{i,t}$, and $P_{i,t}$ refer to imports, demand, and relative prices, respectively, in country i and time t, is estimated, together with other more parsimonious versions, as described in Online Annex 4.1.

[4]The performance of the model in 2020 is the worst since the beginning of the sample (1985) when metrics other than the average forecast error, such as the mean squared forecast error, are examined. Online Annex 4.1 discusses the distribution of errors in 2020, comparing it with that of previous years.

Figure 4.6. Factors Associated with the Demand Model's Forecast Errors for 2020
(Standard deviation, unless noted otherwise)

Domestic factors specific to the pandemic played an important role in determining trade patterns in 2020.



Sources: Global Health Security Index; Google, Community Mobility Reports; Hale and others (2021); Our World in Data; World Trade Organization; and IMF staff calculations.
Note: The figure reports standardized coefficients for a regression of residuals from the demand model on the listed variables. Solid bars show coefficients that are statistically significant at the 5 percent level; hollow bars show those that are not. Trade partners' health preparedness for the pandemic is measured by the Global Health Security Index. "Share of travel service imports" captures the share of travel services in a country's total service imports.

imports was 3 percentage points more positive for countries in the third quartile of the distribution of the number of COVID-19 cases than for those in the first quartile.[5]

For imports of services, the most important factor accounting for the model's overprediction is the extent to which a country imported travel services. That is, the unexplained portion of the fall in service imports was most pronounced in countries where travel services accounted for a large share of total service imports.

These findings are consistent with various conjectures regarding the impact of pandemic-specific factors on trade. First, the rapid recovery in goods trade may reflect a general switching in consumer spending away from services to goods—such as remote-working equipment and medical goods—created by pandemic-specific conditions.[6] Second, part of the shift could be driven by a simple reallocation of income toward goods because some services were unavailable. Third, it is possible that as countries with more severe lockdowns experienced a sharp contraction in the production of some goods domestically, they were pushed to import them instead (for the impact of lockdowns on domestic production, see Chapter 1 of the October 2020 *World Economic Outlook*).

Interestingly, the better the health-preparedness of an importing country's *trade partners,* the less its imports of goods fell relative to predictions. Trade partners' preparedness for the pandemic is measured here by the Global Health Security Index and is associated with more positive forecast errors for goods imports.[7] This suggests some degree of international spillovers; specifically, countries whose trade partners experienced smaller disruptions in domestic supply were less negatively affected by shock transmission in trade networks. Accordingly, the next section focuses on spillovers from lockdown policies in trade partners, which constitute supply shocks from a domestic perspective.

International Spillovers from Pandemic Containment Policies

Supply Shock Spillovers from Lockdowns Accounted for a Large Part of the Decline in Trade

The decline in imports at its trough in mid-2020 appears to be correlated with the stringency of lockdowns in exporting trade partners (Figure 4.7). Intuitively, tighter lockdowns in exporters would constitute a supply shock from the point of view of the importing country. Indeed, with demand factors controlled for, more stringent lockdowns in trade partners had a large and statistically significant negative impact on goods imports. A comparison of the actual evolution of imports between January and May 2020 against a counterfactual without any containment policies in place in trade partners indicates that containment policies accounted for up to 60 percent

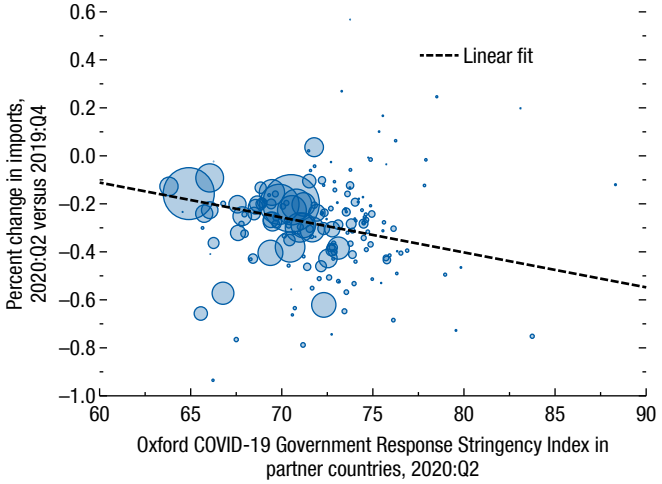
[5]If such disruptions are not fully incorporated by changes in the relative prices, in countries hit hardest by the pandemic, the model will predict a larger decline in the imports of goods than actually occurred.

[6]Among many studies confirming this trend, see Bounie and others (2020) for France; Andersen and others (2020) for Denmark; Baker and others (2020) for the United States; and Chronopoulos, Lukas, and Wilson (2020) for the United Kingdom.

[7]For details on the index, see Cameron, Nuzzo, and Bell (2019), as well as other material that can be found on the Global Health and Security Index website at https://www.ghsindex.org/about/.

Figure 4.7. Change in Imports and Partner Countries' Lockdown Stringency

Spillovers from the lockdown policies of trade partners are associated with lower imports.



Sources: Hale and others (2021); IMF, *Direction of Trade Statistics*; and IMF staff calculations.
Note: The Oxford Stringency Index in partner countries is constructed taking 2018:Q3–2019:Q4 import flows as weights. The size of each country's bubble is proportional to the value of its imports (in US dollars) in 2019:Q4. The solid line is a linear fit of a weighted regression of the change in imports between 2020:Q2 and 2019:Q4 against the Oxford Stringency Index in partner countries, in which the weights are the values of imports (in US dollars) in 2019:Q4. The estimated coefficient is equal to –0.015 (*t*-stat = –2.44).

of the observed decline in imports. That said, the spillover effect from lockdown stringency appears to have been short-lived. The impact first materialized in February 2020, with the first round of restrictions in Asia; grew in strength in March and April, when lockdowns became more geographically widespread, including in Europe; and started declining in May. In June, when goods imports rebounded strongly, even as the stringency of lockdowns eased only moderately, the spillover effects became indistinguishable from zero (see Box 4.2 for further evidence on the declining rate of spillovers, using data at daily frequency for seaborne trade).[8]

[8]Similar results are obtained by Berthou and Stumpner (2022). Heise (2020) also documents the close to 50 percent decline in US imports from China in March 2020 relative to January 2020, when factories were temporarily closed, before those imports bounced back in April 2020. Lafrogne-Joussier, Martin, and Mejean (2021) show that French firms sourcing inputs from China just before the lockdown experienced a drop in imports between February and April 2020 that was 7 percent larger than that of firms sourcing their inputs from elsewhere.

These findings are based on estimates of a gravity model employed widely in the trade literature (Santos Silva and Tenreyro 2006), using bilateral data on monthly imports at the six-digit product level from Trade Data Monitor.[9] The model includes a set of time-varying fixed effects that absorb the effects of all observed and unobserved factors specific to importing countries and industries, including demand shifts, and of factors such as trade agreements that could affect (product-specific) trade flows across each pair of importer and exporter countries. The methodology and results are described in more detail in Online Annex 4.2.

The spillover effect of lockdown stringency is also robust to controlling for the extent of the health crisis in the exporter country, measured by the number of new COVID-19 cases and deaths per capita (both contemporaneous and lagged), changes in export restrictions put in place by trade partners, and the fiscal policy response in trade partners.

