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Insights for Europe

Raju Huidrom, Nemanja Jovanovic, Carlos Mulas-Granados, Laura Papi, Faezeh Raei, Emil Stavrev, and Philippe Wingender

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Executive Summary

Europe is deeply integrated into global value chains, and recent trade tensions raise the question of how European economies would be affected by the introduction of tariffs or other trade barriers. About 70 percent of total European exports are linked to forward and backward supply chains. Therefore, shocks affecting existing trade flows between the major trade hubs—the United States, China, and Germany—could affect European economies through those supply chains.

This paper estimates the impact of trade shocks and growth spillovers using value-added measures to get a more accurate picture of the associated costs across European countries. By measuring the impact of trade shocks through the lens of value-added exports instead of gross exports, we get a better understanding of how trade tensions weigh on activity. This distinction is particularly important for Europe, which has the largest difference between these measures as a result of extensive cross-border supply chains, both within and outside the region.

These are our main findings:

- The distribution across countries of export losses in Europe from tariff shocks is significantly different when measured according to value added versus gross trade. Through a simple accounting exercise based on input-output tables, we estimate the possible impact of a scenario in which the United States imposes a 25 percent tariff on imports of cars and car parts. Our findings suggest that about half of the impact is transmitted directly to the affected sector-country and the rest via supply chains. Most important, the negative impact would spread across more countries when measured using value-added indicators than when using gross exports, and the order of the export losses does not necessarily reflect the order of gross exports.

- The importance of Germany as the core hub country in Europe's trade is smaller when measured in value-added terms; the importance of the United States and China is relatively greater when measured that way. Germany's importance for its European trading partners in the real effective exchange rate (REER) is about 10 percent lower in value-added terms than in terms of gross exports. In contrast, the importance of the United States and China in European countries' REER is appreciably larger in value-added terms. Relatedly, when we simulate the impact of a 5 percent general tariff on all US imports (with retaliation from the rest of the countries), the average reduction in the demand for Europe's value-added output would be 50 percent higher when measured in value-added terms than if estimated in gross terms.
- Growth spillovers from the United States and China to European economies are sizable; the effects are larger for economies more exposed to them in terms of value-added exports. Spillover effects from German growth shocks on European countries are estimated to be much smaller. This likely reflects the German economy's smaller size relative to the United States and China and Germany's openness, which makes it less likely to be an independent source of large shocks. Our analysis, however, does not rule out the role of Germany as a transmitter of shocks originating elsewhere or its potentially larger spillovers if its growth becomes more driven by domestic demand.

The conclusions of this paper could be helpful for policymakers. The findings of this paper could help quantify more precisely the impact of growing trade tensions. Understanding how trade shocks propagate through global value chains could also help policymakers calibrate countercyclical measures as needed and target social policies aimed at the citizens most likely to be affected.

Chapter

1 Introduction

Europe is deeply integrated into global value chains, both within and outside the region. Production processes in Europe and around the world have become geographically dispersed, with different stages of production spread across various locations. Domestic value added is combined with foreign value added either to generate exports that are later embodied in other products or to be consumed as final goods and services. In the past two decades, the development of global value chains and the expansion of the European Union's single market and the euro area have notably increased intraregional trade in Europe and have strengthened trade relations between Europe, the Americas, and Asia. As a result, European economies are more integrated both within and outside the region.

Recent trade tensions raise the question of how European economies would be affected by the introduction of certain tariffs or other trade barriers. About 70 percent of total European exports are linked to forward and backward supply chains, and therefore shocks affecting trade flows between the major trade hubs—the United States, China, and Germany—could affect European economies through those supply chain linkages.

The size and distribution of the impact of trade shocks can be different when trade in intermediate goods and supply-chain linkages are fully considered. Trade shocks, such as increased tariffs, can be amplified as they pass through the steps associated with modern supply chains. The cost of protectionist measures accumulate as intermediate goods are exported and then reexported further downstream, going through different processing nodes before reaching the final consumer. The distribution of the impact also depends on the value-added contributions in the various stages of the supply chains. As a result, the size and distribution of the costs associated with an increase in tariffs can be different (and larger in some cases) when global value chains are taken into account. Measuring the impact of trade shocks through the lens of value-added exports instead of gross exports therefore gives a better understanding of how trade tensions could weigh on activity.[1]

The importance of analyzing trade using global value chain indicators has been widely discussed in the literature. There is already a rich set of studies that documents their increasing relevance (for example, Koopman, Wang, and Wei 2014; Bems and Johnson 2017; Johnson and Noguera 2017; Lee and Yi 2018). There are also several IMF studies that highlight the idea that a country's exposure to final export demand can be different when measured using gross versus value-added trade flows. For example, IMF (2013a) assesses global value chain linkages between Germany and the CE4 economies (Czech Republic, Hungary, Poland, Slovak Republic) and compares the extent of exposure of this group of countries to final export demand outside Europe under global value chain linkages as opposed to exposure captured by bilateral gross trade statistics. IMF (2016) examines the role of global value chains in explaining the trade slowdown in the aftermath of the global financial crisis. Relatedly, IMF (2007, 2013b) analyze business cycle spillovers (and more broadly, comovement) and the role of trade and financial linkages in the cross-border transmission of shocks. The Organisation for Economic Co-operation and Development (Grundke and others 2017; Marcolin, Miroudont, and Squicciarini 2018), the European Central Bank (Frohm and Gunella 2017; ECB 2019), and the World Bank (2016, 2017) have also made significant contributions in this field, emphasizing the importance of global value chains for trade, innovation, productivity, and economic development.

Recently, the IMF (2019) has shown that the effects of bilateral tariffs on value added are amplified by global supply chains. The April 2019 *World Economic Outlook* (WEO) shows that closer integration into global value chains multiplies the effect of tariff changes on output, employment, and productivity. For countries such as Germany and the Republic of Korea, whose manufacturing sectors are big and well integrated into global value chains, tariff increases by all countries of the world would have a much larger effect today than in 1995. If the increase in tariffs were more discriminatory and less generalized across countries (for example, a trade war between the United States and China),[2] third countries could benefit somewhat thanks to trade diversion, but the net effect in terms of GDP losses would still be negative for the world.

[1]This paper uses the terms "global value chain data," "value-added data," and "value-added exports" interchangeably.

[2]To study a hypothetical US-China trade dispute, the WEO chapter uses global general equilibrium models with three approaches that emphasize different transmission channels.

The objective of this paper is to estimate the impact of trade shocks and growth spillovers on Europe and their distribution across countries using measures of value-added trade flows. The key objective is to get a handle on the impact of trade and growth shocks on Europe. The distinction between gross and value-added trade is critical for Europe, given its significant participation in global value chains. Value-added export data are essential for a more accurate assessment of the distribution of costs across countries and sectors. We highlight this point using two illustrative examples.

- Conventional trade indicators, such as gross exports of cars and car parts, would indicate that the Slovak Republic's exposure to the United States is much larger than the exposure of the Czech Republic. This would seem to imply that a US tariff on European cars and car parts would have a larger effect on the Slovak economy than on the Czech economy. Instead, when value-added exports are considered, the opposite is true. The reason is that while direct exports of cars and car parts from the Czech Republic to the United States are not large, the Czech value added embedded in other countries' exports of cars and car parts to the United States is large.
- More broadly, when assessing the potential impact of general tariff hikes imposed by the United States on European exports, measures of trade openness and exposure to the United States should take into account the extent of trade in value added between countries. For example, Germany's share of trade in value added is significantly smaller than what gross measures would indicate.

This paper deploys complementary databases and three different analytical frameworks. To benefit from wide country and sectoral coverage, we use the latest vintages of the EORA Multi-Regional Input-Output (MRIO) and World Input-Output (WIOD) databases. After laying out key stylized facts about Europe's importance in today's global value chains, we use three complementary methodologies to analyze the effects of trade shocks and growth spillovers in the subsequent chapters.

- We start with a simple accounting exercise based on input-output tables to study how tariff-related shocks transmit through global value chains. Chapter 3 carries out a short-term simulation, using a simple setup in which shocks to any sector have direct and indirect implications for other sectors and other countries via supply chain networks as represented in the input-output tables. We consider a scenario in which the United States imposes a tariff of 25 percent on imports of cars and car parts. This network analysis, once repeated for all countries exporting to the United States, allows us to capture the cascade of losses—in terms of lower output demanded by the United States—incurred directly and indirectly by various countries. The analysis of this chapter is granular, but has limitations because it abstracts from potential trading partners' reactions or other potential growth spillovers.[3] The subsequent chapters complement the network analysis by addressing some of these limitations.

- We then move to a demand system that aggregates more sectors of the economy and allows for reactions by different countries to tariff-related price increases. The rise of global value chains means that countries compete over supplying domestic value added to world markets, rather than over final goods or gross exports alone. Therefore, supply chains determine how international relative prices influence the competitiveness of, and hence demand for, domestic value added. Following Bems and Johnsons (2017), Chapter 4 relies on a framework that links changes in the demand for value added to changes in value-added prices and final expenditure levels. A key element of this framework is a value-added REER index that aggregates bilateral value-added price changes into a composite multilateral price of domestic relative to foreign value added. We combine this value-added REER with two additional components—the price elasticity of demand for domestic value added and an indicator of how open the economy is in value-added terms—to summarize the determinants of demand for value added. Using this model, we analyze the change in the demand for value added following a change in relative prices caused by the imposition of a tariff. We illustrate the usefulness of this framework by simulating a general tariff increase of 5 percent by the United States on all foreign products, which leads to a similar retaliation by its trading partners.
- Finally, this paper takes a broader perspective and uses a macroeconometric approach to study growth spillovers from hub countries in the presence of global value chains. Because protectionist measures elicit retaliatory responses from trading partners and generate uncertainty that can lower investment, trade tensions could weigh on global trade and eventually result in a slowdown in growth, especially in the countries directly involved. Under this premise, Chapter 5 studies how global value chains act as a transmission mechanism for growth shocks that spill over to other trading partners. This chapter uses a two-step macroeconometric model to analyze growth spillovers in the presence of supply chain linkages. It first estimates country-specific growth shocks as the residual growth after purging the effects of common shocks. In a second step, it traces the effects of these shocks on growth in other economies; that is, spillovers, using a local projections model. What is new here is the exploration of nonlinearities associated with trade exposure in value-added terms for the size of spillovers. For instance, in the model used to measure spillovers from

[3]This chapter also abstracts from the trade diversion effect that takes place over the medium to long term when exporting countries face a rise in tariffs in their preferred destinations. IMF (2019) also uses network analysis, and instead of focusing on the impact of a specific tariff on the automobile sector, considers a hypothetical tariff common to all sectors of the economy and finds strong trade diversion effects.

the United States, US growth shocks are interacted with other countries' value-added exports to the United States. In this setup, spillovers from the United States depend on the extent to which other economies are exposed to the United States in value-added terms. This is the key new idea explored in this chapter.

Four main conclusions emerge from this paper.

- Europe is highly integrated into global value chains; hence, distinguishing between gross and value-added trade flows is essential. About 70 percent of total European exports are linked to forward and backward supply chains, compared with roughly 40 and 45 percent of total exports from the Americas and Asia, respectively. For Europe, the difference between value-added and gross trade statistics is larger than for Asia or the Americas. This is because of Europe's higher participation in global value chains, which can be traced in part to the expansion of the European single market and the euro area, facilitating the fragmentation of production within the region. In addition, Europe's global value chain participation is concentrated in a few sectors: manufacturing, transport and communications, and wholesale and retail.
- The distribution of estimated losses in Europe from tariff shocks in key trading partners is significantly different across countries when looked at in terms of value-added versus gross exports data. In a scenario in which tariffs on cars and car parts imported to the United States increase to 25 percent, the short-term losses average 0.1 of EU GDP. About half of the impact on European countries' exports occurs directly and the rest throughout the supply chains. Most important, the negative impact would spread across more countries when the impact is measured using value-added indicators than when using gross exports and the order of the export losses does not necessarily reflect the order of gross exports.
- When measured in value-added instead of conventional terms, the importance of Germany as the core hub country in Europe's trade is smaller, while the importance of the United States and China is relatively greater. Germany's importance for its European trading partners in terms of the REER is about 10 percent lower in value-added terms than in terms of gross exports. In contrast, the importance of the United States and China in terms of European countries' REER is almost 50 percent larger in value-added terms. This is consistent with the idea of extensive regional supply chains—characteristic of the European internal market—in which countries behave more as complements than as competitors, trading inputs intensively, with very small additional value added embodied in each production step. Relatedly, when we look at the impact of a US tariff increase on Europe, the negative impact on Germany is smaller than expected, and other European countries in its value chain also take a hit. For example,

after a 5 percent US tariff on all its imports (with retaliation from the rest), the average reduction in the demand for Europe's value-added output is 0.2 percent. As expected, this negative impact is larger than in the car tariff scenario, because tariffs are applied to all sectors across the board, and there is a cumulative effect of retaliatory responses. But the bottom line is that once again, measuring the impact in value-added terms provides a better sense of its size and distribution across European countries.

- Growth spillovers from the United States and China to European economies are sizable; the effects are larger for economies with more value-added exports used in these economies. In our simulations for the median European economy, a 1 percent negative US growth shock would have a peak cumulative growth impact during a two-year horizon of about –0.6 percentage point. For countries most exposed to the United States, the estimated impact would be –1.4 percentage points. Within European economies, growth spillovers originating in the United States would be smaller for emerging Europe than for advanced Europe, reflecting their smaller exposure in value-added terms. The effect of German growth shocks on European countries is estimated to be much smaller, consistent with other studies. This likely reflects the smaller size of the German economy relative to those of the United States and China and the fact that Germany, given its openness, is less likely to be an independent source of large shocks. Our analysis, however, does not rule out the role of Germany as a transmitter of shocks.

Chapter

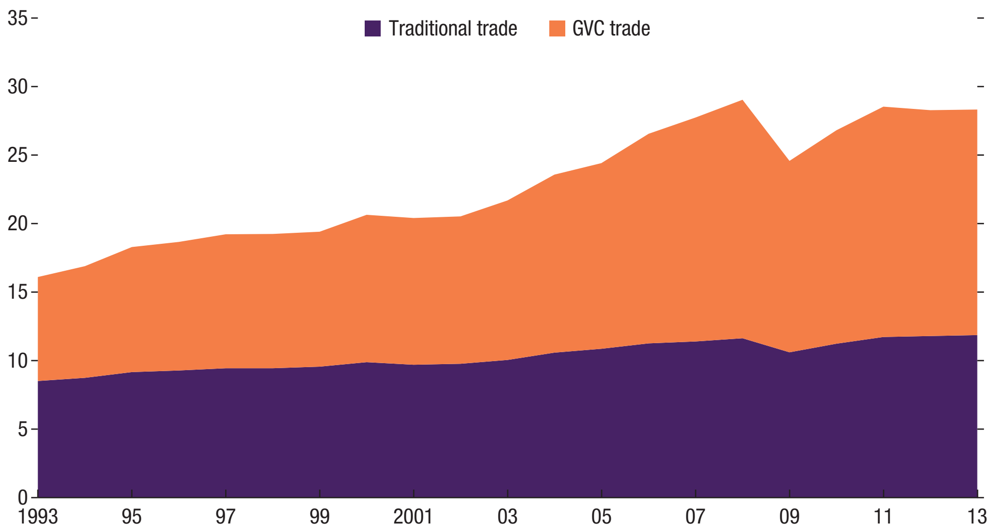
2 Global Value Chains and Europe: Stylized Facts

Since the early 1990s, global value chains have become the center of global production and trade (Figure 1). Advances in technology and lower trade barriers have made it easier to carry out production tasks in different locations, allowing firms to benefit from different factor costs (Feenstra and Hanson 1997; Grossman and Rossi-Hansberg 2008) and leading to a higher volume of intra-industry trade. Global value chain participation is positively associated with income per capita and productivity growth (Box 1). Such production fragmentation means that intermediate goods and services cross borders several times along the value chain, often passing through countries more than once (Baldwin and Lopez-Gonzalez 2013; Ignatenko, Raei, and Mircheva 2019). The value chain describes the full range of firms' and workers' activities that take a product (good or service) from conception to end use. This includes activities such as design, production, marketing, distribution, and support to the final consumer.[1] These multipolar global production arrangements have called into question the validity of traditional trade statistics, since official gross measures of trade by a country-sector mask the embodied value added by other countries and sectors (World Bank 2017; ECB 2019). Hence, to properly analyze the potential impact of trade shocks, it is crucial to understand to what extent countries participate in global value chains.