Spillovers Were More Pronounced within GVCs and Were Mitigated by the Extent of Teleworking

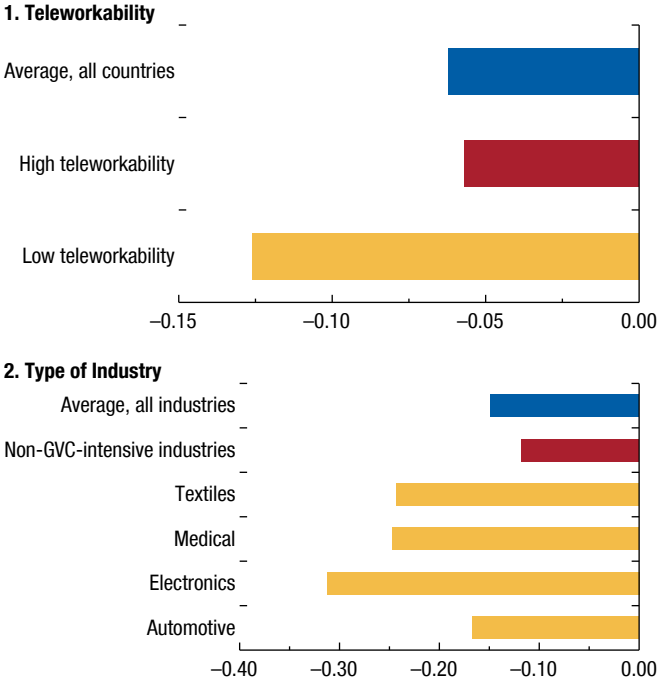
The average spillover effects mask several sources of heterogeneity.

- First, the spillover effect of lockdowns is more than twice as strong for countries whose exporting partners are less able to rely on remote working (Figure 4.8, panel 1). The finding is consistent with existing

[9]The chapter estimates the following specification: $M_{m,e,i,t} = g(\beta Stringency\ Index_{e,t} + \delta Controls_{m,e,t} + \alpha_{m,e,i} + \gamma_{m,i,t} + \varepsilon_{m,e,s,t})$. Bilateral imports of products in industry i ($M_{m,e,i,t}$) by importer country m from exporter country e in month t are regressed on (1) the time-varying index of lockdown intensity in the exporter country e (*Stringency Index*$_{e,t}$), measured using the monthly average values of the Oxford COVID-19 Government Response Stringency Index; (2) a set of variables that vary across country pairs and time (*Controls*); and (3) a set of fixed effects ($\alpha_{m,e,i}$, $\gamma_{m,i,t}$). The Oxford Stringency Index records the strictness of "lockdown style" policies that restrict people's behavior. It ranges from 0 to 100 and is calculated using eight ordinal containment and closure policy indicators (such as school and workplace closures) and restrictions on movement, plus an indicator recording public information campaigns. The stringency index used in this chapter is highly correlated with the component related to workplace closings, which has less variability, being a categorical variable (assuming four values). The model employed in the chapter considers an importing country (such as the United States) and compares its imports of a product (such as vehicles) in each month from trade partners with different containment policies. Under the plausible assumption that US demand for vehicles is the same across partner countries, the analysis controls for demand factors, including the role of domestic containment policies, and exploits only the variation in the intensity of lockdowns across trade partners.

Figure 4.8. Semielasticity of the Oxford COVID-19 Government Response Stringency Index

Spillovers were larger in GVC-intensive industries and among partner countries less able to rely on teleworking.



Sources: Dingel and Neiman (2020); Hale and others (2021); Trade Data Monitor; and IMF staff calculations.
Note: GVC = global value chain.

evidence showing that the feasibility of remote work mitigated the negative effects of reduced worker mobility (Pei, de Vries, and Zhang 2021).[10]

- Second, spillover effects are stronger in GVC-intensive industries (yellow bars, Figure 4.8, panel 2), and especially in electronics, than in non-GVC-intensive ones (red bar). Intuitively, imports in GVC-intensive industries would be relatively more exposed to disruptions in the supply chain (in this case resulting from lockdowns).[11]
- Third, the negative effect of stringency measures is dampened in industries that are more upstream in the production process (such as metals and minerals products), while it is stronger for those downstream (such as transportation and textiles).[12] A one-standard-deviation increase in the upstreamness index reduces the spillover supply effect of the lockdown by almost one-third. This is consistent with the intuition that downstream industries are more likely to be affected by disruptions to the supply chain, such as lockdowns in countries supplying intermediate goods used as inputs (see Box 4.3 for a detailed analysis using customs data from France).

To summarize, evidence from granular bilateral trade data shows that after demand in importing countries is controlled for, there were statistically significant negative spillovers from lockdowns in partner countries, consistent with findings in the literature (Espitia and others 2021; Berthou and Stumpner 2022). These spillovers were larger in GVC-intensive industries and in downstream industries. However, the spillovers tended to be short-lived and were mitigated to the extent that partner countries were able to use telework. Moreover, the spillover effects waned in magnitude over time, as countries gained experience with functioning under mobility restrictions; thus imports fell by much less in response to lockdowns in partner countries in 2021 than in 2020 (Box 4.2).

Resilience in GVCs

Trade Data Suggest That GVCs Adapted to Pandemic Conditions during the Crisis

The preceding analysis suggests that with the rotation in demand toward goods and the short-lived negative impact of spillovers from lockdowns, goods trade was resilient overall, including in GVC-intensive goods. The resilience of trade in goods can also be traced to the adaptability of GVC networks. Trade data show that there were sizable changes in trade market shares between regions with significant participation

[10]Teleworkability is measured using the cross-country data computed by Dingel and Neiman (2020). The sample of trade partners is split between those with a low share of jobs that can be performed remotely (the bottom quartile of the distribution) and those with a high share of teleworking.

[11]The six-digit product codes for goods in GVC-intensive industries are compiled from Frederick and Lee (2017) (electronics), Sturgeon and others (2016) (automobiles), and Frederick (2019) (textiles, medical devices).

[12]To test the upstreamness hypothesis, the model includes the interaction between the lockdown stringency index and a measure of industry "upstreamness" (the average distance from final use) computed by Antràs and others (2012) from a US input–output table. The (time-invariant) upstreamness of the industry is a measure of its exposure to the (time-varying) lockdown supply shock. This specification makes it possible to control for exporter-time effects, making the model fully consistent with gravity models that control for time-varying "multilateral resistance" factors.

in GVCs early in the pandemic.[13] With the asynchronous development of the pandemic, regions that exited lockdowns earlier experienced sizable increases in market share vis-à-vis other regions, especially in GVC-intensive industries. However, these changes in market shares appear to be reversing course over time, suggesting that they are unlikely to persist as countries learn to adjust to pandemic-related restrictions.

Asian countries, which were hit early by the COVID-19 shock but then managed to contain the virus—while other regions were experiencing surges in COVID-19 infections and lockdowns—gained market share compared with 2019; European and North American countries lost market share. By June 2020, "Factory Asia" countries increased their market share in GVC-intensive industries by 4.6 percentage points in "Factory Europe" and by 2.3 percentage points in "Factory North America."[14] Factory Europe is the regional bloc that lost the most during the first phase of the crisis (Figure 4.9, panel 1).