Global value chain exposure and participation involve forward and backward trade linkages. To identify these linkages, this paper follows the methodology developed by Koopman, Wang, and Wei (2014) and described in Aslam, Novta, and Rodrigues-Bastos (2017) to decompose gross exports into value-added components based on the location of value-added creation and its purpose. As illustrated in Figure 2, gross exports can be decomposed into two broad components: the foreign value added embedded in gross exports of a country (backward linkages) and the domestic value added in exports. The latter part is further decomposed into exports absorbed in the destination

[1]See https://globalvaluechains.org/concept-tools.

Figure 1. Global Trends in Global Value Chain (GVC) and Traditional Trade[5]
(Percent of world GDP)



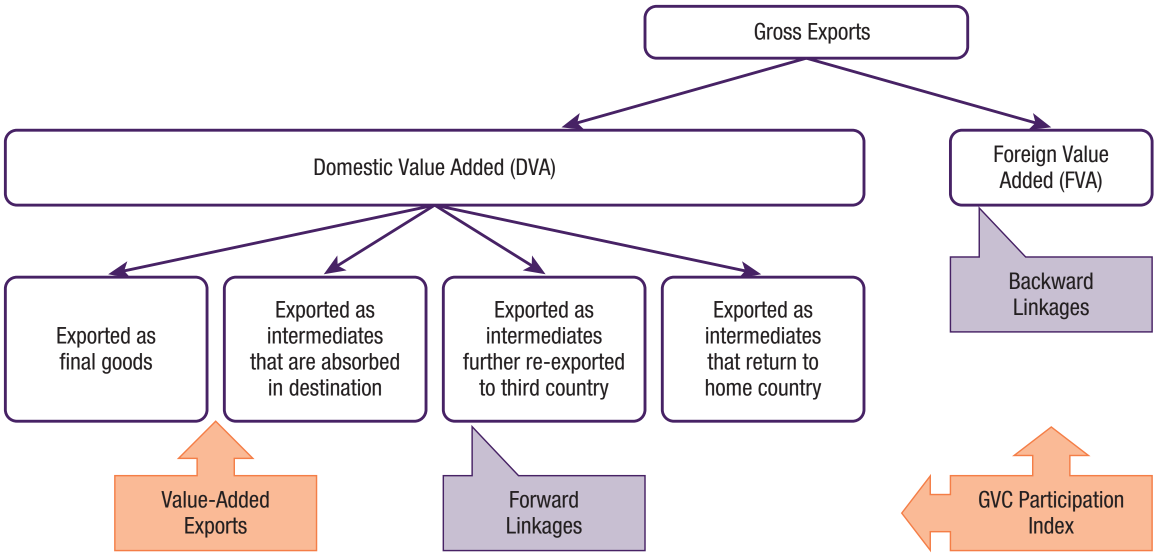
Sources: EORA database; and IMF staff calculations.
Note: Traditional trade comprises exports of goods and services that are produced in one country and absorbed in the destination country. GVC trade comprises exports of goods and services that are produced in more than one country.

country and those used as intermediate inputs for exports to third countries (forward linkages) or returned to the home country. To generate the two most common indicators used in this field—namely, value-added exports and global value chain participation—we proceed as follows.

- The indicator of value-added exports equals the share of domestic value added exported in final goods plus the share of value added in intermediate goods, both absorbed in the country of destination. Put simply, this measure reflects value added consumed abroad (Los and Timmer 2018). Researchers use value-added exports to understand how a trade barrier in the destination country would affect value added and final demand in the origin or exporting country.
- The indicator of *global value chain participation* is the sum of forward and backward linkages. This index is a measure of openness and is helpful to portray a country's integration into global value chains.

Countries' exposure to and participation in global value chains can be measured using various databases that differ in the coverage of countries, sectors, and time spans. Disentangling gross export flows published in official statistics from value-added flows created in different locations requires intensive work to identify input-output linkages both within and across countries and sectors and generating standard measures of global value chain participation

Figure 2. Decomposition of Gross Exports into Value-added Exports and GVC Participation



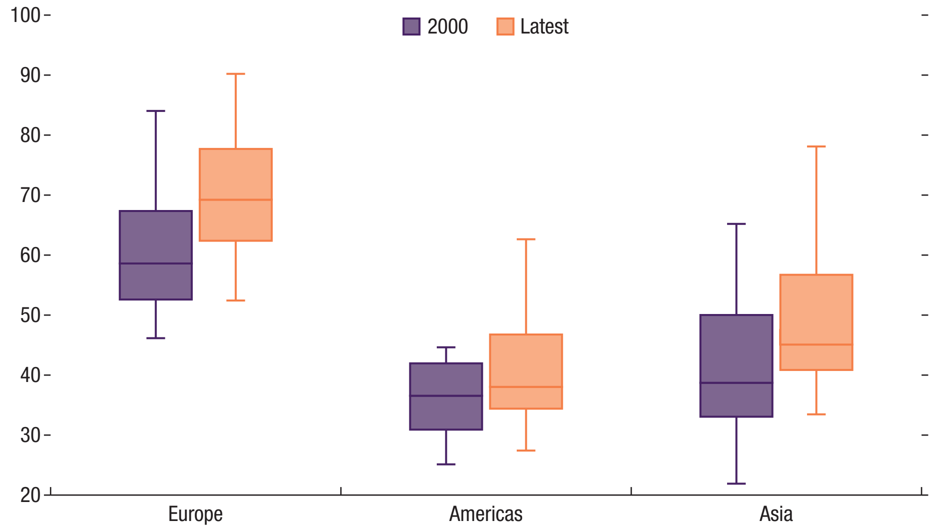
Sources: Authors' elaboration, based on Koopman, Wang, and Wei (2013); Rahman and Zhao (2013); Aslam, Novta, and Rodriguez-Bastos (2017).

and value-added exports consistent with the literature. Such data became available to researchers through initiatives such as the Trade in Value-Added Statistics (TiVA), which covers 64 countries and 36 sectors[2]; the World Input-Output Database (WIOD), which covers 43 countries and 56 sectors[3]; and the EORA MRIO database, which provides data on input-output linkages for 190 countries and 26 sectors.[4] In this paper, we use either the EORA MRIO database, when we want as large a country coverage as possible, especially for European countries, or the WIOD data set, when having more sectors provides more accurate estimates of input-output linkages or for consistency with existing studies. For example, we use EORA in Chapter 3 and WIOD in Chapter 4.

Europe is deeply integrated into global value chains—more than the Americas and Asia—and the integration has increased over time. Figure 3 illustrates Europe's rising trend in global value chain participation—defined as the sum of forward and backward linkages. Between 2000 and 2013, the share of European exports involved in global value chain trade increased 10 percentage points, from about 60 to 70 percent of total exports of goods and services. Over this period, this ratio increased only 2 percentage points in the Americas and 6 points in Asia. There is significant heterogeneity across

[2]http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm.
[3]http://www.wiod.org/home.
[4]http://worldmrio.com.

Figure 3. GVC Participation
(Percent of exports, sum of forward and backward linkages)

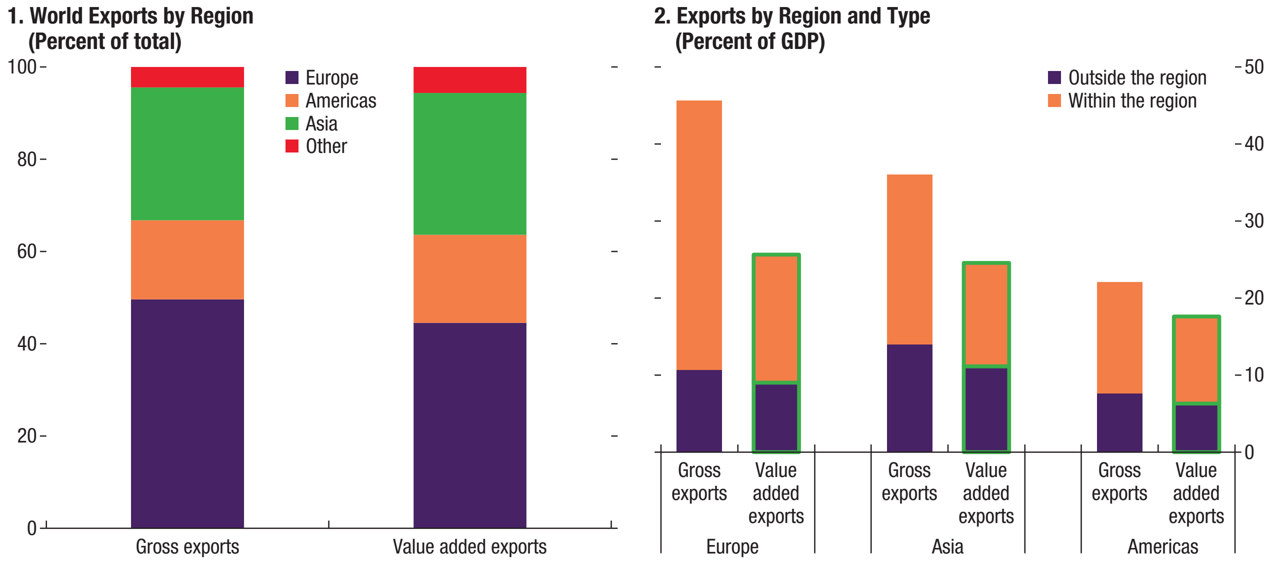


Sources: EORA database; and IMF staff calculations.
Note: The line refers to the median, the box to the 25–75 percentile range, and the error bars to the min-max range. Latest data available in EORA are 2013.

and within regions, but it is evident that on average Europe is more integrated into global value chains than the Americas and Asia. This may be because of the European Union's single market and its expansion, as well as the euro area—recent research suggests that deeper trade agreements boost countries' participation in global value chains (Laget and others 2018)—or it could simply be that European countries have been more successful in finding workers, technology, and markets abroad than members of other trading blocs.

Value-added exports are concentrated around three clusters of intraregional trade, especially in Europe. Almost half of world trade occurs in Europe, about 30 percent in Asia, and 20 percent in the Americas (Figure 4, panel 1). In Europe gross exports are 18 percentage points of GDP higher than value-added exports; the difference is 9 percentage points for Asia and 3 percentage points for the Americas (Figure 4, panel 2). In addition, more trade takes place within the three regions—exchanging goods and services with direct neighbors or with geographically-close countries. This is especially true in Europe, where about two-thirds of value-added exports go to regional partners and a third go outside the region. Nevertheless, when measured in value-added terms, exports destined outside of Europe are almost as large as those of Asia and larger than those of the Americas. Importantly, Europe has the biggest difference between gross and value-added regional trade, reflecting

Figure 4. Regional Clusters of Gross and Value-Added Trade



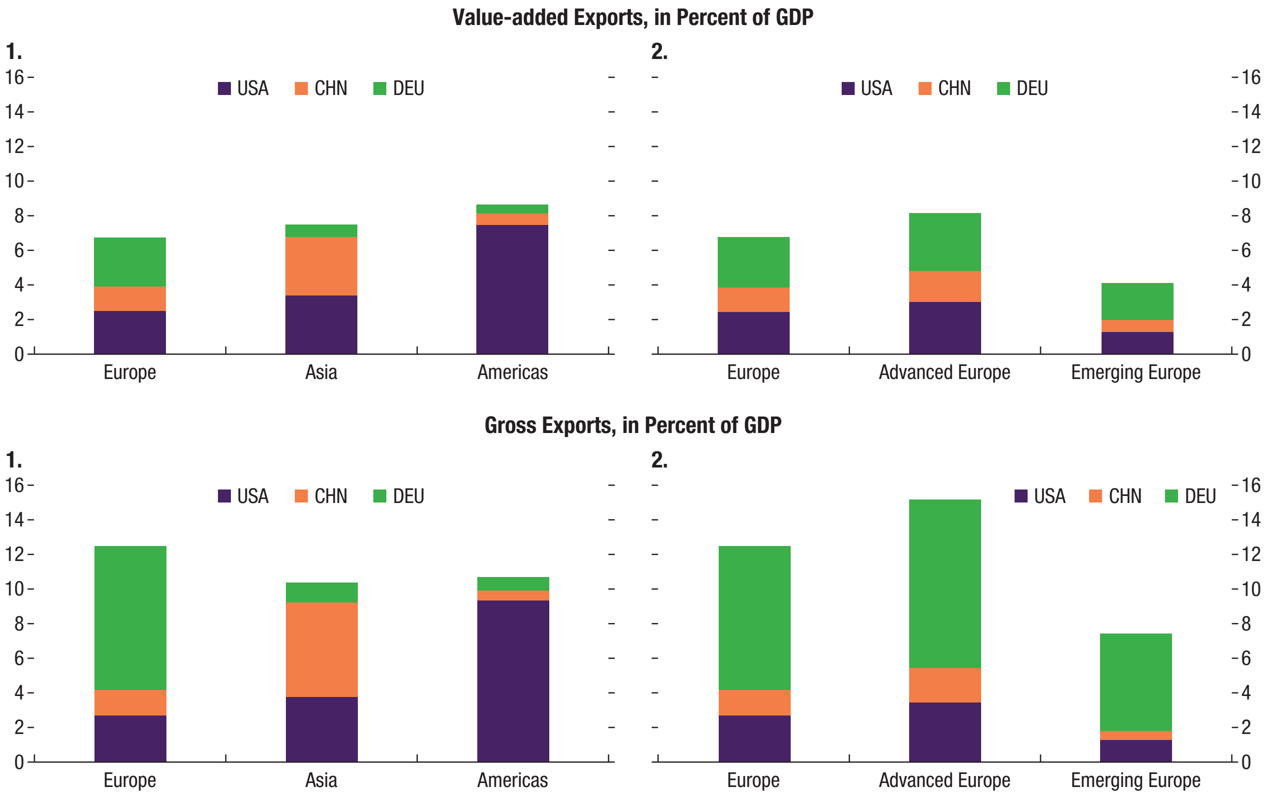
Sources: EORA database; and IMF staff calculations.
Note: Figures refer to simple averages across countries in each region. Latest data available in EORA are 2013.

the development of cross-border supply chains in response to the European common market and the integration of central and eastern Europe, with its highly qualified and cheap labor. Even the sectoral distribution of global value chains is concentrated, with manufacturing, transport and, communications, and retail and wholesale trade dominating (Box 2). These are sectors that have experienced rapid automation since the 1990s, a process that has so far been positively associated with growing value-added exports (Box 3).

Europe's exposure to the United States, China, and Germany—the trade hub countries—is sizable. Each hub country is a major player in its respective region: Germany in Europe, the United States in the Americas, and China in Asia (Figure 5). However, the importance of the hub country is particularly dominant in gross exports, whereas when value-added exports are considered, the dominance of the hub country in each region diminishes. Within Europe, advanced European economies have larger value-added exports to each of the three hub countries than emerging European economies. This suggests that emerging Europe, despite being typically characterized as small open economies, is not necessarily more open than advanced Europe.[5] When exports are measured in gross terms, trade exposure of European economies to Germany is greatly exaggerated. For example, exports of other European countries to

[5]Although automation has so far been associated with greater value-added exports in Europe, it is unclear whether this trend will continue: advances in robotics, artificial intelligence, and automation could shorten global value chains (Box 3).

Figure 5. Exposure to Trade Hub Countries

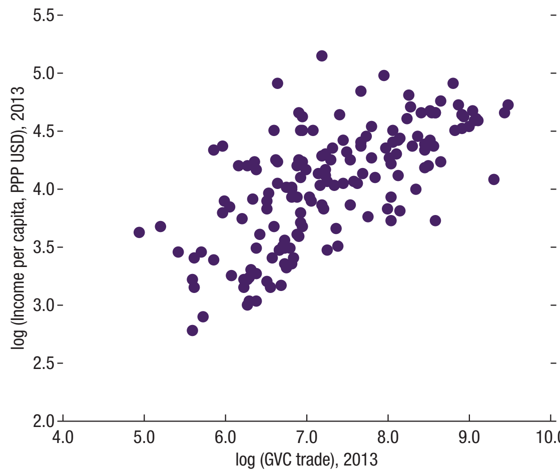


Sources: EORA database; and IMF staff calculations.
Note: Figures refer to simple averages across countries in each region. Latest data available in EORA are 2013. CHN = China; DEU = Germany; USA = United States.

Germany are 8.3 percent of GDP in gross terms, but only 2.9 percent of GDP in value-added terms (Figure 5). On the other hand, European exports to the United States are very similar both in gross and value-added terms, representing 2.7 percent of GDP. The exposure to the United States implies that in a possible trade war scenario, higher trade barriers imposed by the United States could weigh on European exports and growth. The following chapters study these possible impacts under different scenarios and using alternative approaches.

Box 1. Global Value Chain Participation and Productivity

Box Figure 1.1. GVC and Income per Capita



Source: Ignatenko, Raei, and Mircheva (2019).

Global value chain participation is positively correlated with income per capita (Box Figure 1.1). The theoretical literature suggests several reasons for these positive correlations, including productivity effects and investment boosting. In this box, we summarize the econometric analysis of Ignatenko, Raei, and Mircheva (2019), who study the relationship between global value chain participation and income per capita.

Econometric evidence suggests that global value chain participation is related positively to income per capita, human capital, and productivity. Specifically, we find that it is mostly trade in intermediate goods, as well as the share of trade flows related to global value chains—as opposed to conventional trade—that contributes to a country's income per capita. Investment is also affected positively by global-value-chain-related trade flows. Human capital and productivity mirror this relationship. Table 1 summarizes our main findings. Column (1) reports the results from a regression exploring the relationship between (lagged) shares of final and intermediate goods trade in countries' GDP and countries' income per capita. It suggests that it is mostly trade in intermediate goods that contributes to countries' income per capita. In column (2) we distinguish between trade that is related to global value chains and trade that is not. Trade that is not related to global value chains is defined as imports and exports that are directly absorbed in other countries. The results suggest that it is mostly the share of global-value-chain-related trade flows in countries' GDP that is positively related to income per capita. In columns (3)–(5), we study the channels through which global value chain participation and trade could affect income per capita. Columns (4) and (5) show that the trade share that is related to global value chains also positively affects human capital and productivity, measured as a residual in the income decomposition equation. In column (6), we find that the results of column (1) cannot be replicated if we restrict the sample to 50 countries typically available in other databases of value added, highlighting the importance of the larger EORA database for studying global value chains. In columns (7) and (8) we explore whether income gains from global value chain trade depend on a country's income level or its position in the chain.

This box is based on Ignatenko, Raei, and Mircheva (2019).

Box 1. Global Value Chain Participation and Productivity *(continued)*

Table 1. GVC participation and income per capita

	(1) Log(I/N)	(2) Log(I/N)	(3) Log(I/N)	(4) Human capital	(5) Productivity	(6) Small Sample Log (Y/N)	(7) Income class Log (Y/N)	(8) Upstream Log (Y/N)
Share of final trade in GDP	0.143							
	(0.728)							
Share of Intermed. trade in GDP	1.610***							
	(0.339)							
log(population)	−0.041	−0.060	−0.007	−0.024	−0.059	0.019	−108	−0.069
	(0.068)	(0.069)	(0.020)	(0.043)	(0.051)	(0.052)	(0.58)	(0.697)
log(area)	−0.012	−0.013	0.007	0.028	−0.030	0.043	0.0145	−0.0130
	(0.061)	(0.060)	(0.013)	(0.036)	(0.047)	(0.50)	(0.064)	(0.065)
Share of regular trade in GDP		0.227	−0.07***	0.402	−0.351	.617	−0.0383	0.301
		(0.458)	(0.002)	(0.302)	(0.489)	(.531)	(0.387)	(0.549)
Share of GVC-trade in GDP		2.738**	0.367***	1.366*	1.869*	−.409		2.080**
		(1.148)	(0.103)	(0.750)	(1.107)	(0.990)		(1.030)
GVC-trade*(Low Income)							−0.947	
							(0.3875)	
GVC-trade*(Low Middle Income)							1.413*	
							(0.915)	
GVC-trade*(High Middle Income)							2.143**	
							(0.855)	
GVC-trade*(High Income)							2.848***	
							(0.948)	
Upstream Index								−0.370
								(0.2561)
Downstream Index								0.102
								(0.229)
Constant	9.459*	9.674***	2.943***	1.562***	6.573***	9.939***	10.160***	9.758***
Observations	3,049	3,049	3,045	2,777	2,625	970	2,770	1,165
R-squared	0.172	0.183	0.042	0.261	0.072	0.170	0.160	0.275

Clustered robust standard errors in parentheses; Year fixed effects are included.
***, **, and * denotes significance at 1, 5, and 10 percent.
Source: Ignatenko, Raei, and Mircheva (2019).

Box 2. Europe's Global Value Chain Participation

Most of Europe's global value chain participation and jobs are concentrated in a few sectors. Manufacturing, transport and communications, and wholesale and retail sectors are highly integrated into global value chains (Box Figure 2.1). Forward and backward linkages of Europe's manufacturing sector represent almost 30 percent of total exports. Within manufacturing, machinery and equipment and motor vehicles[1] are the subsectors with the highest percentage of value-added exports, followed by the manufacture of chemicals and metal products. The shares of the other two main sectors range between 10 percent (transport and communications) and 5 percent (wholesale and retail trade). These three sectors also employ large shares of Europe's workforce. The wholesale and retail trade sector employed nearly 50 million people in 2014 (or about 20 percent of total employment), closely followed by manufacturing and double the figure of the transport and communication sector, which employed more than 20 million workers. Recently, the manufacturing sector has undergone a structural transformation in the form of "servification": a portion of manufacturing exports is value added generated by the service sector (IMF 2018). The nature of global value chain participation by services and manufacturing sectors is markedly different, with services (business and financial) exhibiting more forward linkages and manufacturing more backward linkages (Ignatenko, Raei, and Mircheva 2019).

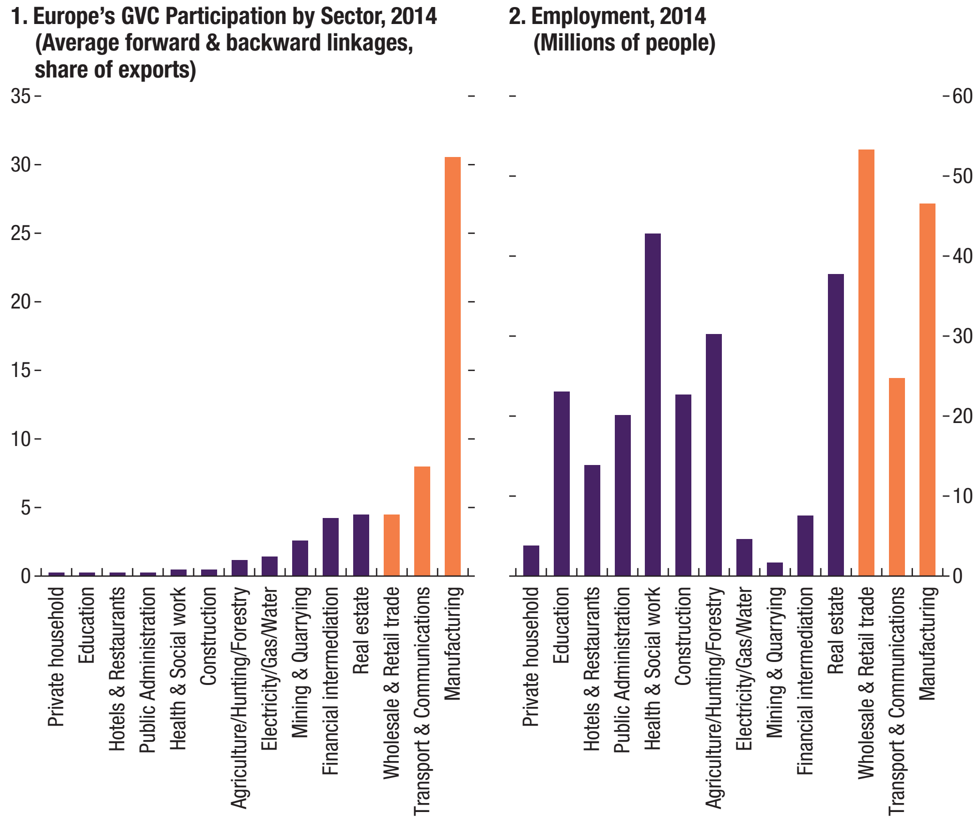
Europe's degree of participation in global value chains is related to market size, quality of institutions, and skills of the labor force. Recent studies show that high population and domestic demand (as proxies for market size) and other variables—such as trade union density, tax wedge, and the size of the welfare state—are factors conducive to higher global value chain participation (Van der Marel 2015; ECB 2019). High political stability and a good score on the World Bank's Ease of Doing Business Index are also positive factors associated with higher global value chain participation.[2] Regarding the role of skills, recent survey results underline the importance of cognitive skills—such as literacy, numeracy, and problem solving—for any industry to thrive in the global economy. In addition, a persistent and positive association between labor productivity and participation in global value chains is seen, at the industry level, for noncognitive skills such as management and communication ability, information and communication technology skills, and workers' readiness to learn and think creatively.

[1]Within the manufacturing sector, the manufacture of motor vehicles represents about 4 percent of total value-added exports.

[2]A drawback to using institutional indicators is that they are available only at the country level and cannot be used to explain global value chain participation at the sectoral level.

Box 2. Europe's Global Value Chain Participation *(continued)*

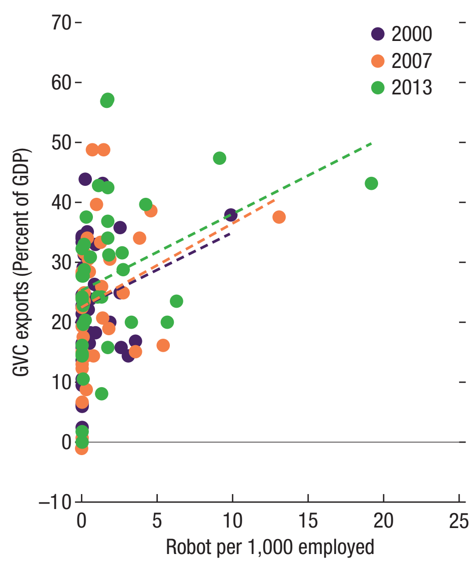
Box Figure 2.1. Europe's GVCs and Jobs by Sector



Sources: Data on global value chains from World Input-Output Database (2016); and IMF staff calculations.

Box 3. Automation and Participation in Global Value Chains

Box Figure 3.1. Europe's GVCs Exports and Robot Exposure, 2000–13



Sources: International Federation of Robotics; IMF, *World Economic Outlook*; and IMF staff calculations.

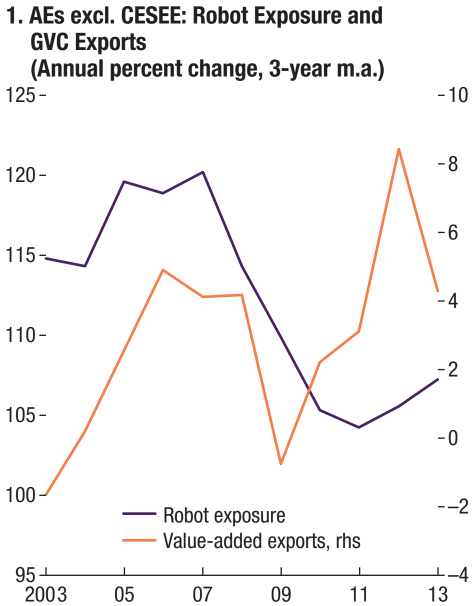
Automation has so far been positively associated with growing value-added exports. The increasing presence of industrial robots in Europe's factories since the mid-1990s has boosted productivity and raised the amount of domestic value-added content in final and intermediate exports going to other countries. Box Figure 3.1 shows that the positive relationship between value-added exports and the number of robots per thousand workers strengthened in Europe between 2000 and 2013.

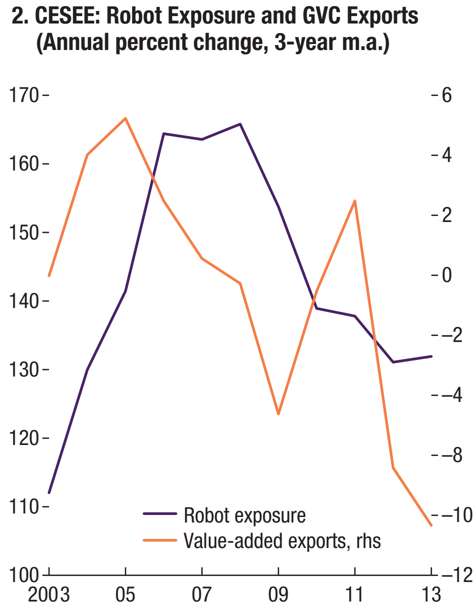
The positive relationship between robotization and value-added exports is more apparent in central, eastern, and southeastern European countries (Box Figure 3.2). The annual growth in value-added exports was positively correlated with the annual percent change in robot exposure in the region between 2003 and 2013. The relationship was also positive in advanced economies until the early 2000s, but it weakened at the end of that decade, a period during which the growth of robot penetration slowed.

As robotics, artificial intelligence, and automation intensify, global value chains may become less extensive and shorter. This could happen if automation makes offshoring less attractive as differences in labor costs become less relevant and intermediate goods are increasingly sourced domestically in advanced economies.

Box 3. Automation and Participation in Global Value Chains *(continued)*

Box Figure 3.2. GVCs Exports and Robot Exposure, Advanced Europe and CESEE





Sources: Data on global value chains from World Input-Output Database (2016); International Federation of Robotics; and IMF staff calculations.
Note: AEs = advanced economies; CESEE = Central, Eastern, and Southeastern Europe.

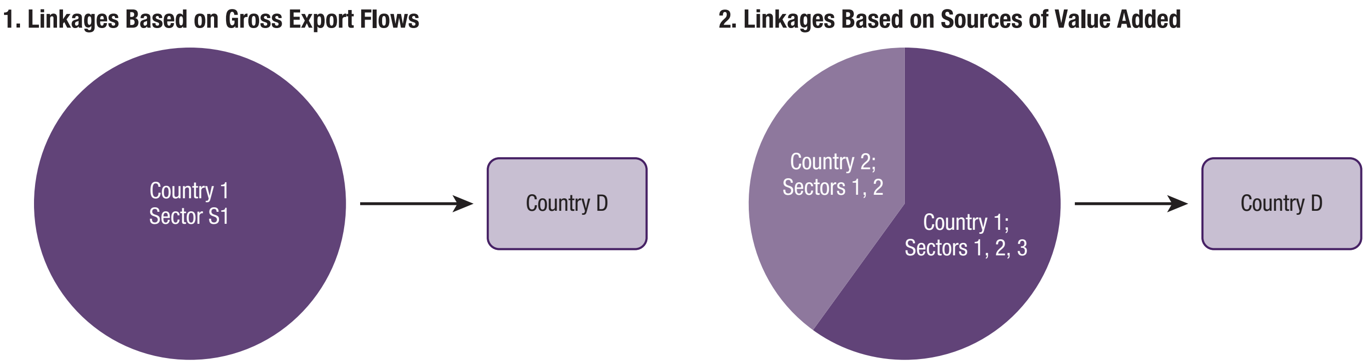
Chapter

3 Short-term Impact of Tariff Shocks in a Supply Chain Network

The impact of trade shocks is often different when value-added trade flows are considered. Global value chains present a web of linkages where any sector in a country provides and uses inputs to and from other sectors and countries. These networks imply that shocks to any sector will have direct and indirect implications for other sectors and other countries that feed into or from it. The direct effect is due to bilateral input-output linkages between any two sectors and countries. The indirect effect is linkages going through a third country or sector. Figure 6 (panel 1) provides a simple stylized case showing exports of sector S1 in country 1 to destination country D. Taken at face value, tariffs by country D on country 1 would affect sector S1 in country 1. However, breaking down exports into sources of value added, we can see that such tariffs would affect country 2 and other sectors in country 1 as well (Figure 6, panel 2).

Theoretically, the impact of a trade shock considering global value chain linkages may look different for several reasons. One reason is that different sectors and countries are impacted as discussed in the example above. In linear examples, such as the one described above, total losses may be the same in both gross and global value chain representations, but distributed differently across countries and sectors depending on the organization of production. However, in the presence of nonlinearities, the magnitude of total losses could also differ. For example, if in Figure 6 (panel 2) value-added exports travel from country 1 to country D and back, they would be affected by tariffs in nonlinear ways, and the cascading effect would generate larger reductions in demand and output. In real-world situations, with more than two countries involved, the impact of trade costs under global value chain linkages are likely to be larger than under conventional trade measures. Koopman, Wang, and Wei (2014) explain how global value chains amplify the effects of trade costs, both because goods cross borders more than once

Figure 6. Stylized Visualization of GVC Linkages



Source: Authors' elaboration.
Note: The illustration in panel 1 shows the gross exports from country 1 sector 1 to the destination country (country D), which once broken to source of value added (panel 2) reveals the contribution of other countries and sectors.