However, the most recent data, up to June 2021, show that the initial gains in market share for Factory Asia and the initial losses in market share for Factory Europe were both pared back during the recovery phase, suggesting that the change in market shares may be temporary. Factory North America continued to lose market share, predominantly within its own domestic markets (Figure 4.9, panel 2). To put these changes in a longer historical context, panel 3 of Figure 4.9 shows the evolution of Asia's market share in Europe since 2000, before China's accession to the World Trade Organization.[15] The gains in Asia's market by mid-2020 were large and quick relative to historical changes but also appear to be reversing rapidly.

[13]Because of lags in input–output data availability, granular analysis of changes in GVC participation is difficult. Bilateral trade data can thus shed some light on recent trends. For 2020, GVC participation metrics show that at the macroeconomic level, disruptions in supply chains led to a sharp reduction in GVC participation compared with 2019 (WTO 2021), especially in some sectors (such as transportation and electrical equipment).

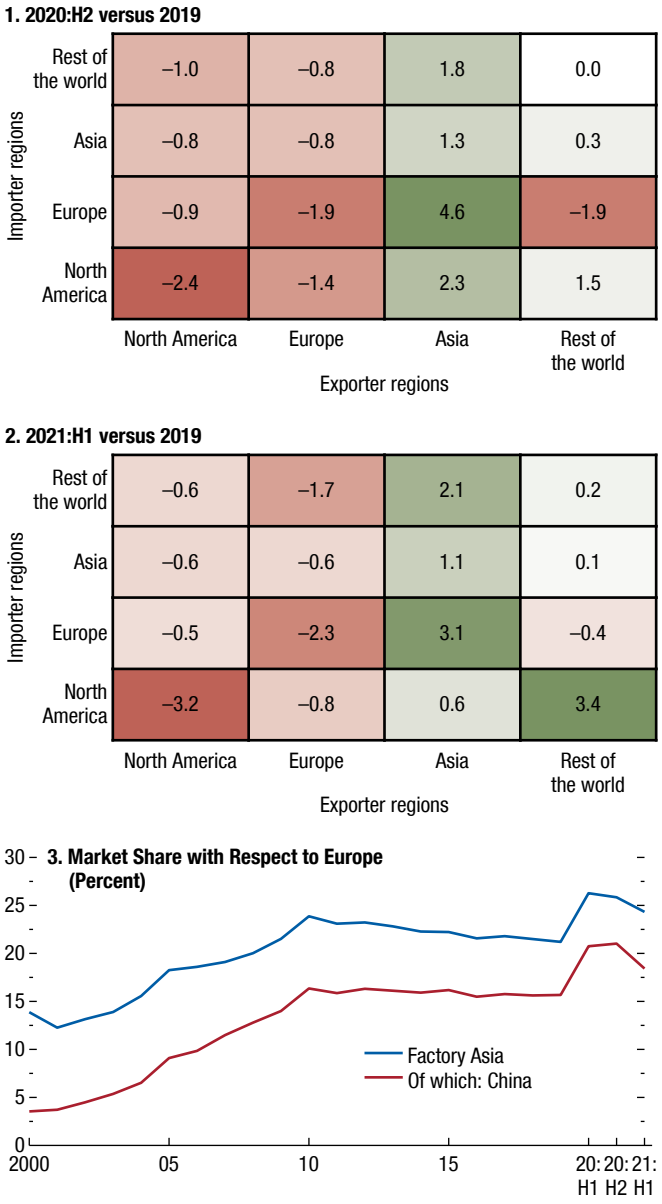
[14]The classification of countries included in each of the three regional blocs follows Baldwin and Freeman (2020). Factory Asia comprises Australia, China, India, Indonesia, Japan, the Republic of Korea, and Taiwan Province of China. Factory Europe comprises France, Germany, Italy, the Netherlands, Spain, Switzerland, Turkey, and the United Kingdom. Factory North America comprises Canada, Mexico, and the United States.

[15]While China predominated in the increase in Asia's market share in Europe, changes in global market shares have seen winners and losers. Online Annex 4.3 shows that across countries, the increase in market share was positively correlated with an increase in mobility during the pandemic period.

Figure 4.9. Changes in Regions' Market Shares of GVC-Intensive Products

(Percentage points, unless noted otherwise)

Changes in trade market shares during the pandemic indicate that GVCs adjusted to asynchronous lockdowns in different countries and regions.



Sources: Trade Data Monitor; and IMF staff calculations.
Note: Market shares are computed using only GVC-intensive products, as defined in the chapter. Panel 3 plots only the market shares of Factory Asia and China in GVC-intensive products with respect to Factory Europe, as defined in the chapter. GVC = global value chain.

Notwithstanding the overall resilience of GVCs, some industries such as automobiles have faced large supply disruptions. Moreover, shipping costs remain elevated along some routes despite having come down from their peaks, and some ports remain congested, contributing to continuing supply chain disruptions (Box 4.1; Komaromi, Cerdeiro, and Liu 2022). Other types of shocks—not just health emergencies, but also international or civil conflicts, cyberattacks, or extreme weather events associated with climate change—could also pose challenges (Baumgartner, Malik, and Padhi 2020; McKinsey Global Institute 2020). In this light, assessing options to strengthen resilience in GVCs is important, especially in view of growing calls to reshore production. The next section uses a model-based framework to analyze two options for building supply chain resilience that have been proposed in the literature: greater geographical diversification of input sources and greater substitutability of inputs from one source with inputs from another source (OECD 2021).

Policies to Boost Resilience: Insights from a Model-Based Approach

To analyze these options, this chapter extends the general equilibrium model of global production networks and trade proposed by Bonadio and others (2021). The model includes trade in intermediate goods (such as raw materials, parts, and energy that are produced by one firm and used in production by another firm) and services and thus captures global value chains.[16] Each sector in each country has a representative firm that produces using a technology characterized by constant return to scale. The model is calibrated to 64 countries and 33 sectors, as described in Online Annex 4.4. Note that the model does not feature endogenous input–output linkages and cannot speak to possible trade-offs between diversification and efficiency.

In the model, supply disruptions in source countries spill over to other countries through trade in intermediates. The analysis considers two scenarios: supply disruption in a single large input supplier country and supply shocks to multiple countries. It compares outcomes under high levels of diversification or substitutability with those under the levels actually observed. The precise sense in which these options are considered is as follows:

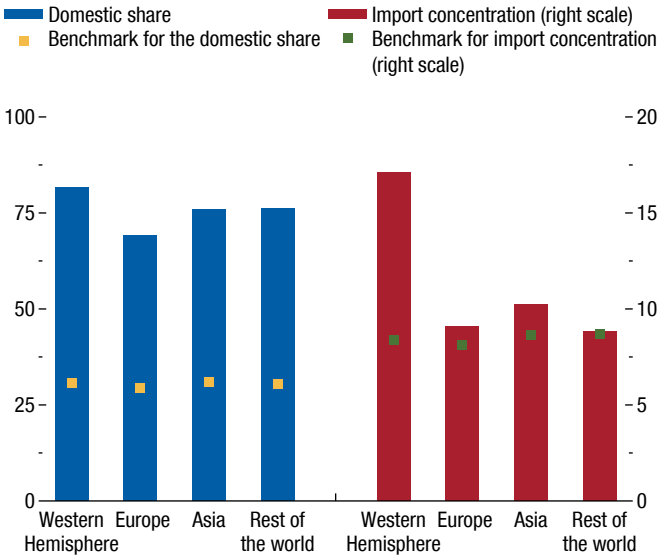
- *Diversification:* Countries could diversify their suppliers of intermediate inputs internationally, sourcing them in more equal amounts across countries. *Diversification* is a widely used term in economics (see, for example, Cadot, Carrère, and Strauss-Kahn 2013), but the meaning here is very specific. This chapter refers to diversification (1) across countries, not across products; (2) of intermediate goods and services, not final goods and services; and (3) of the use of intermediate inputs, not the production or export thereof. Diversification might enhance resilience by reducing reliance on a single country or by establishing relationships in good times that can be tapped during a crisis. In principle there could also be downsides to diversification. For example, diversification could expose a country to more volatile supplier countries. Empirical evidence to date on the benefits of diversification is mixed.[17]
- *Substitutability*: This refers to how easy it is in the production process for a producer to switch inputs from a supplier in one country with those from another country. While geographic diversification is about establishing relationships with suppliers in different countries, substitutability can be interpreted either as making firms' production technologies more flexible, in the sense that they can accommodate slightly different inputs of the same type from different suppliers, or as standardizing intermediate inputs internationally. An example of greater flexibility in production is Tesla's response to the semiconductor shortage. The company rewrote software to enable it to use alternative semiconductors that were more available at the time. As an example of standardization, General Motors recently announced that it is working with chipmakers to reduce the number of unique semiconductor chips that it uses

[16]In the model intermediate goods and services from one country are used as inputs into production in a second country, and then the resulting intermediate or final goods are exported to a third country. The model does not include inventory management and therefore cannot address risk mitigation options such as inventory management practices and their impact on trade (Alessandria, Kaboski, and Midrigian 2011).

[17]An emerging body of literature shows mixed benefits of diversification. Caselli and others (2020) find benefits at the national level of greater openness to overall trade (that is, exports and imports) and to trade in intermediate and final goods and services. At the firm level, Jain, Girotra, and Netessine (2015) find that diversification exposes firms to smaller suppliers that take longer to recover from a disruption, and Lafrogne-Joussier, Martin, and Mejean (2021) find negligible gains from diversification.

Figure 4.10. Room to Diversify the Sourcing of Intermediates
(Percent)

Substantial home bias in sourcing inputs suggests room for international diversification.



Sources: Organisation for Economic Co-operation and Development, Inter-country Input-Output Tables; and IMF staff calculations.
Note: Blue bars show the share of intermediates sourced domestically. Yellow squares show the benchmark concentration in world production. Red bars show the extent of import concentration (Herfindahl concentration index) across foreign countries within the share of intermediates that is imported. Green squares show the world exports concentration benchmark. See Online Annex 4.2 for details.

by 95 percent, down to just three families of microcontrollers. In principle, each family of microcontrollers would replace a host of chips, eliminating any costs of substituting among them.[18]

The evidence suggests that countries and sectors have substantial room to diversify away from domestic sourcing of intermediate inputs internationally. For example, the blue bars in Figure 4.10 show that on average, firms in the Western Hemisphere source 82 percent of their intermediates domestically, which is far above a benchmark of 31 percent that reflects the concentration of world production of these intermediates.[19] This points to a sizeable "home bias" in the sourcing of intermediates.[20] One important implication of this home bias is that any reshoring of production would *lower* diversification even further, thereby increasing concentration risk. This is a simple argument against reshoring. Fuller analyses of reshoring find that this increased concentration would indeed result in more volatile economic activity, even after the economy adjusts structurally by expanding some sectors and shrinking others (OECD 2021; Bonadio and others 2021).

In contrast, there is not much room to diversify further among inputs sourced from abroad, except in the Western Hemisphere (Figure 4.10). Therefore, the main scope for diversification is in diversifying away from domestic sources, by sourcing more intermediates from abroad. Online Annex 4.4 shows that the sectors with the greatest room to diversify are services industries such as hospitality, finance, and health care.

Greater diversification is modeled by constructing a simple average of (1) a distribution that sources from each country with equal weight and (2) the actual data. Effectively, the domestically sourced share is set to roughly half of what it is in the observed data.

To increase substitutability across suppliers in different countries, an increase in the elasticity of substitution between intermediate inputs from different countries from 0.5 to 2.0 is modeled, similar to the range found in Feenstra and others (2018).[21] The increase is equivalent to going from the short-term elasticity used by Bonadio and

[18]See, for example, "Ford Moves to Ensure Supply of Chips and Guide Their Design," *New York Times*, November 18, 2021 (https://www.nytimes.com/2021/11/18/business/ford-global foundries-chip-shortage.html). Note that if substitutability is achieved by standardization, then it might also carry the cost to producers that suppliers are less "locked in" and could more easily switch between producers.

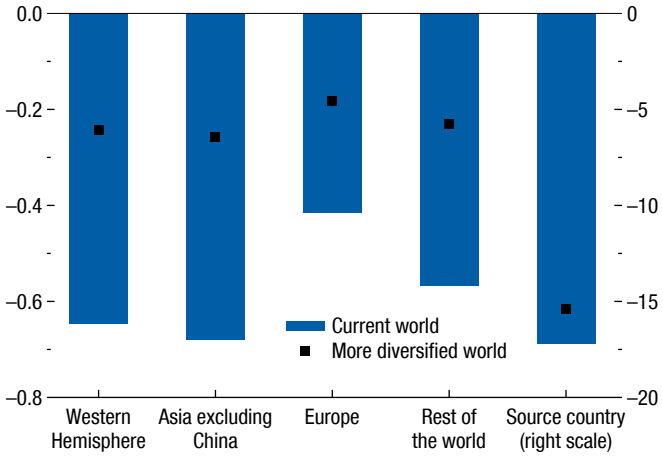
[19]This benchmark illustrates the limits on how much a firm can diversify its sourcing of intermediates in the short term. For each country-sector pair, the share of *domestically sourced* intermediates is compared with a benchmark for the concentration of world production of those intermediates. The concentration of *imported* intermediates is compared with a benchmark for the concentration of exports of those intermediates. For example, suppose the US motor vehicles industry uses two inputs, A and B, in equal parts. Suppose that the country producing the largest share of input A has a 20 percent share in world production and the country producing the largest share of input B has a 40 percent share. Then the benchmark concentration for domestic sourcing of these inputs, A and B, for the US motor vehicles industry is 30 percent (= (20 + 40)/2). The benchmark of 31 percent in the text then averages across all country-sector pairs in the Western Hemisphere. The room for diversification shown here may look different within more narrowly defined product categories.

[20]This is similar to the home bias identified in overall trade by McCallum (1995).

[21]This is an extension of the baseline model of Bonadio and others (2021), as explained in Online Annex 4.4.