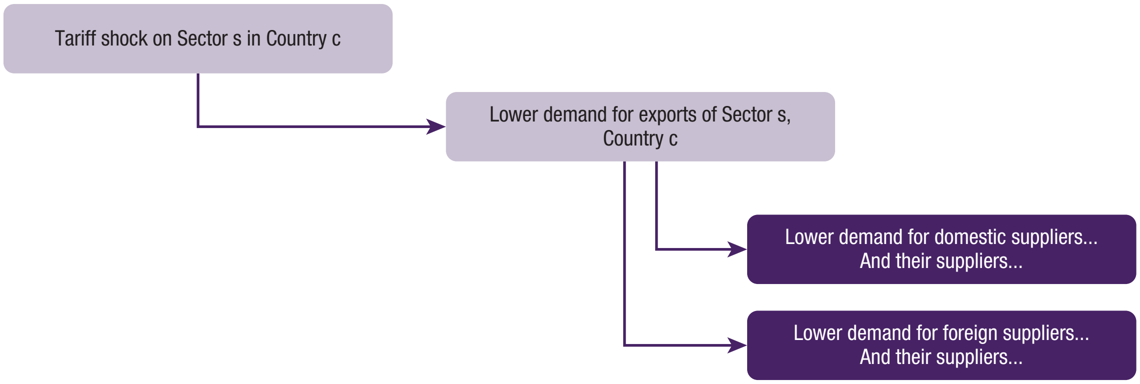
and because tariffs are levied on gross imports. In this exercise, however, these nonlinearities are not factored in.

In this chapter, we use network analysis to illustrate the short-term impact of a hypothetical shock to trade costs in the presence of global value chain linkages. Network analysis is particularly well suited for analyzing shocks under global value chains (Miura 2012) because it generates indicators capturing both the number of linkages between countries and the volume of trade in value added embodied in those links (OECD 2017). In this way, network analysis allows researchers to estimate the output impact of trade shocks after taking into account how "central" a sector or a country is to a global value chain for a particular sector—as a seller of intermediates for the production of exports of a particular product or as a buyer of this particular product as an intermediate for the production of exports.

We consider a scenario in which the United States raises the tariff (τ) on imports of cars and car parts to 25 percent.[1] To gauge all direct and indirect links, we consider the set of all countries exporting cars and car parts to the United States. A tariff of τ percent on exports of country c, sector s (exp_{cs}) would imply a loss of $\alpha \times \tau \times exp_{cs}$ in exports, in which α is based on import elasticities. The part of this loss borne by the exporting country would be $\frac{DVA}{exp_{cs}} \alpha \times \tau \times exp_{cs}$, in which $\frac{DVA}{exp_{cs}}$ is the share of domestic value added in

[1]This potential measure was initially threatened by the US administration in the first half of 2018. The US president and the European Commission president agreed in July 2018 to start negotiations; in the meantime the United States would refrain from raising tariffs. A US report regarding the national security implications of imports of cars and car parts was completed in February 2019, but a decision is still pending as of May 21, 2019.

Figure 7. Tariff Shocks through GVC Linkages



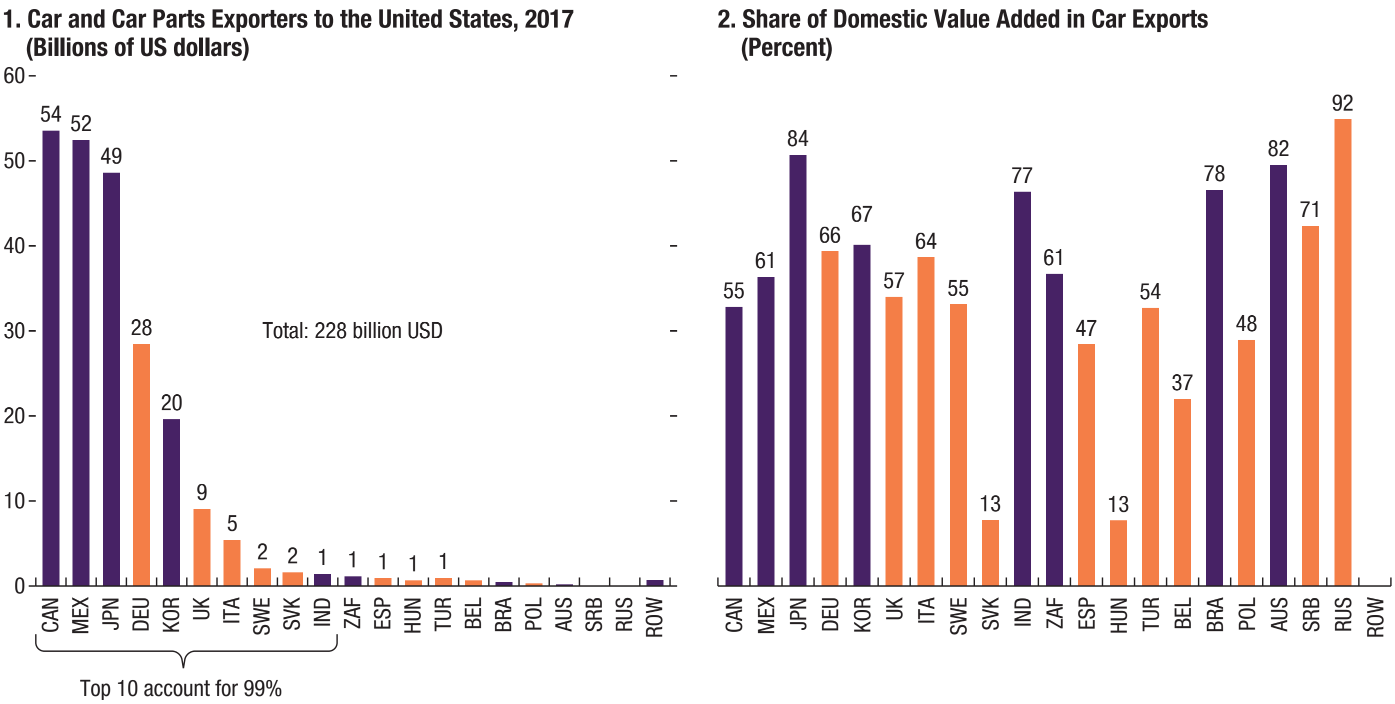
Source: Authors' elaboration.

the exports of cars and car parts. The remaining part $\left(1 - \frac{DVA}{exp_{cs}}\right) \times \alpha \times \tau \times exp_{cs}$ is accrued to the set of foreign country-sectors that comprise the foreign-value-added component of exp_{cs}. Annex 1 presents the details of the calculations.

The import elasticity is taken from estimates found in the literature. For simplicity, in this exercise we calibrate an elasticity of imports to tariffs (α), where a 10 percent tariff on imports of a certain good implies a decline in demand for that good by 8 percent in nominal terms. Our 8 percent calibration falls around the midpoint of the range—0 to 15 percent—often found in the literature (Ossa 2014; Imbs and Mejéan 2010). This is a simplified choice in several ways. Individual country and goods elasticities based on more micro data and taking into account particular product characteristics could vary across countries. The estimates are best viewed as illustrative point estimates, and the losses could be higher or lower depending on the choice of elasticity in a linearly proportional way.

Figure 7 illustrates the various channels through which a tariff shock can impact different countries and sectors. The shock has a domestic impact—on sector *s* directly affected by the tariff, plus on the related sectors that feed into it through the domestic supply chain—and it also has an indirect foreign impact through the foreign suppliers that provide inputs to the sector in that country, which can also be split between the direct and indirect impact. This exercise once repeated over all exporting countries allows us to capture the cascading of losses incurred directly and indirectly by various countries and sectors.

Figure 8. Auto Exports to the United States and Domestic Value Content



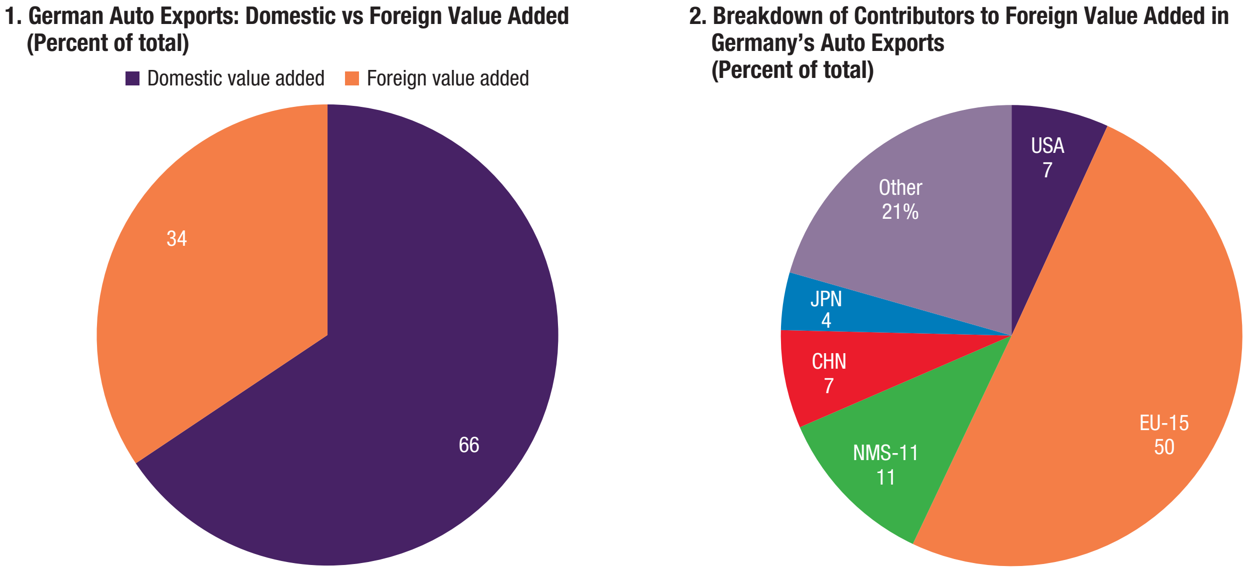
Sources: EORA MRIO database; UN COMTRADE; and IMF staff calculations.
Note: Country list uses International Organization for Standardization (ISO) country codes.

The major car and car part exporters to the United States are Canada, Mexico, Japan, and Germany. As shown in Figure 8 (panel 1) the top 10 exporters accounted for 99 percent of the exports in 2017. Five European countries—Germany, the United Kingdom, Italy, Sweden, and the Slovak Republic—are among the top 10. These export values, however, embody the value added not only by the exporter country but also by other countries in their supply chain. In fact, Figure 8 (panel 2) shows that the percent of value added by the exporting country is generally about 40–70 percent, with large variations across countries. The domestic value-added share is particularly low for the Slovak Republic and Hungary, at 13 percent.[2]

About a third of the value of German car exports can be attributed to other countries in its supply chain. Figure 9 plots the geographic value-added breakdown of German car exports. Other older EU members (the EU15

[2]This figure is based on the EORA MRIO database, and although it is broadly in line with other databases such as the WIOD in aggregate, individual country values could be different. For this exercise EORA is chosen due to the broader country coverage. Please see Antràs and De Gortari (2017) and Aslam, Novta, and Rodrigues-Bastos (2017) for comparisons of the EORA and WIOD databases, which generally find comparable aggregate outcomes based on either database.

Figure 9. Auto Exports to the United States and Domestic Value Content



Sources: EORA MRIO database; UN COMTRADE; and IMF staff calculations.
Note: The scenario assumes a 25 percent tariff imposed on US imports of cars and car parts.

countries—for example, Italy), China, the United States, and the newer EU members (NMS11) are the main providers of value added to Germany. Countries such as the Czech Republic (as part of the NMS11) are exposed to the United States through Germany's supply chain even though its direct car exports to the United States are negligible. On the other hand, countries such as Italy both export directly to the United States and provide inputs to exports of other countries (such as Germany) destined for the United States.

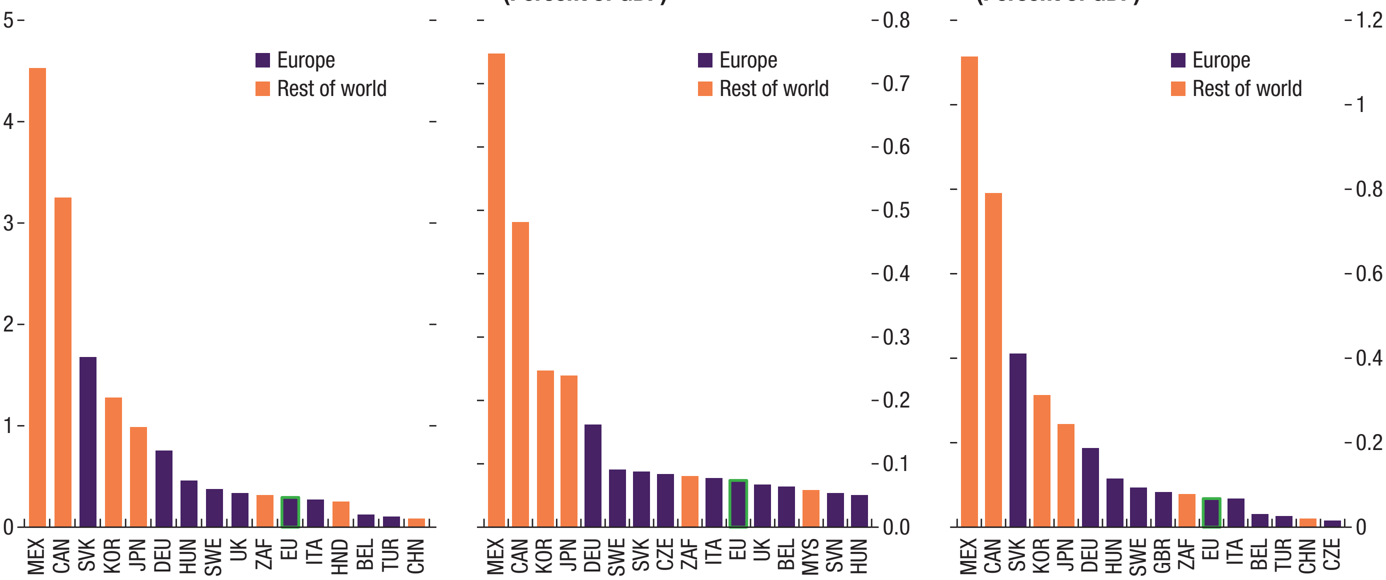
The European countries most exposed to the United States through value chains, such as Germany and Sweden, would be the most affected by a tariff shock on cars and car parts. Gross exports of cars and car parts from the European Union to the United States in percent of GDP are small, roughly 0.3 percent of EU GDP (Figure 10, panel 1). Mapping the export losses of the car tariff shock throughout supply chains reveals that the impact on the European Union is 0.1 percent of GDP. The estimated impact would be larger if some countries were exempt from the tariffs (for example, at least to some extent, if the United States–Mexico–Canada Agreement were ratified) or if confidence and financial shocks were to compound the trade shock. On the other hand, trade diversion might result in a mitigation of the impact, or even a positive impact, as in IMF (2018).

Figure 10. Impact of US Car Tariffs

1. Car and Car Parts Gross Exports to the United States, 2017 (Percent of GDP)

2. Distribution of Losses from United States Tariffs on Imports of Car and Car Parts Using Value-Added Exports (Percent of GDP)

3. Distribution of Losses from US Tariffs on Imports of Car and Car Parts Using Gross Exports (Percent of GDP)

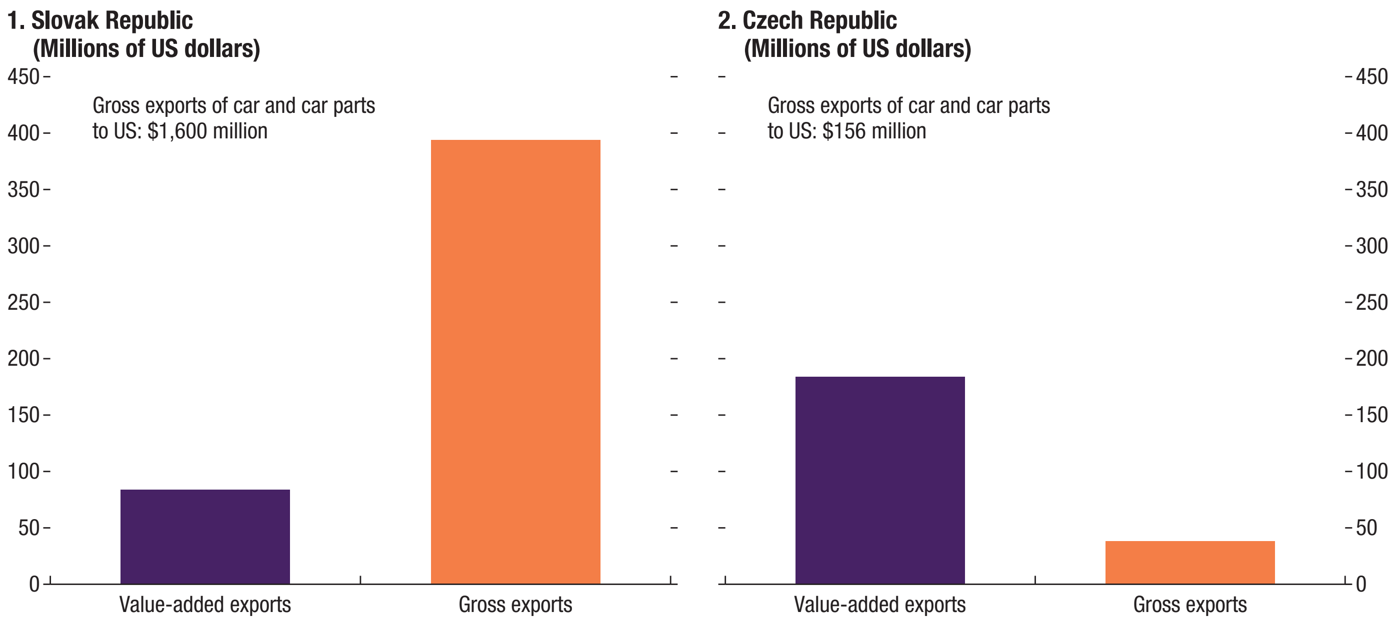


Sources: EORA database; UN COMTRADE; and IMF staff calculations.
Note: The scenario assumes a 25 percent tariff imposed on US imports of cars and car parts. Country list uses International Organization for Standardization (ISO) country codes.