Figure 4.11. Gains from Diversification Following a Supply Disruption in a Large Supplier Country
(Percent)

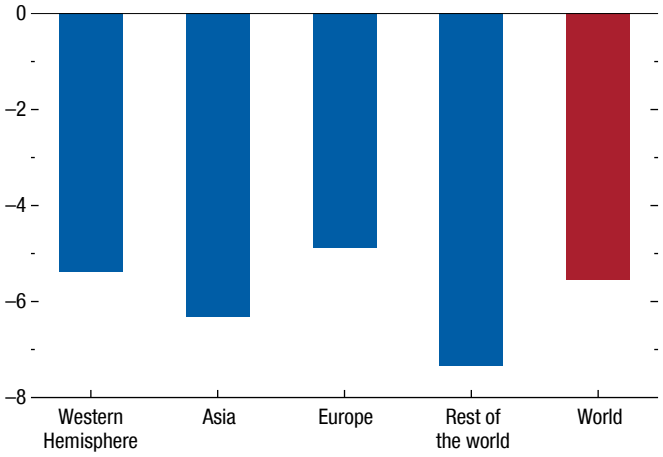
Greater diversification reduces GDP losses by almost half, on average, following a shock to a large input supplier.



Source: IMF staff calculations.
Note: The figure shows GDP declines in response to a 25 percent labor supply contraction in a country that is a large global supplier of intermediates. The bars and squares show simple averages of GDP declines across countries within each region. Elasticity of substitution = 0.5.

Figure 4.12. Gains from Diversification under Shocks to Total Factor Productivity
(Percent)

Greater diversification reduces the volatility of GDP by 5 percent under correlated total factor productivity shocks.



Source: IMF staff calculations.
Note: The bars show simple averages within each region of the percentage reduction in volatility. The shock is calibrated by drawing 100 years of changes in total factor productivity across multiple countries with replacement from yearly Penn World Table data between 1995 and 2019. The average pairwise correlation between the shocks is 25 percent.

others (2021) to an estimate closer to the long-term substitutability implied by Boehm, Levchenko, and Pandalai-Nayar (2020).[22]

Diversification and Substitutability Can Boost Resilience to Cross-Border Supply Shocks

Diversification substantially reduces the GDP losses in all regions of the world following a sizable (25 percent) labor supply contraction in a single large global supplier of intermediate inputs.[23] In this scenario, the average economy's GDP falls by 0.8 percent under the baseline level of diversification. In the high-diversification scenario, Figure 4.11 shows that the decline in GDP is reduced by almost half.[24] Most of this benefit accrues to countries other than the source country, as higher diversification makes them less dependent on intermediates produced by the source country. The source country also benefits, as diversification makes it less dependent on domestic sources.

Higher diversification also reduces the volatility of GDP growth when a series of shocks affect more than one country, with some correlation across countries. Figure 4.12 shows the results from simulations that draw multicountry shock scenarios from historical productivity data.[25] Diversification offers some protection against

[22]The elasticity of tariff-exclusive trade flows to tariff changes estimated by Boehm, Levchenko, and Pandalai-Nayar (2020) equals the elasticity of substitution in the Armington (1969)/Krugman (1980) setting. Boehm, Levchenko, and Pandalai-Nayar (2020) estimate that the long-term elasticity ranges from 1.75 to 2.25. The counterfactual analysis chooses a parameter value of 2.0 to discipline the upper bound of short-term elasticity. Online Annex 4.4 discusses the selection of the parameter value in detail.

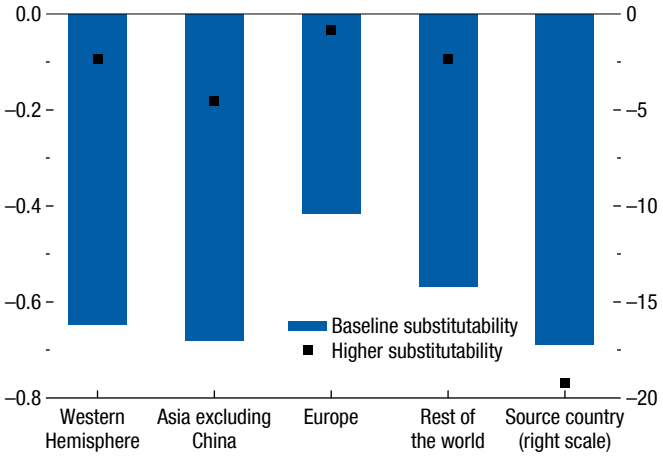
[23]The global supplier is calibrated to closely match China. The scenario assumes a drop of two standard deviations in China's total factor productivity, using Penn World Table data, which is equivalent to a labor supply contraction of about 22 percent (rounded up to 25 percent in the scenario), assuming Cobb-Douglas production with Organisation for Economic Co-operation and Development averages of labor supply elasticity and labor share of income (as explained in Online Annex 4.4).

[24]These are simple averages across countries. The GDP-weighted average across countries is a loss of 3.2 percent under baseline levels of diversification (with China contributing 2.7 percentage points of that loss) and 2.6 percent in the high-diversification world (with China contributing 2.4 percentage points).

[25]Specifically, 100 years of multicountry total factor productivity changes are sampled with replacement (bootstrapped) from yearly Penn World Table data between 1995 and 2019. These shocks should be seen as having a medium to high correlation with one another, because member countries of the Organisation for Economic Co-operation and Development make up a large portion of the sample. The average pairwise correlation between the shocks is 25 percent.

Figure 4.13. Gains from Substitutability Following a Supply Disruption in a Large Supplier Country
(Percent)

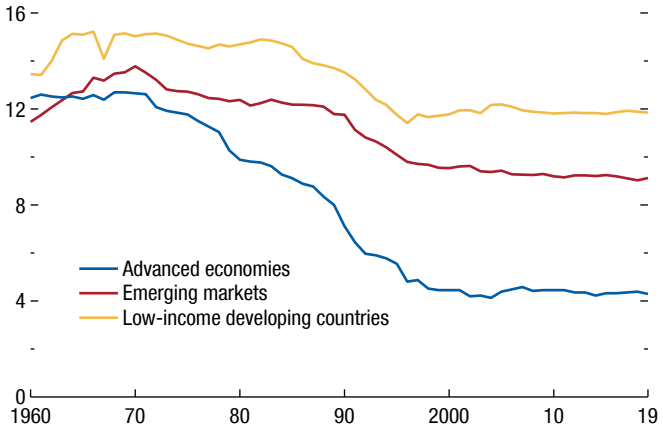
Greater substitutability reduces GDP losses by about four-fifths relative to the baseline in non–source countries.



Source: IMF staff calculations.
Note: The figure shows GDP declines in response to a 25 percent labor supply contraction in a country that is a large global supplier of intermediates. The bars and squares show simple averages of GDP declines across countries within each region. Baseline elasticity of substitution = 0.5. Higher elasticity of substitution = 2.0.

Figure 4.14. Nontariff Barriers Index
(Simple average)

There is room to lower nontariff barriers among emerging markets and low-income developing countries.



Source: Estefania-Flores and others (2022).

shocks with this level of correlation, reducing the volatility of GDP growth in the average country by 5 percent.[26]

By contrast, diversification offers little protection against exceptionally highly correlated shocks. For example, under the scenario calibrated to the first four months of the COVID-19 pandemic that Bonadio and others (2021) analyze, world GDP falls by the same amount under high diversification as it does under levels of diversification observed in the data.