The impact on Germany, the country most affected, is estimated to be about 0.15 percent of GDP. Even in Germany, half of this impact would be related to supply chains. This analysis also shows that the losses are distributed across more European countries than gross export data would suggest and that the order is different. A good example is the case of the Czech Republic. The Czech Republic does not even appear in panel 1 of Figure 10 because its direct car exports to the United States are very small, but it appears as the 4th country potentially most affected by car tariffs when supply chains are fully considered (Figure 10, panel 2). This is because there is a lot of Czech value added embodied in other countries' car exports to the United States. Hungary provides an opposite example: it is the third-largest European country in terms of gross exports of cars to the United States, but the ninth in terms of export losses in terms of value-added export data. The reason for this is that its domestic value added is low.

In Europe, the distribution of output losses from a tariff shock under global value chains could differ significantly from those calculated under gross flows. For some countries, such as the Czech Republic and the Slovak Republic, this difference is particularly important. As shown in Figure 11, it seems that the Slovak Republic, exporting $1,600 million in cars and car parts to the United

Figure 11. Losses Resulting from US Car Tariffs



Sources: EORA database; UN COMTRADE; and IMF staff calculations.
Note: The scenario assumes a 25 percent tariff imposed on US imports of cars and car parts. The purple bars denote losses estimated using value-added exports, whereas the orange bars denote losses estimated using gross exports.

States, is far more exposed to the US trade shock than the Czech Republic, which exports merely $156 million in cars and car parts to the United States. However, value-added flows reveal that the Slovak Republic accounts for only 13 percent of the value of those exports, whereas the Czech Republic has about 50 percent value-added content. Moreover, once we calculate the indirect value added by each of these countries in exports of other countries and sectors, the total loss for the Czech Republic under the scenario of a 25 percent tariff on car imports is higher than for the Slovak Republic in nominal terms (even though losses as a share of GDP would be similar, as shown in Figure 8, given the smaller size of the Slovak economy).

These results are illustrative and are subject to a number of caveats. This chapter makes a strong case in favor of using valued-added export measures instead of conventional trade measures when analyzing tariff shocks. Also, it allows us to carry out granular analyses of sectoral impacts. The main limitation of this chapter is that network analysis mostly represents a short-term estimation, based on several assumptions. For example, it abstracts from the potential policy responses to the introduction of tariffs, confidence effects, nonlinearities, and other potential spillovers that may kick in at some threshold level of disruption. It also abstracts from the trade diversion effect that may take place when exporting countries face higher tariffs in their preferred destinations.

Chapter

4 Price Shocks, Demand for Value Added, and Global Value Chains

Global value chains have changed our understanding of how international relative prices affect countries' competitiveness in world markets. Conventional macroeconomic analysis emphasizes demand-side final expenditure switching as the key channel through which changes in international relative prices affect real economic activity and external balances.[1] For example, consider how a price shock induced by a US tariff on European cars could affect other trading partners. The tariff would increase the price of those European goods making them relatively more expensive, US consumers would switch expenditure away from them, and this would increase the demand for similar cars produced in Asia for instance. But when input trade is important, this conventional logic, which considers only final demand, is incomplete.[2] Because Asia also supplies inputs to European car industries, the lower demand for European cars would also impact upstream Asian producers, potentially reducing demand for their exports. Intermediate expenditure switching may therefore counterbalance the final expenditure-switching channel, so which channel dominates is ultimately an empirical matter (Bems 2014; Bems and Johnson 2017). These intermediate input linkages alter how relative price changes influence international competitiveness—that is, the ability to sell domestic goods, and ultimately domestic value added, on world markets.

This chapter extends the previous analysis by using a partial equilibrium demand system to analyze spillovers in the presence of global value chains. We move from the accounting exercise of the previous chapter, in which

[1]Johnson (1958); Corden (1960); Armington (1969); McGuirk (1987); Marsh and Tokarick (1994); Backus, Kehoe, and Kydland (1993); Obstfeld (2001).

[2]The recent literature has underscored the importance of distinguishing between these types of traded goods. See Bayoumi, Saito, and Turunen (2013); Cheng and others (2016); Bems (2014); Bems and Johnson (2017); and Bayoumi and others (2018).

every country has the same price elasticity of trade, and take the analysis a step further. The rise of global value chains implies that countries specialize in adding value at different stages of production, rather than in producing entire finished products. This means that countries compete over supplying value added to world markets rather than only over final goods or gross exports alone, as in the conventional approach. Therefore, supply chains determine how international relative prices influence the competitiveness of, and hence demand for, domestic value added. The purpose of this chapter is to estimate how sensitive demand for value added is to changes in relative prices and subsequently model the impact of tariffs on countries' demand for value added. To tackle some of the limitations of the previous chapters, the results from this chapter allow countries' reactions to relative price changes to depend on their structure of production and trade. An important limitation of the analysis, however, is that we do not allow all prices to change in response to tariffs. In particular this prevents an analysis of trade diversion effects, which can be important (IMF 2019; Gunnella and Quaglietti 2019).

The chapter also uses alternative measures of trade openness to capture the degree of countries' exposure to shocks. In the previous chapters, we followed most papers in the literature and looked at how tariff shocks could affect countries, depending on their openness and degree of exposure to the originating economy. Acknowledging that conventional indicators such as the ratio of gross exports to GDP are unable to capture the full realities of modern global value chains, we showed that using value-added exports to GDP gave a different picture of the distribution (and potentially also the size) of those shocks. There is, however, an alternative way to provide a meaningful comparison of trade openness. Recent studies (Bems and Johnson 2017; Bayoumi and others 2018) have argued that measures of openness should use consistently either turnover-based or value-added-based measures of economic activity in the numerator and the denominator. Dividing gross exports by GDP mixes a turnover measure of economic activity in the numerator with a value-added measure in the denominator. To correct for this potential source of bias, this chapter relies instead on the ratios of gross exports to gross turnover (GO),[3] while value-added exports are divided by total value added (GDP). Using an appropriate normalization gives us a more accurate picture of countries' exposures to external demand shocks.

By introducing the concept of value-added REER (VA-REER) we illustrate how global value chains affect competitiveness and demand spillovers.[4] Whereas conventional macro trade models used to derive REER indices typ-

[3]Gross turnover is available from national input-output tables and is equal to the sum of intermediate consumption, taxes minus subsidies, transportation margins, and value added. GDP itself can be calculated as the sum of value added across sectors.

[4]For this chapter, we follow Bems and Johnson and use the WIOD database (http://www.wiod.org/release16).

ically look only at aggregate turnover measures of trade (that is, gross trade flows), Bems and Johnson (2017) provide a framework that maps underlying trade in intermediate and final goods into demand for value added. An advantage of the VA-REER is that it allows us to quantify directly the effects of international relative price changes on demand for value added, which more closely relates to GDP, itself a value-added concept.

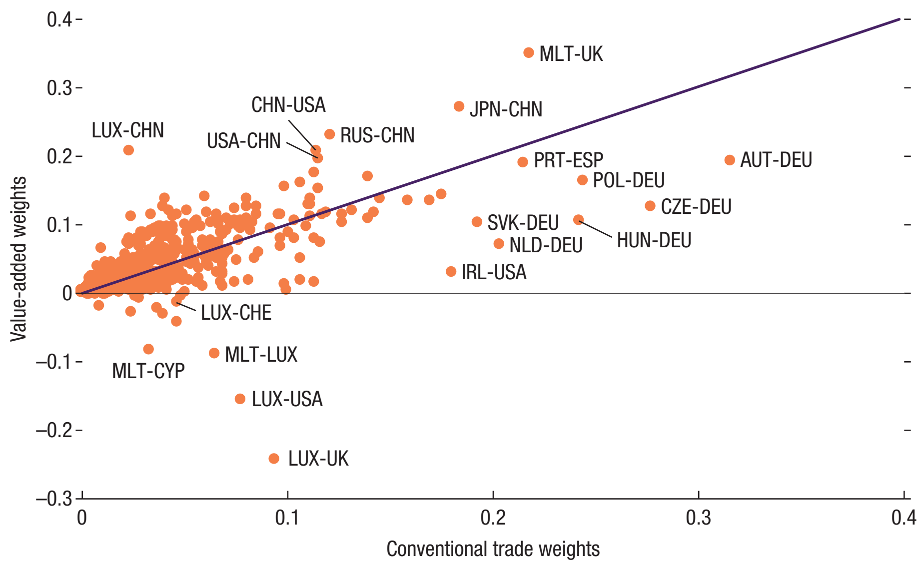
The VA-REER differs from conventional indices of gross output REER (GO-REER) along three main dimensions.[5] A first difference is in terms of the weights assigned to trading partners—that is, the impact of relative price changes on countries' own cost-competitiveness as measured by the REER. A second important distinction is in the degree of substitutability between imports from various partners and a country's own inputs, value added, and final goods. The third main difference is in terms of the degree of openness to trade.

- A first difference between conventional and VA-REERs is that partner weights reflect the extent of trade in value added. The use of "double-export" weights captures the degree of head-to-head competition between two countries in each destination, including their respective markets, scaled by the export share of each market.[6] For countries that trade intensively across highly integrated supply chains, the value added embodied in each production step is often much lower than the turnover value of trade. In these cases, partners will tend to have lower VA-REER weights, implying that countries in regional supply chains (such as the European internal market) compete less with each other than could be inferred by looking only at gross exports. In some cases, weights can even be negative, so that countries would be complements, as opposed to substitutes, in global trade. Some European countries participating in German supply chains are such an example. This is especially the case for countries that provide financial services (considered intermediate services or goods) to large exporters—for example, Luxembourg, Malta, and Cyprus. The intuition for negative VA-REER partner weights relies on the intermediate expenditure-switching effects discussed above: an increase in the price of value added from exporting country *i* raises downstream country *j*'s cost of

[5]An additional difference between VA-REER and GO-REER is the price measure used in REER indices. Many conventional indices rely on the consumer price index to capture changes in relative prices, consistent with the emphasis on trade in final goods and the expenditure-switching channel. The VA-REER, however, relies on changes in the GDP deflator, a more accurate measure of the price for value added. See Bems and Johnson (2017) for further discussion.

[6]In the conventional framework, these weights are determined by gross trade flows. In the VA-REER framework, however, the weights reflect trade in value added—namely, the amount of value added originating in one country that is ultimately used in another (Koopman, Want, and Wei 2014; Aslam, Novta, and Rodrigues-Bastos 2017).

Figure 12. VA-REER vs GO-REER Partner Weights

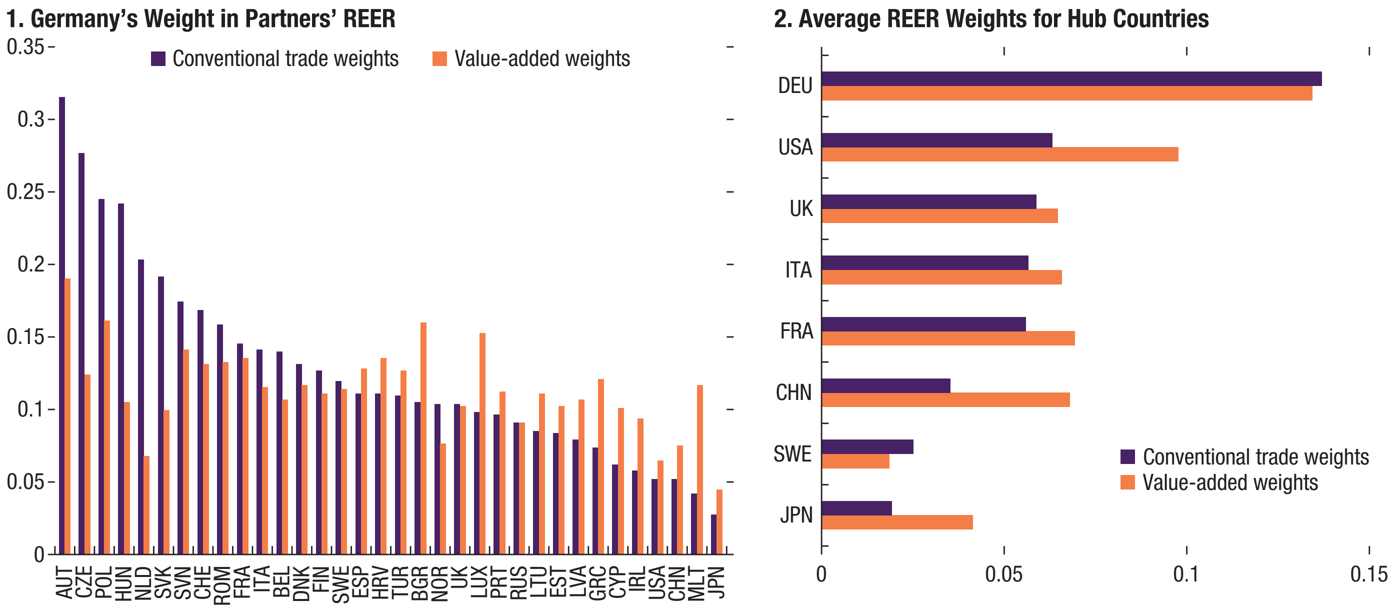


Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: GO = gross output; REER = real effective exchange rate; VA = value-added. Country list uses International Organization for Standardization (ISO) country codes.

production and hence diminishes demand for its own value added (Bems and Johnson 2017).

- Although overall value-added weights are highly correlated with conventional REER weights, differences tend to be larger for small, open economies. Another feature of value-added weights is that large, but remote, economies such as the United States and China, tend to become more important trading partners in value-added terms than in conventional trade terms (Figure 12). Relatedly, countries' exposures to competitiveness shocks are less concentrated under a value-added framework than in gross trade flow terms, as seen also in the previous chapter. One such measure is the weight assigned to the largest trading partner. On average across countries, conventional weights of the largest trading partner were 16 percent larger than value-added weights in 2000. In 2014, they were 32 percent larger. This implies less vulnerability to shocks in partners' price levels than conventional indices would suggest.
- The importance of Germany as the core hub country in Europe's trade is smaller when measured in value-added than in conventional terms, whereas the importance of the United States and China is relatively greater. Germany's weight in the VA-REER index of the Czech Republic, for instance, is more than twice as small as its conventional GO-REER weight. This confirms our earlier finding that European value-added exports to Germany were typically smaller than gross exports (see Figure 5). The differ-

Figure 13. German and Hub Countries REER Weights



Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: Panel 1 shows the weight of Germany in each European country's REER index. Panel 2 shows the average weight of selected large trading hubs in European partners' REER indices. Country list uses International Organization for Standardization (ISO) country codes.

ence is also reflected in other central and eastern European economies, such as Poland, the Slovak Republic, and Hungary. More broadly, Germany's weight in the VA REERs is about 10 percent lower than in gross trade terms among its trading partners in Europe (Figure 13, panel 1). Unlike the case for Germany, value-added REER weights are almost 50 percent larger on average than conventional weights for many trading hubs outside Europe, such as the United States, China, and Japan (Figure 13, panel 2). This reflects the fact that trade between these large hubs and European countries consists relatively more of final goods with higher value-added content than typical bilateral trade flows. These differences confirm the importance of using value-added exports, as opposed to gross exports, for an accurate measure of competitiveness (Box 4).

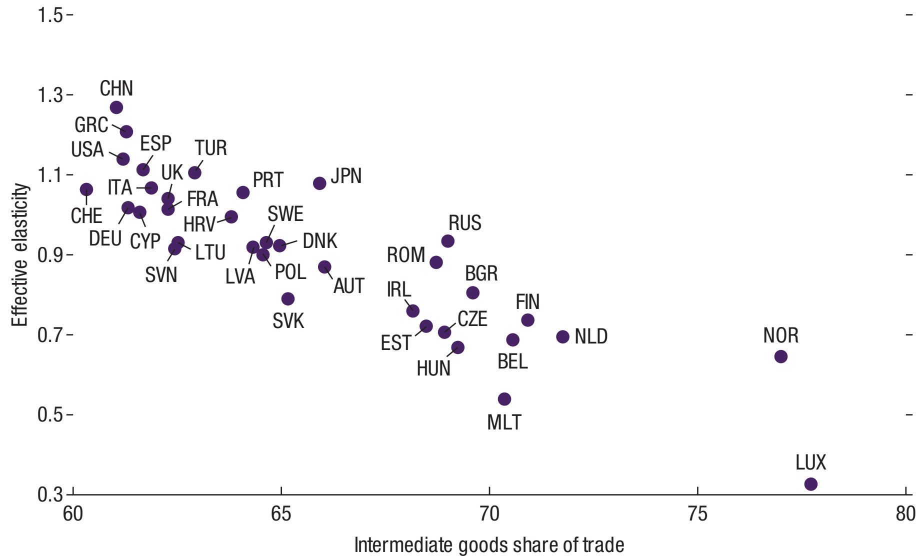
- A second key difference between the two frameworks is the effective degree of substitutability between goods originating in different countries. In the conventional REER framework, the elasticity of substitution (EoS)—that is, the degree to which countries adjust the composition of their imports in response to relative price changes—is fixed and equal across countries by assumption. In the VA-REER framework, the effective EoS, meaning the degree to which countries substitute value added by country of origin in response to relative price changes of value added, varies by country.

The three main determinants of the size of the effective EoS are first, the relative size of the EoS for final and intermediate goods—with final demand typically assumed to be more elastic than demand for intermediate goods, which are often traded in supply chains featuring little short-run flexibility. For the subsequent analysis, we make the assumption of Leontief production so that elasticities of substitution in production are zero. This provides a good characterization for some of the short-run effects of price shocks, since supply chains can take time to reconfigure in response to relative price changes of inputs.[7] The second main determinant is the relative importance of final and intermediate trade in total trade flows. The third determinant is the size of market shares in value-added terms. In our sample of 32 European countries for this chapter of the paper, the effective EoS varies between 0.3 and 1.2 across countries in the latest year for which we have input-output data.

- The effective elasticity of substitution is lower for countries that trade relatively more in intermediate goods. This is because it is typically harder to substitute away from trading partners within the same supply chain due to the need for close relationships between producers and their suppliers. For instance, specialized economies such as those of Luxembourg and Malta tend to have lower effective EoS since financial services represent business inputs with limited short-run substitutability for their larger partners (Figure 14). Countries with relatively lower market shares, when measured in value-added terms, than in gross trade flows also tend to have lower effective EoS. Large and more distant economies such as China, the United States, Japan, and the United Kingdom typically display larger EoS since they have larger market shares in value-added terms. This allows them to substitute more easily to third countries when relative prices change.
- A final key difference between the conventional and the value-added frameworks is the degree of trade openness. As shown in Figure 15, countries are more open in value-added terms than in gross trade flow terms. The reason is that firms trade more in intermediate consumption and less in value-added terms within countries than between countries. As a consequence, indicators based on value-added measures show more openness than the analogous measures defined in gross turnover terms. This is a subtle but important result since more openness in value-added terms also translates into more responsive demand to relative international price changes. In 2014, the share of domestic value added used abroad was about 70 percent larger on average than the analogous measure based on gross output. Despite lower EoS, higher shares of intermediate trade resulted

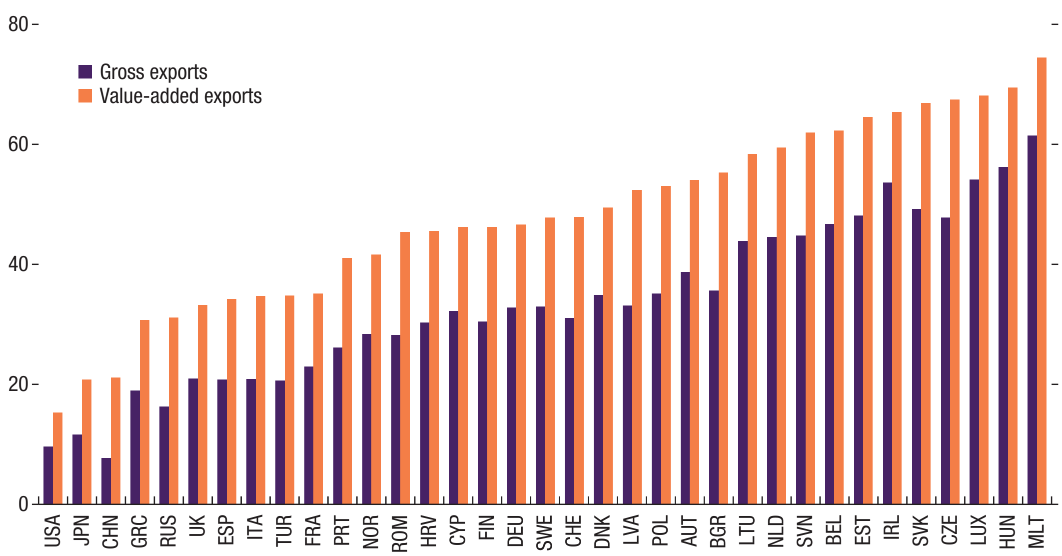
[7]The calculations assume nested constant elasticity of substitution (CES) demand with a final demand EoS of 3 and Leontief production elasticities—between differentiated inputs and between total inputs and domestic value added—of zero. Bems and Johnson (2017) and Bayoumi and others (2018) discuss calibration of these parameters.

Figure 14. Effective Value-Added Elasticity of Substitution



Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: Country list uses International Organization for Standardization (ISO) country codes.

Figure 15. Trade Openness in Value-Added and Conventional Terms
(Percent)



Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: Gross exports denotes the ratio of gross exports over gross turnover. Gross turnover is the sum of all intermediate and final goods transactions that occur across sectors in an economy. Value-added exports denotes value-added exports over gross value added. Country list uses International Organization for Standardization (ISO) country codes.

in demand for value added that was about 50 percent more responsive to relative price changes than demand for gross output.

The model proposed by Bems and Johnson can be used to relate changes in relative international prices to changes in aggregate demand.[8] The framework can be especially useful to compare some of the short-run impacts of tariff-induced price shocks on the demand for gross trade and value-added flows.[9] However, since the model considers only the demand side of trade—holding the supply side fixed—the impact of price changes across countries should be viewed as short-run partial equilibrium effects. In particular, the model does not allow for trade diversion We also omit other considerations that can be important at a business cycle frequency, such as confidence effects (see IMF 2019) and Ebeke and Siminitz (2018). We illustrate the effects of trade tensions, contrasting how demand for gross and value-added trade responds to the introduction of new tariffs. To do so, we analyze the effect of a 5 percent tariff imposed by the United States on its imports across the board, with retaliation by all countries using the same tariff. A 5 percent tariff was chosen to simulate what would happen to countries' exposure to the United States if it decided to increase its average tariff level to the average level of tariffs maintained by China during the past decade.[10] For simplicity, we assume full pass-through of a country's own tariff to its own prices.[11] We also make the simplifying assumption that prices and demand for countries' exports are not affected by the tariffs imposed on other countries. Importantly, this limitation in our approach precludes an analysis of trade diversion, which is potentially important (IMF 2019). Although we run the model for the whole sample of countries, we focus our analysis of results on European countries.

The impact of a 5 percent tariff on all US imports would be an average decrease in the demand for European value added of about 0.2 percent. The impact in terms of demand for gross output would be 0.1 percent. This negative impact is larger than in the car tariff scenario of the previous chapter because in this scenario tariffs are applied to all sectors across the board, and there is a cumulative effect of retaliatory responses. Once again,

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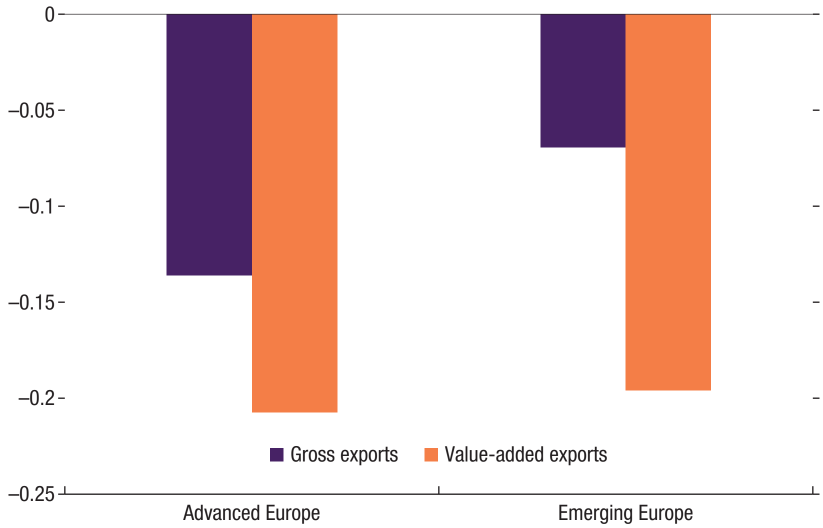
[8]See Annex 2 for a description of the demand equations relating relative prices and demand for goods.

[9]We use the Matlab code provided in the online additional materials of Bems and Johnson (2017) to calculate gross and value-added trade flows, partner weights, effective elasticities of substitution, and demand spillovers https://www.aeaweb.org/articles?id=10.1257/mac.20150216). We rely on the 2016 vintage of the World Input-Output Database (http://www.wiod.org/database/wiots16) to conduct the analysis for 43 countries, from 2000 to 2014. Bilateral exchange rates, the consumer price index, and the GDP deflator are taken from the *World Economic Outlook*.

[10]For average tariff rates across the world, see https://data.worldbank.org/indicator/TM.TAX.MRCH.WM.AR.ZS.

[11]This means a 5 percent tariff increases the value of the relative price index for gross output of country *i* from 100 to 105. See Annex 2 for details.

Figure 16. Change in the Demand for Valued Added of Advanced and Emerging Europe after a 5 Percent US Tariff
(Change in demand, percent)

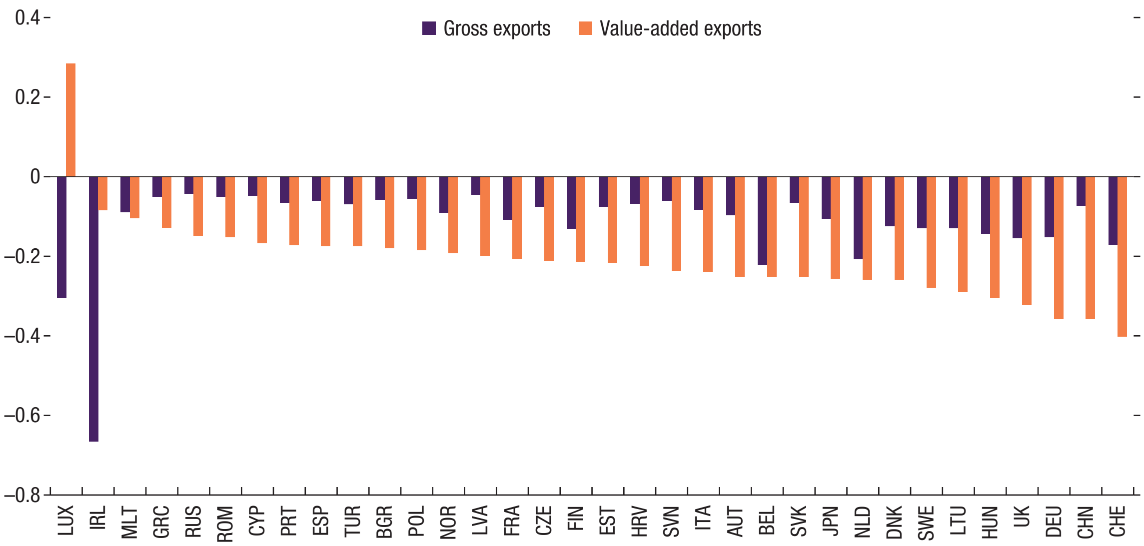


Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: The effect through gross exports reflects the direct exposure of partner countries to the US and vice versa, and is measured in percent of gross turnover. The value-added exports are divided by GDP.

these results show that measuring the impact of tariff shocks in value-added terms provides a better sense of the size and the distribution of the impact on Europe. On average the decline in the demand for Europe's output is 50 percent higher when the 5 percent tariff shock is measured in value-added terms than when measured in gross terms. Demand for both advanced and emerging market European economies is affected in a broadly similar way. But the difference between the estimated impact in value-added terms and in gross terms is three times larger for emerging Europe (Figure 16). As for the countries around the German value chain, the decline in demand after the US tariff is twice as large in value-added terms as in gross terms for Germany, but this difference is three times larger for Poland and four times larger for the Czech Republic, Slovenia, and the Slovak Republic.

Our results show that European countries are 50 percent more exposed to the United States in value-added terms than in gross trade terms. Almost all European countries, with the exception of Luxembourg, Ireland, and Malta, would suffer a larger decline in demand in value-added terms than in gross terms, following a US tariff increase (Figure 17). This is in part because the United States is a more important destination market for final goods than for intermediate goods. Another reason discussed earlier is that European countries are also generally more open in value-added than in gross flow terms. The countries least affected are countries that provide large exports of finan-

Figure 17. Change in the Demand for European Countries' Value Added after a 5 Percent US Tariff
(Change in demand, percent)



Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: The effect through gross exports reflects the direct exposure of partner countries to the US and vice versa, and is measured in percent of gross turnover. The value-added exports are divided by GDP. Country list uses International Organization for Standardization (ISO) country codes.

cial services. In the case of Luxembourg, the effect is even estimated to be positive in the short run as more domestic activity in the United States leads to more demand for financial services exports.

In summary, this chapter has used the concept of demand for value added to illustrate how global value chains affect demand spillovers. Using this approach, the chapter has arrived at the following conclusions. First, partner weights differ when value-added exports are used instead of gross trade flows, with lower weights given to country pairs that trade intensively in intermediate goods. Second, different trading patterns give rise to different degrees of substitutability, unlike the conventional framework, which typically assigns constant elasticity of substitution across countries. Finally, the framework clarifies the definition of trade openness when using either gross trade flows or value-added exports. Important insights from other chapters are confirmed here—namely, that there is less competition between countries joined in regional value chains, such as those in the European single market. Notably, Germany is less important in value-added terms for countries in eastern Europe than implied by a gross trade flow analysis. The chapter also provides evidence that countries are more exposed to US-based tariffs in value-added terms than in gross trade and output terms.

Box 4. Value-Added Real Effective Exchange Rates in European Countries

We compare the value-added real effective exchange rate (VA-REER) with the conventional REER for European countries to illustrate the difference between the two measures. The figures below show the path of both REER indices for selected advanced and emerging European economies. Even though the indices display high comovement over time, cumulative gaps emerge in several countries, with VA-REER indices showing more real appreciation than conventional indices (gross output real effective exchange rate, GO-REER) for most countries. The gaps peaked in 2008, reaching almost 10 percentage points on average, before declining as most European countries improved competitiveness relatively more in value-added terms than in gross trade flow terms following the global financial crisis.[1] On average, in 2014, European countries remained 6 percent less competitive in value-added terms relative to their competitiveness in 2000 (Box Figures 4.1 and 4.2). This average hides substantial variation across countries. For example, Romania and Russia are about 30 percent less competitive in value-added terms relative to the conventional measure, while Ireland is 13 percent more competitive according to the VA-REER. This pattern holds more generally as emerging economies were substantially less competitive in value-added terms than in gross trade flow terms, compared to advanced economies.[2] Finally, the competitive imbalances were more pronounced in value-added terms: the standard deviation of the VA-REER index was 45 percent larger in 2014 than the GO-REER.

[1]Bems and Johnson (2017) decompose the source of the REER gaps in terms of relative price changes, effective elasticities, and partner weights.

[2]The Netherlands, Spain, Germany, the Slovak Republic, Turkey, Greece, and Ireland were deemed more competitive in value-added terms in 2014.