Turning to substitutability, countries benefit from being able to more easily substitute away from one country's inputs to those produced in another country. Considering again the scenario of the 25 percent labor supply contraction in a large global supplier of intermediate inputs, the results show that with greater substitutability—even though it amplifies the shock in the source country—all countries other than the source country benefit, as their GDP losses are reduced by about four-fifths (Figure 4.13).[27]

In terms of achieving greater diversification, the model also shows that reducing trade costs can help. A one-quarter reduction in the costs of trading in intermediates lowers the Herfindahl index of geographic concentration in the sourcing of intermediates by 4 percentage points from 60 percent as observed in actual data.[28]

Conventional policy tools for reducing trade costs include tariff and nontariff barriers. With tariff barriers having declined globally to low levels, there is still ample scope to reduce nontariff barriers, particularly in emerging markets and low-income developing countries (Figure 4.14). Consistent with the model, other evidence from the literature suggests that such trade cost reductions could lead to sizable GDP gains (October 2021 *Regional Economic Outlook: Asia and Pacific*; Estefania-Flores and others 2022).

The model's results on the benefits of diversification and substitutability naturally raise the question of why profit-maximizing firms do not already take advantage of these opportunities. To some extent this could reflect government policies that favor domestic sourcing and thus tilt the scales against greater diversification (for example, Made in China 2025, the Make in India initiative, and the United States Innovation and Competition Act of 2021).[29] But it is also important

[26]Online Annex 4.4 shows that the results on diversification and volatility are symmetric, in that lower diversification would increase volatility.

[27]For modeling purposes, the characteristics of the large global supplier are calibrated to those of China. However, the conclusions are robust to using other countries for calibration.

[28]The increase in diversification is similar across regions.

[29]See McBride and Chatzky (2019) for China, Press Information Bureau (2017) for India, and Hufbauer and Jung (2021) for the United States.

to emphasize that the model does not capture all the factors feeding into firm-level decisions. There are likely to be costly trade-offs for firms in building resilience, including the costs of holding larger inventories, fixed costs of establishing new supply relationships, and efficiency gains from dealing with a smaller number of suppliers—which, if large, could reduce gains from diversification. That said, the trade-off between efficiency and lower risk may not be acute, given that firms that are best at mitigating risks also tend to be the most efficient.[30]

To summarize, the evidence from a modeling approach suggests that resilience to cross-border supply shocks can be increased with greater input source diversification (using more foreign inputs) and greater input substitutability (across suppliers), although the benefits are smaller if shocks are more widespread and correlated across countries. From a policy perspective, these findings on gains from diversification and substitutability suggest the need to provide a supportive environment for firm-level measures to enhance GVC resilience.

Policy Implications

The role of factors specific to the pandemic in shaping trade patterns suggests that the pandemic-induced rotation in demand from services to goods may not be lasting. In particular, services trade should recover as travel restrictions are lifted. The pace of the recovery is therefore likely to be closely related to the success of global public health efforts, and a quicker-than-expected easing of mobility restrictions could pose an upside risk to global trade projections.[31] Facilitating the full return of mobility should therefore be an important element in boosting services demand back to pre-pandemic trends. That said, it is possible that some changes in services trade may be more persistent. For instance, increasing familiarity with virtual interactions may reduce certain kinds of travel more permanently (Antràs 2021).

The evidence on international spillovers presented in this chapter further underscores the urgency of dealing with the pandemic everywhere. Vaccinating widely across countries is important not just from the perspective of domestic economic activity, but also to minimize supply disruption spillovers onto partner countries. Moreover, strengthening health systems and investing in digital infrastructure would help mitigate the transmission of shocks in future shock scenarios, including further COVID-19 variants or other possible pandemics.

The chapter emphasizes that overall, trade was fairly resilient in the pandemic—falling sharply initially, but then recovering rapidly in line with economic activity and demand, despite significant bottlenecks in trade logistics. Trade was also resilient in key GVC-intensive industries—with the notable exception of the automotive sector. Policy proposals to reduce dependence on foreign suppliers, especially in strategic sectors, have gained prominence (Javorcik 2020), including in major markets such as Europe and the United States (Le Maire 2020; White House 2021). The resilience of trade through the pandemic suggests that such proposals may be premature, if not misguided (Baldwin and Freeman 2021; Antràs 2021; OECD 2021; Miroudot 2020; Eppinger and others 2021).

This chapter argues instead that greater diversification in international sourcing of inputs and greater substitutability in input sourcing could enhance GVC resilience. The lessons from Toyota's adaptations following the Tohoku earthquake are instructive (APEC 2021). Toyota took measures to increase diversification and substitutability, much in line with the model-based evidence presented by this chapter. In particular the company (1) standardized some components across vehicle models to enable global sharing of inventory and flexibility in production across various sites, (2) built a comprehensive database of its suppliers and parts held in inventory, (3) regionalized its supply chains to avoid depending on a single location, and (4) asked its single-source suppliers to disperse production of parts to multiple locations or hold extra inventory. Firms may also choose to adopt greater mechanization as a way to gain resilience against shocks to labor supply (Box 4.3).

The lessons from this chapter suggest the following policy recommendations.

- **Enhancing Infrastructure.** While firm-level decisions will predominantly shape the future resilience of GVCs, government policies can help by providing a supportive environment and lowering the costs of greater diversification and substitutability.

[30]For example, firms with just-in-time inventory management also enjoy lower inventory costs and would be best placed to increase inventories if needed, while remaining competitive (Miroudot 2020; van Stekelenborg 2020).

[31]Separately, advances in digital technology could provide a further boost to trade in services, for example, in areas such as health and education (Baldwin and Freeman 2021).

One obvious area is infrastructure. The pandemic has shown that infrastructure investments in certain areas are critical for mitigating supply disruptions related to trade logistics. For example, upgrading and modernizing port infrastructure on key global shipping routes would help reduce global choke points.

- **Closing Information Gaps.** Governments could also step in to resolve informational externalities, which could help firms to make more strategic decisions. For example, evidence suggests that automobile manufacturers on average have about 250 Tier 1 suppliers (with which the manufacturers conduct business directly), but this number rises to 18,000 suppliers in the full value chain (Baumgartner, Malik, and Padhi 2020).[32] It is easy to see how visibility over the supply chain would be challenging for firms that lack the resources of large corporate entities. Filling informational gaps could thus be a key role that governments can play. Advancing digitalization of firms' document filings, such as tax returns, can help generate more information on interfirm transactions and supply chain networks.[33] This information could be useful in stress-testing exercises to identify supply chain weaknesses and risks.
- **Reducing Trade Costs.** Finally, reducing trade costs can help boost diversification in inputs. Considerable scope exists to reduce nontariff barriers in particular, which would carry substantial medium-term growth benefits, especially in emerging markets and low-income developing countries (October 2021 *Regional Economic Outlook: Asia and Pacific*). In addition, reducing trade policy uncertainty and providing an open and stable, rules-based trade policy regime can also support greater diversification (Handley and others 2020; OECD 2021).

[32]Tier 1 suppliers provide parts or systems directly to an "original equipment manufacturer" or enterprise (such as Chevrolet). Tier 2 suppliers in turn supply inputs to Tier 1 suppliers.

[33]For example, Gadenne, Nandi, and Rathelot (2019) use value-added tax (VAT) data from the state of West Bengal (India) to map supply chains. VAT-paying firms are required to report transactions with other tax-registered firms, providing matches between client and supplier tax identifiers. Similarly, Alfaro-Ureña, Manelici, and Vasquez (2020) use tax identification data in firms' tax declarations in Costa Rica to match buyer firms with supplier firms.