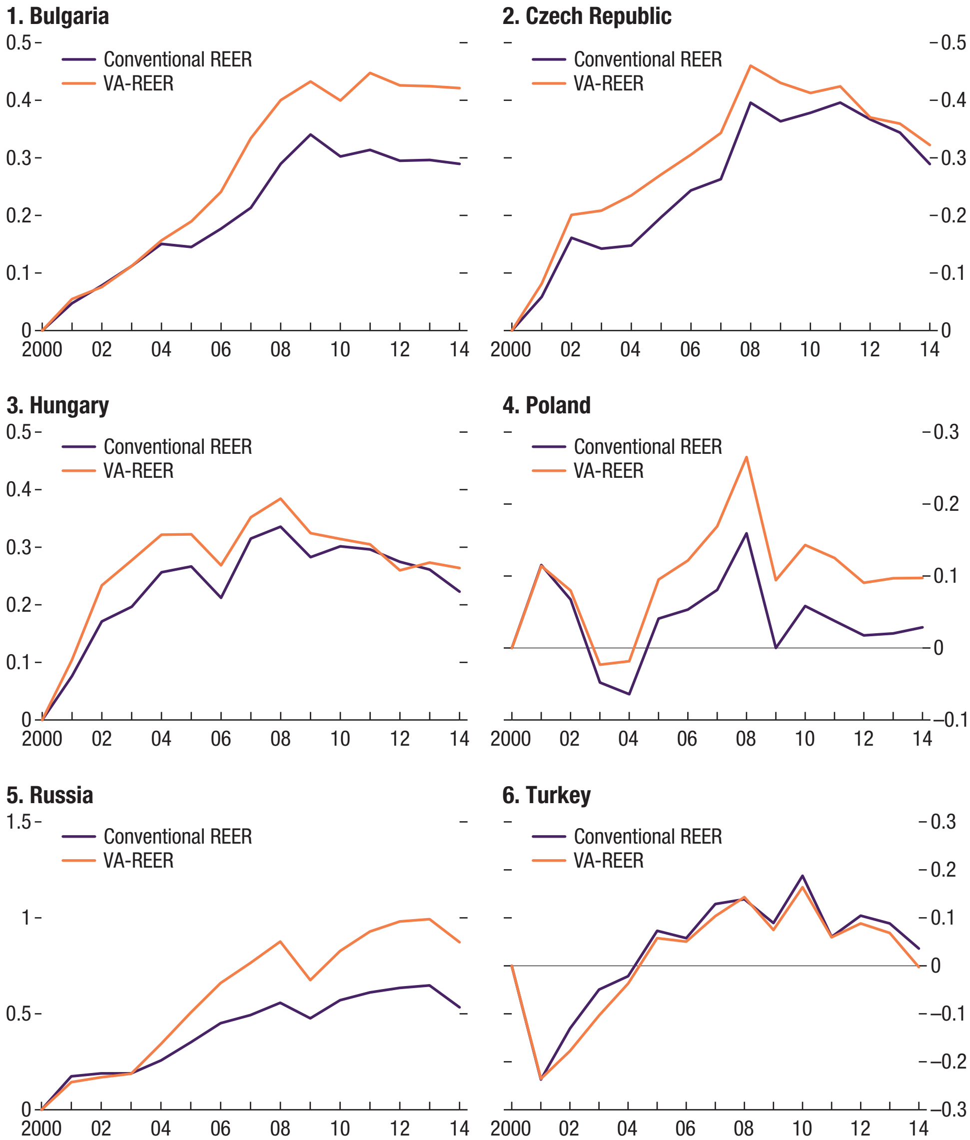
Box 4. Value-Added Real Effective Exchange Rates in European Countries *(continued)*

Box Figure 4.1. REER Indices, Selected European Countries
(Index, log levels)

Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: REER = real effective exchange rate.

Box 4. Value-Added Real Effective Exchange Rates in European Countries *(continued)*

Figure 4.2. REER Indices, Selected European Countries



Sources: Bems and Johnson 2017; Timmer and others 2015; and IMF staff calculations.
Note: REER = real effective exchange rate.

Chapter

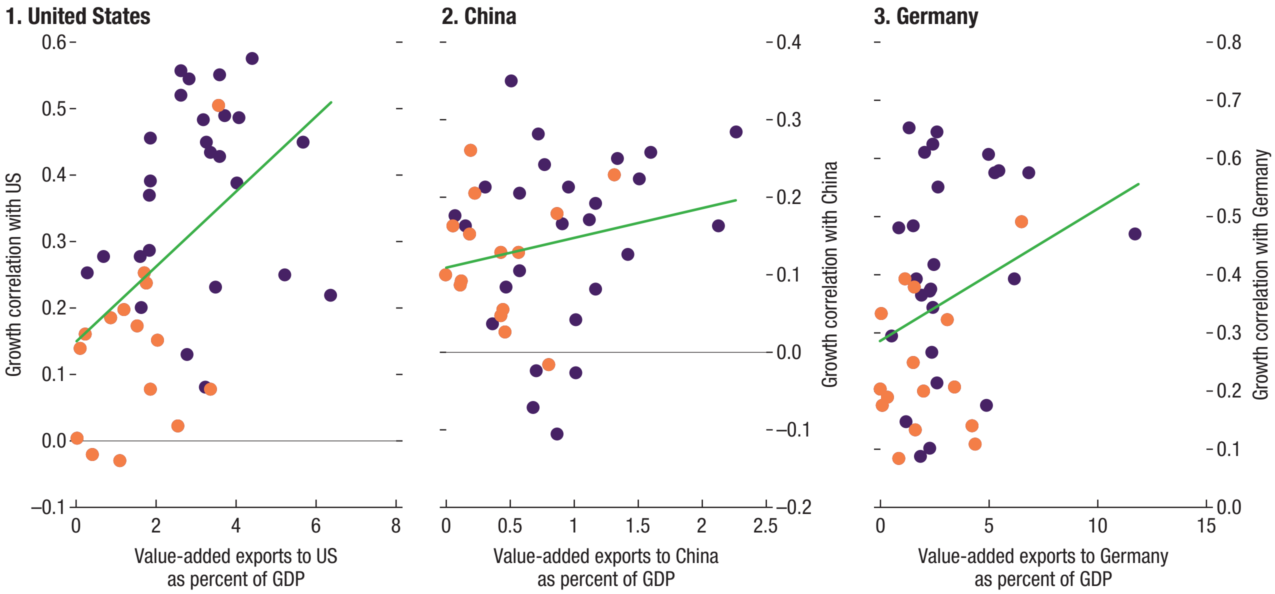
5 Growth Spillovers in the Presence of Global Value Chains

The last chapter of this paper offers a more general perspective and studies how growth shocks could affect economic activity in the presence of global value chains. Because protectionist measures can elicit retaliatory responses from trading partners, generate uncertainty that can lower investment, and can be compounded by confidence and financial shocks, trade tensions could weigh on global trade and eventually result in a slowdown in growth, especially in countries that are directly involved.[1] Under this premise, the objective of this chapter is to understand how, after accounting for global value chain exposures, major economies' growth slowdowns are transmitted to their trading partners.

We use a macroeconometric framework to estimate the spillovers of growth shocks originating in the United States, China, and Germany to European economies via global value chains. The shocks that we consider are growth shocks in the three trade hub countries (United States, China, Germany), which we also refer to as spillover source countries. For the spillover destinations, our primary focus is on European economies. The macroeconometric framework used in this chapter to explore the dynamic impact of growth shocks complements the analyses in previous chapters that look at the static impact of shocks. In addition, the spillovers presented here are based on econometric estimates, whereas the previous chapters use a calibrated approach. It is important to note that the growth shocks we consider here are much more general than the tariff shocks presented in the earlier chapters. For example, growth shocks could also embody other fundamental drivers such as fiscal, monetary, and financial shocks (for a discussion of these drivers, see IMF 2013b). Accordingly, the growth slowdown due to pure tariff shocks would be generally smaller than the growth shocks considered here.

[1]IMF (2018) discusses several channels through which trade tensions can affect economic activity. Ebeke and Siminitz (2018) analyze the impact of trade policy uncertainty on investment in the euro area.

Figure 18. Growth Correlations and Value-Added Exports



Sources: EORA MRIO database; and IMF staff calculations.
Note: The *x*-axis in the panel 1 shows value-added exports to the US as percent GDP. The *y*-axis shows correlations between US quarter-over-quarter growth and growth in European economies during 1995–2018. Panels 2 and 3 show similar analysis for China and Germany, respectively.

Nevertheless, countries' bilateral value-added trade exposures are likely to impinge on the relative magnitude of the spillovers, which we estimate below.

Simple scatterplots suggest that growth correlations are positively associated with the degree to which European economies are exposed to hub economies in value-added terms. Figure 18 presents the growth correlations between European countries and the three hub countries (United States, China, Germany) against the respective value-added exports to these hubs as measure of trade exposure.[2] The positive trends in the scatterplots suggest that, on average, the greater the value-added exports of an economy to each of the trade hubs, the greater the growth correlation between that economy and the respective hub country.[3]

[2]The trade exposure of an economy to the United States, for instance, is defined as value-added exports of that economy to the United States as percent of that economy's GDP. See Table 2.

[3]There is a rich set of literature that looks at the role of trade for business cycle synchronization and spillovers (for example, Frankel and Rose 1998; Baxter and Kouparitsas 2005; Imbs 2004; Inklaar and others 2008; Iacoviello and Navarro 2018). Most of these studies have, however, relied on gross trade data (conventional trade). The role of global value chains, despite its increasing relevance, has received scant attention in the literature. Recent work (for example, Duval and others 2016) suggests that supply chain linkages are important for business cycle synchronization. We extend this relatively new work stream by exploring the role of global value chains for growth spillovers.

We use a two-step procedure to estimate growth spillovers, defined as the effect of country-specific shocks on growth outcomes in other countries after controlling for common shocks. Business cycle comovement can be driven either by common shocks or spillovers, and hence controlling for common shocks is important for a proper assessment of spillovers (IMF 2013b). In the context of our exercise, controlling for common shocks is set up to yield orthogonal country-specific growth shocks which then helps us to meaningfully compare spillovers from the three hub countries. We proceed in two steps. First, we estimate country-specific growth shocks as the residual growth after purging cross-country commonalities in growth.[4] Second, we trace the effects of these shocks on growth in other economies, that is, spillovers, using a local projections model. Here, we allow model variables to interact with the share of bilateral value-added exports. This yields a framework where spillovers depend on the extent to which an economy is exposed to the hub countries in value-added terms. This is what makes our approach novel.

For the first step, we use principal components analysis (PCA) to estimate the common components. The model is estimated using GDP (quarter-over-quarter) growth for a panel of 68 economies during the first quarter of 1995 and the third quarter of 2018.[5] In our implementation, we estimate three principal components which account for much of the cross-country commonalities in growth.[6]

Country-specific shocks are then calculated as the residual growth after purging the effects of these estimated common components. It turns out that growth shocks calculated in this manner are close to orthogonal, which suggests that common factors affecting growth simultaneously in countries across the world are largely purged. For instance, the correlations between the estimated US, Chinese, and German-specific growth shocks are close to zero, thus reassuring that the model can yield independent exogenous variations in growth in each of the spillover source countries.

The second step uses a local projections model. Based on Jordà (2005), we follow the implementation of the model done by Iacoviello and Navarro (2018). Previous studies on spillovers have deployed vector autoregressions

[4]The methodology is similar to the one used in IMF (2013b) which computes the exogenous growth shock for an economy as the residual growth after purging out the effects of average growth over time of that economy and growth in the rest of the economies at a given point in time.

[5]The sample starts in the first quarter of 1995 since this is the earliest period for which a balanced panel can be compiled for the countries we cover. In addition to the European economies, the panel includes the major advanced as well as emerging market and developing economies, thus providing a global representation. The latter is crucial since we want to capture the common shocks in the first step.

[6]The three principal components, on average, explain about 28 percent of the variance in GDP growth. The first principal component explains the bulk of the variance, about 21 percent. For robustness, we estimate a version of the PCA model with only the first principal component. It yields very similar residual growth shocks.

(VARs), global VARs (GVARs), and panel regressions.[7] Standard panel regressions provide only static spillover effects; local projections, on the other hand, provide a dynamic profile. The local projections framework provides a flexible alternative that does not impose dynamic restrictions implicitly embedded in multivariate systems like VARs or GVARs and can conveniently accommodate nonlinearities in the response functions (Jordà 2005; Auerbach and Gorodnichenko 2013). We exploit this feature of the local projections model to explore nonlinearities associated with the importance of value-added exports—that is, how the size of growth spillovers depends on the level of trade exposure in value-added terms. For example, in the model that is used to measure spillovers from the United States, exogenous US growth shocks from the first step are interacted with the rest of countries' value-added exports (as percent of GDP) to the United States.[8]

In this setup, the spillover impact of US growth shocks depends on the level of trade exposure in value-added terms. We illustrate this dependency by presenting spillover estimates for a "median" European economy whose level of value-added exports is at the median in our sample, and for a "high-exposure" economy whose value-added exports is at the 90th percentile. The model is estimated as a panel using the same period (1995:Q1 and 2018:Q3) as in the first step, but only for the European economies as spillover destinations so as to facilitate a more straightforward Europe-specific inference. We estimate a similar version of the model for spillovers from China and Germany. Annex 3 presents the details of the local projections model.

It is important to note some caveats about the framework used. First, while this framework allows us to carry out a meaningful comparison of growth spillovers originating from the hub countries, the extrapolation of the analysis to ongoing trade wars is not straightforward, given that tariff increases in one of the hub countries could affect all economies simultaneously. At the same time, addressing this issue by working with global rather than country-specific shocks would yield estimates of spillovers from a systemic country that are overstated (see IMF 2013b). Moreover, spillovers can operate beyond trade, for example, via financial, commodity prices, and confidence channels.[9] Second, we estimate the spillover impact of a 1 percent country-specific growth shock in the hub countries. A shock of such a size could result from a tariff shock larger than those considered in Chapters 3 and 4 or from a similar tariff sock that is compounded by additional shocks, such as, for example, financial shocks: hence, the results of this chapter are

[7]See World Bank (2016) for a survey.

[8]The propagation of common shocks is a relevant question. It is, however, unclear what the interaction term should be if one were to estimate the effects of common shocks using the framework.

[9]See, for instance, World Bank (2016), Rey (2015), Miranda-Agrippino and Rey (2017), Bruno and Shin (2016) for a discussion.

not strictly comparable to those of earlier chapters.[10] Finally, a shock from a large systemic country could influence output in the rest of the world, which would then feed back to its growth, thus scaling up the spillovers to destination countries.

Spillovers from the United States, China, and Germany

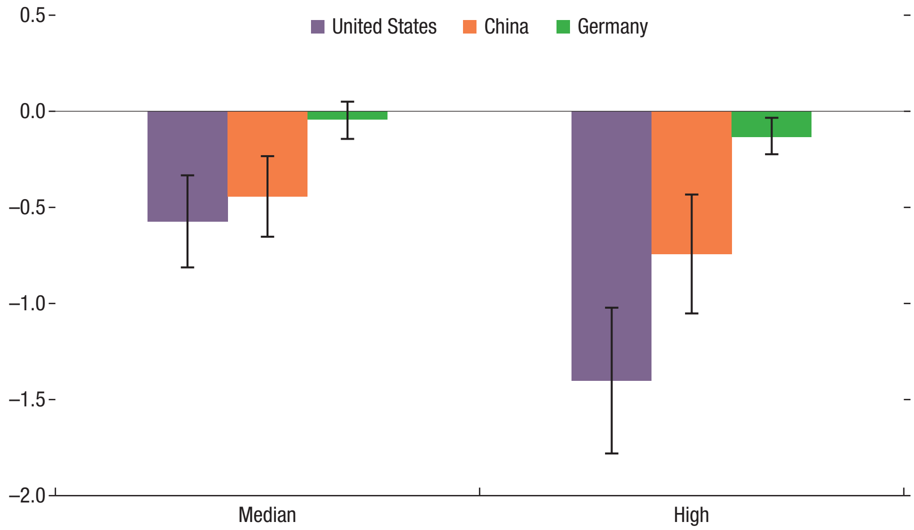
The estimated size of growth spillovers from the United States are sizable and larger than those from China. Figure 19 compares the peak cumulative impact of exogenous growth shocks originating in the three hubs countries on the median European economy, as well as the high-exposure European economy. Results can be summarized as follows: for the median European economy, a 1 percent negative US growth shock would have a peak cumulative growth impact during a two-year horizon of about –0.6 percentage point, similar to estimates in other studies (see IMF 2013b). For the high-exposure European economy, the estimate is higher, at about double that for the median economies (–1.4 percentage points), which underscores the point that more exposed economies are hit harder by a US growth slowdown. Note that these estimated cumulative impacts on European countries reflect the buildup of US shocks over time. The dominance of the United States as a spillover source reflects its economic size and integration in global trade and finance. As a result, the reduced form framework used here, via feedback effects with the rest of the world and the impact of other channels, would result in higher estimated spillovers than from a pure higher tariffs shock (see caveats earlier). Spillovers from China are also sizable, but smaller than those from the United States.