Box 4.1. Effects of Global Supply Disruptions during the Pandemic

Supply chain pressures increased to unprecedented levels at the onset of the COVID-19 pandemic, and after a significant easing in the second half of 2020, accelerated again to reach a new peak by the end of 2021. Shipping costs steadily increased until September 2021, when they started a moderate decline. Delivery times lengthened in 2021, and indices of future delivery times indicate that supply chain disruptions persist. Trade flows closely mimicked the evolution of supply chain disruptions in the first phase of the crisis. Although the recovery in trade continued even when supply chain pressures resumed in late 2020 (Figure 4.1.1), flat import volumes and rising unit values in 2021 suggest that supply disruptions have contributed to inflationary pressures (Helper and Soltas 2021; Leibovici and Dunn 2021).

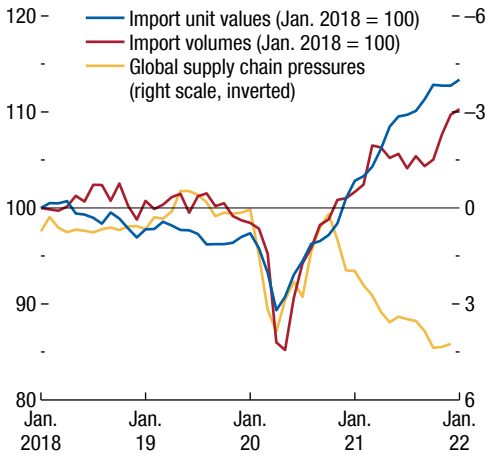
Supply chain disruptions have large real effects on firm inventories, production, and sales (Bonadio and others 2021; Carvalho and others 2021). These effects were still in evidence in the first weeks of 2022. High-frequency data from the United States show that the share of firms that reported foreign supplier delays increased from 9 percent in October 2020 to 20 percent in December 2021. A growing share of small businesses have also reported difficulties in locating alternative foreign suppliers. These developments are particularly severe in the manufacturing, construction, and trade sectors and have translated into an increase in the share of firms reporting delays in production and delivery to their customers, which reached 14 percent and 26 percent, respectively, in December 2021 (Figure 4.1.2). These persistent pressures, which increased in January 2022 as the Omicron wave spread in the United States, indicate a need to discuss policy options to improve global value chains' risk management through more flexibility, better knowledge and information, and better adaptability to shocks.

Disruptions in some industries have been particularly conspicuous. The automotive industry is a case in point. Trade in (and sales of) automobiles collapsed during spring 2020 and then started rebounding in the second half of the year, although without reaching pre-pandemic levels. The shortage of automotive chips was a key factor behind this drop. At the beginning of the pandemic, the shift to remote working led to a sharp increase in demand for semiconductors. By contrast, the demand for cars fell, and pessimism

This box was prepared by the Chapter 4 authoring team.

Figure 4.1.1. Global Goods Trade and Supply Chain Pressures

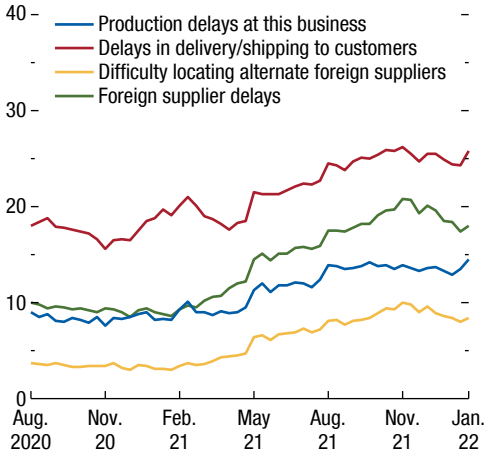
(Index)



Sources: Benigno and others (2022); CPB World Trade Monitor; and IMF staff calculations.
Note: The index of global supply chain pressures is a composite measure of several variables combining cross-border transportation costs with country-level supply chain measures of delays, backlogs, and inventories from manufacturing surveys.

Figure 4.1.2. Foreign Suppliers, Production, and Delivery Delays in the United States

(Percent)

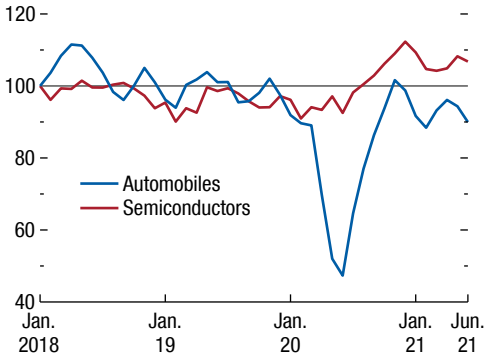


Sources: US Census Bureau, Small Business Pulse Survey; and IMF staff calculations.
Note: Data are as of January 20, 2022.

Box 4.1 *(continued)*

about the economy led car producers to limit their orders for semiconductors. When pent-up demand for cars accelerated more than expected in the second half of 2020, the semiconductor industry had limited production capacity to meet the demand for automotive chips because it had already shifted production to meet demand from other sectors (such as consumer electronics) (Deloitte 2021). Trade tensions and domestic shocks (such as a drought in Taiwan Province of China) aggravated this shortage, which has constrained recovery in the automotive sector, despite strong demand (Figure 4.1.3), and has resulted in higher prices. More generally, the shortage of semiconductors, a key component for many products, has highlighted the vulnerabilities of global value chains and driven calls for reshoring and for increasing supply chain resilience.

Figure 4.1.3. Trade in Automobiles and Semiconductors
(Index, January 2018 = 100)



Sources: Trade Data Monitor; and IMF staff calculations.
Note: "Automobiles" comprises Harmonized System six-digit codes for manufactured intermediate inputs and final goods (vehicles). "Semiconductors" comprises Harmonized System six-digit codes 854150 and 854190.

Box 4.2. The Impact of Lockdowns on Trade: Evidence from Shipping Data

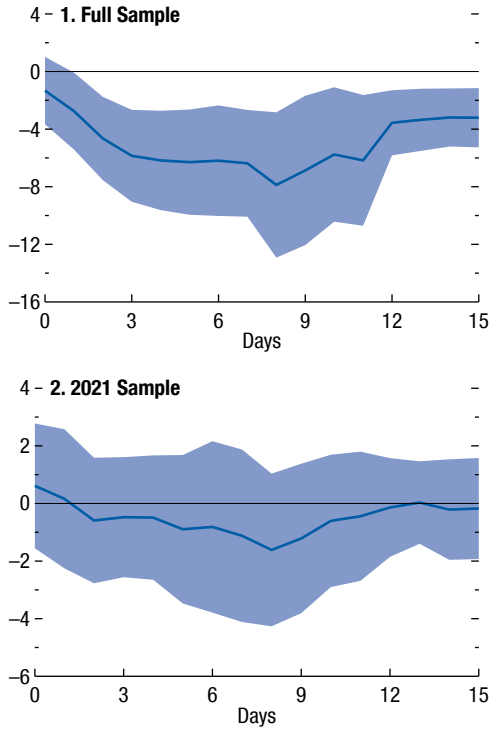
This box examines the effect on trade of pandemic containment measures, using a unique data set of daily bilateral seaborne trade volumes (see Cerdeiro and others 2020). A country's imports during a pandemic are affected by lockdowns imposed by trade partners (suppliers). Domestic factors (health situation, macroeconomic policies, consumer sentiment) are also likely to influence bilateral trade. The following import equation is estimated at a *daily* frequency to measure the effect of a lockdown imposed by country j on the growth of country i's imports from country j (bilateral import growth) at horizon h, $\widehat{M}_{ij,t+h}$:

$$\widehat{M}_{ij,t+h} = \gamma_{it} + \alpha_{ij} + \beta LS_{jt} + \mathbf{X}'_{jt}\delta + \sum_{k=1}^{7} \widehat{M}_{ij,t-k} + \varepsilon_{ij,t+h},$$

in which bilateral import growth from j to i ($\widehat{M}_{ijt}$) is the seven-day moving average of year-over-year growth rates with respect to pre-pandemic (2017–19) averages and LS_{jt} denotes the lockdown stringency (0–100) of the exporter country (Hale and others 2020).[1] The specification includes importer-time fixed effects, γ_{it}, to control for any unobserved time-varying factors affecting country i's imports; a bilateral pair fixed effect α_{ij}; and a vector of control variables $\mathbf{X}'_{jt}$ (the ratio of new COVID-19 cases to the population and an aggregate measure of exporters' exposure to foreign lockdowns).[2]

Over the full 2020–21 sample, exporter lockdowns have a large and statistically significant impact on bilateral trade volumes (Figure 4.2.1, panel 1). As the stringency variable has a range of 0–100, the point estimates of around 5 imply that less than a full lockdown (a change in stringency of just 20 points) can temporarily halt bilateral trade. Notably, lockdowns have no statistically significant effect on trade volumes in 2021 (Figure 4.2.1, panel 2). This finding is consistent with activity becoming less susceptible to lockdowns as economies adapt to the pandemic and underscores the resilience of global value chains.

Figure 4.2.1. Response of Bilateral Import Growth to Exporter Lockdowns
(Percent)



Source: IMF staff estimates based on Cerdeiro and others (2020). Automatic Identification System data were collected by Marine Traffic.
Note: The shaded areas indicate 95 percent confidence bands; robust standard errors.

The authors of this box are Andras Komaromi, Diego Cerdeiro, and Yang Liu.

[1]Lockdown measures are lagged to account for delivery lags in shipping. For example, if all voyages from country j to country i take three days, then lockdown stringency measures in j are lagged by three days in the equation for imports into i.

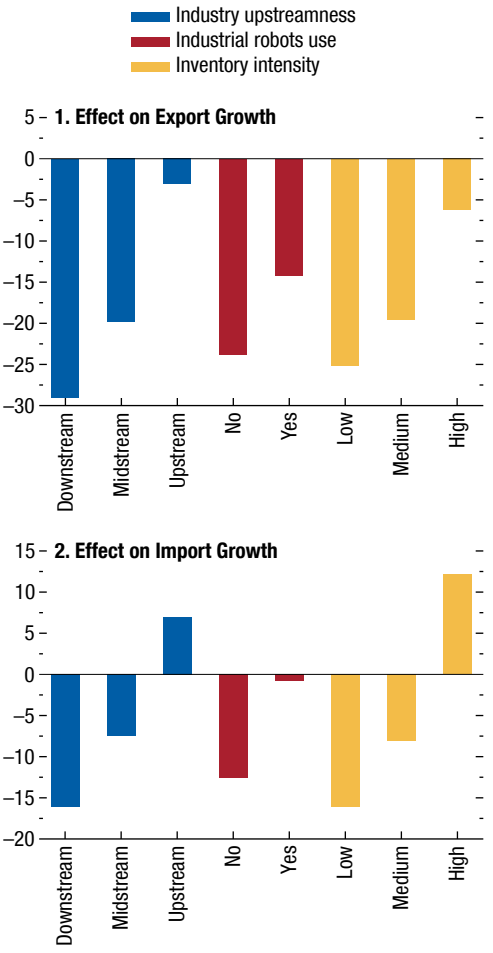
[2]This empirical specification captures lockdown-induced trade disruptions at the bilateral level, but it does not rule out cases in which a drop in bilateral imports is made up for by sourcing goods from a different country. For an alternative approach that takes into account potential substitution effects and measures lockdown disruptions in terms of aggregate imports, see Cerdeiro and Komaromi (2020). The bilateral specification presented here has the important advantage that one can control for any time-varying confounding factors specific to the importer.

Box 4.3. Firm-Level Trade Adjustment to the COVID-19 Pandemic in France

This box uses monthly French Customs data on firms' imports and exports for 2019 and 2020 to examine the duration of, and margins of adjustment to, the shock induced by the COVID-19 pandemic. Adjustment occurred mainly along the intensive margin (volumes). The extensive margin, with varieties dropping out of France's trade basket, contributed marginally to the total trade adjustment, indicating the temporary nature of the shock (Antràs 2021).[1] The trade recovery was supported by the rebound in consumer demand and extensive economic relief policies implemented by the French government.

- *The trade of downstream firms was more affected.* The average impact of importing-country lockdowns on exports of firms selling final consumer goods (downstream firms) was nearly nine times larger than that for firms selling intermediate inputs (upstream firms).[2]
- *Greater automation was associated with more resilience.* The impact of lockdowns and the spread of the virus (measured by COVID-19 deaths) on exports was almost 67 percent larger for firms that are less automated (Figure 4.3.1, panel 1).
- *Firms in low-inventory industries experienced larger contractions in trade.* Imports of firms in industries holding the lowest stocks of inventories fell more than twice as much as those among firms in industries with average inventory intensity (Figure 4.3.1, panel 2).[3] Firms in industries with the highest inventory intensity increased imports. Exporters in more inventory-intensive industries also experienced a smaller drop in sales (Figure 4.3.1, panel 1), suggesting that inventories play a shock-absorbing role.

Figure 4.3.1. Impact of Supply Chain Upstreamness, Automation, and Inventories on Trade Adjustment
(Percent)



Sources: Antràs and others (2012); French Customs data; Hale and others (2021); and IMF staff calculations.
Note: Each bar corresponds to the average effect for a given group of firms derived from the regression of firms' exports and imports on COVID-19 lockdown intensity and COVID-19 deaths in trade partner countries interacted with the industry's upstreamness index, its median ratio of inventories to sales, and firms' use of industrial robots. Downstream industries are closest to the final consumer, whereas upstream and midstream industries specialize predominantly in production of intermediate inputs.

The authors of this box are Mariya Brussevich, Chris Papageorgiou, and Pauline Wibaux. For details on data and estimation methodology, see Brussevich, Papageorgiou, and Wibaux (forthcoming).

[1]A variety is defined as a trade-partner-specific product, following the eight-digit Combined Nomenclature classification.

[2]To evaluate the heterogeneous effects of lockdown stringency and deaths by industry or firm characteristics, stringency and deaths variables are interacted with one of the variables of interest: an industry-level measure of upstreamness (Antràs and others 2012), firm-level imports of industrial robots as a proxy for automation, and an industry-level measure of inventory intensity (ratio of inventory to sales).

[3]The results on inventory intensity are sensitive to the measure of industry-average inventory-to-sales ratios.

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