Growth spillovers from Germany are estimated to be much smaller than those from the United States and China. The spillover effects of a 1 percent negative German growth shock on the median European economy are not statistically significant. Even for the high-exposure European economy, the peak cumulative impact, though statistically significant, is quite small at around –0.1 percentage point.

Although Germany remains a key hub for intra-European trade, several factors help reconcile the estimated small size of spillovers from Germany. First, *other channels* are likely at play. For example, the larger estimated size of spillovers from the United States relative to Germany could reflect the role of other channels, such as finance, where the United States is a dominant player in the world (as noted above, these are not modeled explicitly in our frame-

[10]Mapping the size of the tariff shocks in the previous chapters to the size of the growth shocks is not straightforward. Hence, without loss of generality, we simply take a unit growth shock that allows an easy comparison across the hub countries.

Figure 19. Spillover Comparison by Source Countries

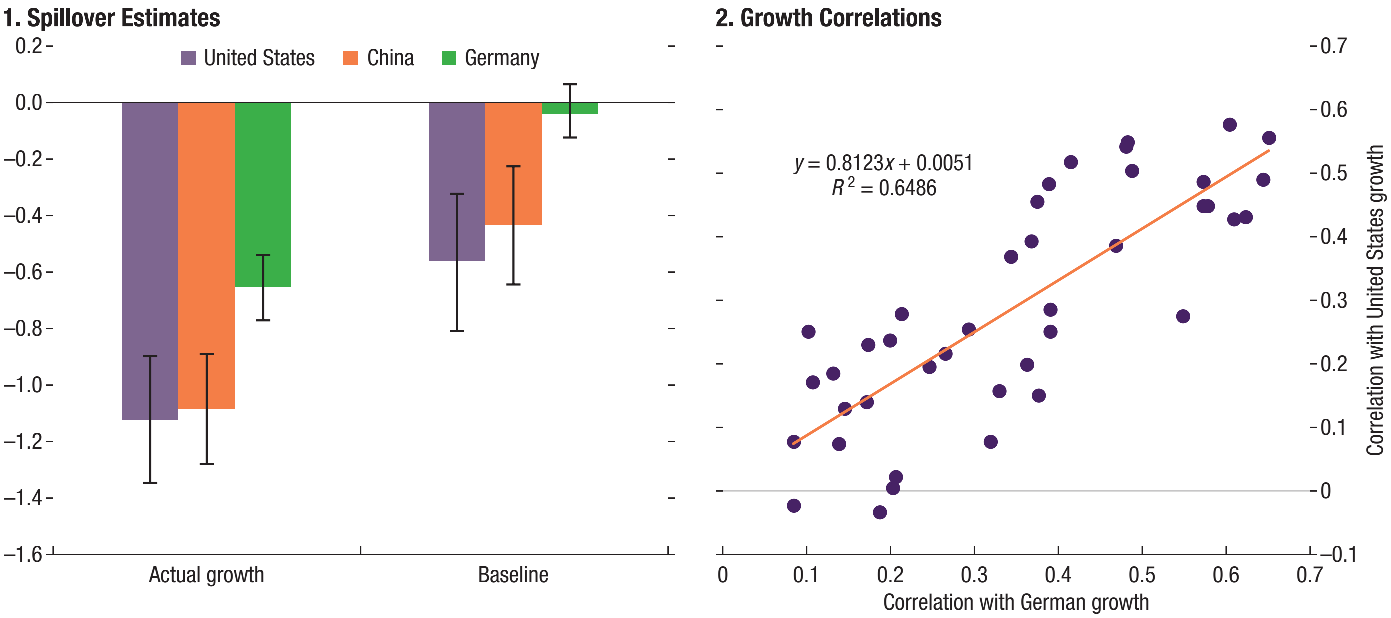


Sources: IMF, *World Economic Outlook*; EORA database; Haver Analytics; and IMF staff calculations.
Note: Peak cumulative impulse response to a 1 percent negative growth shock in US, China, and Germany. Median refers to response of a median European economy with median level of value-added exports. High refers to a "high-exposure" European economy with exposure at the 90th percentile of the distribution. Bars denote the point estimates and errors bars denote 2 s.d. deviation confidence bands.

work). Second, *economic size* matters. The German economy is only about one-fifth the size of the US economy and less than one-third that of China. Thus, shocks from these two countries would have a larger impact on European economies than those from Germany (Elekdag and Muir 2013). Third, *large autonomous domestic demand* matters as well. Economies that generate the largest estimated outward spillovers are the ones in which growth is to a larger extent driven by autonomous sources of domestic demand, such as the United States and China. In contrast, countries which themselves are highly sensitive to external shocks, such as Germany, tend to generate relatively small independent outward spillovers. It is important to note that the growth shocks that we consider are already stripped off the common shocks, and hence they only reflect exogenous growth shocks that originate specifically in Germany. Our results suggest that Germany has not been a major source of independent shocks during the post-1995 period that is analyzed in this chapter. Overall, this finding is consistent with other studies that show that Germany is not an important independent source of large shocks itself (Poirson and Weber 2011).

Estimates without controlling for common shocks show that spillovers from Germany remain smaller than those from the United States and China. To implement this robustness check, we estimate the model in one step by replacing the exogenous growth shocks in the hub countries with their actual

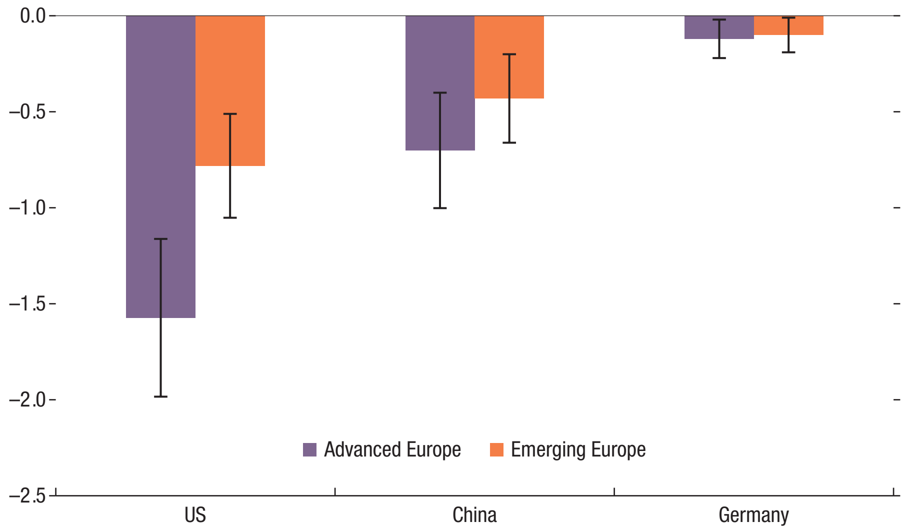
Figure 20. Spillovers without Controlling for Common Shocks



Sources: IMF, *World Economic Outlook*; Haver Analytics; and IMF staff calculations.
Note: Figure 20.1. shows peak cumulative impulse response to a 1 percent negative actual growth in the United States, China, and Germany. This is the response of a median economy in Europe. Bars denote the point estimates and errors bars denote 2 s.d. deviation confidence bands. Baseline refers to spillovers based on growth shocks as in the baseline specification. Figure 20.2 shows a scatter plot of correlations of growth in European countries with actual German growth (horizontal axis) against the corresponding correlations with US growth (vertical axis).

GDP growth. Thus, the alternative specification traces the spillover effects from, say Germany's actual growth as opposed to Germany's growth shocks identified in the first step. As Figure 20 shows, the estimated spillovers are admittedly larger than those in the baseline specification. For instance, the peak cumulative impact due to a 1 percent negative German growth on the median European economy is now about –0.7 percentage point, which is much larger than the estimated spillovers using German growth shocks (baseline). Estimated spillovers using actual growth in United States and China, however, are also larger than the respective baseline estimates. Thus, across the hub countries, the relative ranking of the spillover estimates broadly remains the same as in the baseline specification. It is worth pointing out that estimates using actual growth in the hub countries confound the effects of spillovers and common shocks, which would render the inference about spillovers somewhat unclear. As shown in Figure 20, European economies that exhibit high (low) correlations with German growth also tend to exhibit high (low) correlations with US growth. This trend illustrates the potential role of common shocks in driving growth in the hub countries in the first place.

Figure 21. Spillover Comparison by Destination Countries



Sources: IMF, *World Economic Outlook*; EORA database; Haver Analytics; and IMF staff calculations.
Note: Peak cumulative impulse response to a 1 percent negative growth shock in the United States, China, and Germany. This is the response of a "high-exposure" economy in advanced Europe and emerging Europe with exposure at the 90th percentile of the distribution in each group. Bars denote the point estimates and errors bars denote 2 s.d. deviation confidence bands.

Our analysis does not rule out the importance of Germany as a transmitter of shocks. As discussed above in the version of the model using actual German growth, which confounds common shocks as well as spillovers from other major economies, the estimated impact on other European economies is larger. This finding suggests that Germany does play a role in the transmission of shocks from the rest of the world to other European economies. In addition, our analysis also does not rule out potentially sizable spillovers from Germany going forward if its growth becomes more domestic-demand driven, such as during the period around the reunification.

Spillovers are somewhat smaller for emerging Europe than for advanced Europe. This is particularly true for spillovers that originate in the United States. For a high-exposure economy in advanced Europe, the peak cumulative impact due to a 1 percent negative US growth shock is about –1.6 percentage points; it is only about half that for a high-exposure emerging market European economy (Figure 21). The smaller spillover impact on emerging Europe reflects a smaller value-added trade exposure to the United States and China (Figure 5). We obtain similar results when the model is estimated separately for advanced Europe and emerging Europe.[11] On the other hand, the

[11]Also, note that value-added exports for a spillover destination economy (as a measure of trade exposure) are calculated relative to its GDP. So this already takes into consideration the fact that economies in emerging Europe are smaller than those in advanced Europe.

size of spillover estimates from a Germany shock on advanced and emerging Europe is comparable.

In summary, Europe is an important recipient of spillovers from growth shocks in the hub countries. Spillovers from the United States and China to European economies are estimated to be sizable, with larger effects for economies that are more exposed in terms of value-added exports. Spillover effects from Germany's growth shocks are estimated to be much smaller. Within European economies, spillovers from the United States and China are, in general, smaller for emerging Europe than advanced Europe, reflecting the former's smaller exposure in valued-added export terms.

CHAPTER

6 Conclusions

Europe is deeply integrated into global value chains, and understanding how growing trade tensions could affect Europe via these supply chains is an important policy issue. Europe is the region with the highest degree of global value chain integration, with extensive supply chain linkages both within and outside the region. About 70 percent of total European exports are linked to forward and backward supply chains, and therefore shocks affecting existing trade flows between the major economies can easily affect European economies through those supply chain linkages. Growing trade tensions could therefore weigh on European exports and induce a deceleration in economic activity.

The perspective of global value chains helps give a more accurate picture of the distribution of the impact across countries. Intermediate goods are exported and then reexported further downstream, going through different processing nodes before reaching the final consumer. As a result, the size and distribution of the impact associated with an increase in tariffs can be different when supply chains are taken into account. For Europe, the difference between value-added and gross trade statistics is larger than for Asia or the Americas due to its higher participation in global value chains—and the intensity of intraregional trade stemming from the European single market and the euro area—which makes it necessary to use value-added exports for an accurate analysis of the impact of trade shocks. And by measuring the impact of trade shocks through the lens of value-added exports instead of gross exports, this study offers a better understanding of how trade tensions could weigh on European exports and growth.

This paper deploys three complementary approaches. Chapter 3 develops an accounting exercise based on input-output tables to study how car tariffs could spread through supply chains and affect European economies. To tackle some of the shortcomings of the accounting exercise, Chapter 4 uses a partial demand system to calculate how the demand for value added would respond to a variation in relative prices as a result of a generalized tariff shock. Finally, the paper takes a more general perspective and uses a macroeconometric approach to study how growth shocks could affect Europe's economic activity.

The key conclusions of the paper are as follows:

- The distribution of export losses using global value chain data differs significantly from what gross trade suggests. For example, estimates of the potential impact of 25 percent tariffs on US imports of cars and car parts from the European Union suggest that short-term losses could average about 0.1 percent of GDP. Half of this impact would be direct, through a decline in exports in the country-sector directly affected, and the other half would be through the effects in supply chains. Hence, the distribution of losses associated with these tariffs would be significantly different when measured using value-added exports than when using gross exports. The negative impact would spread across more countries and sectors when using value-added indicators. The order of the export losses also does not necessarily reflect the order of the gross exports of cars and car parts to the United States.
- The importance of Germany, as the core hub country in Europe's trade, is smaller when measured in value-added terms than in conventional terms, while the importance of the United States and China becomes relatively greater. Germany's importance for its European export partners is about 10 percent lower in value-added terms than in gross trade terms in the VA-REER. The opposite is true for the United States and China, with their weight almost 50 percent larger. This is consistent with the idea of regional supply chains, which characterize the European internal market, in which countries behave more as complements than as competitors, trading inputs intensively with very small additional value added embodied in each production step. Relatedly, when we look at the impact of a US tariff increase, the negative impact on Germany is smaller than expected, and other European countries in its value chain also take a hit. For example, after a 5 percent US tariff on all its imports (with retaliation from the rest), the average reduction in the demand for Europe's value added is 0.2 percent. This impact is higher when measured in value-added terms than when measured in gross terms.
- Growth spillovers from the United States and China to European economies are sizable, with larger effects for economies that are more exposed to these hub countries in terms of value-added exports. For instance, a 1 percent negative US growth shock would have a peak cumulative growth impact during a two-year horizon of about –0.6 percentage point for a median European economy. For a high-exposure economy, the correspond-

ing impact is about –1.4 percentage points. Within European economies, spillovers are, in general, smaller for emerging Europe than advanced Europe, reflecting the former's smaller exposure in value-added terms. Spillover effects from German growth shocks are estimated to be much smaller, consistent with other studies. This likely reflects the smaller size of the German economy relative to the United States and China and the fact that Germany, given its openness, is less likely to be an independent source of large shocks. Nevertheless, our analysis does not rule out the importance of Germany as a transmitter of shocks. Nor does it rule out potentially sizable spillovers from a purely exogenous German growth shock if Germany's growth becomes more driven by domestic demand.

The conclusions of this paper could be helpful for policymakers. The findings of this paper could help quantify more precisely the impact of growing trade tensions on specific countries and sectors. Understanding how trade and growth shocks propagate through global value chains could also help policymakers calibrate countercyclical measures as needed and target social policies aimed at citizens most likely to be affected.

Annex 1. Network Analysis

This annex describes the steps used in Chapter 3 to illustrate the short-term impact of a hypothetical tariff shock through global value chain linkages. The calculation is based on the network of linkages between country-sector pairs within and across countries. Such linkages describe how the value added generated by each country sector embeds value added from and contributes value added to output of other country sectors, including to the country itself. These linkages are calculated using global input-output tables provided by EORA and the methodology described in Aslam, Novta, and Rodrigues-Bastos (2017). The data derived comprise several levels of aggregation, including country level, bilateral country level, and bilateral country-sector level. The main variables of interest are domestic value added and foreign value added in exports of each country sector, either in the aggergate (using country-level data) or by specific origin (using bilateral data).

The steps to calculate the impact of a tariff shock τ on country c, sector s, are as follows: a tariff of τ percent on exports of country c, sector s (exp_{cs}) is assumed to imply a loss of $\alpha \times \tau \times exp_{cs}$ in exports, in which α is based on import elasticities as described in Chapter 3. The elasticity applies to the total monetary value of exports and for simplification abstracts from delving into how much volume and prices react to such tariffs. Since exp_{cs} embeds value added by other countries, the loss incurred by country c would amount to $\frac{DVA}{exp_{cs}} \alpha \times \tau \times exp_{cs,}$ in which $\frac{DVA}{exp_{cs}}$ is the share of domestic value added in country c, sector s. The remaining loss $\left(1 - \frac{DVA}{exp_{cs}}\right) \times \alpha \times \tau \times exp_{cs}$ is accrued to the set of foreign country-sectors that comprise the foreign value-added component of exp_{cs}. This loss is then traced back to the countries of origin that comprise the foreign value added in country c, sector s, using bilateral country-sector linkage data. In the above scenario, a country sector could be affected directly, incurring a loss, or indirectly, through participation in the supply chain of another country. This exercise once repeated over all exporting countries allows us to capture all the losses incurred directly and indirectly by various countries and sectors. It is worth noting that the losses incurred by country c itself can be broken down in turn into losses directly incurred by sector s and losses by other sectors within country c that feed into sector s. The latter part, plus the sums of losses incurred through participation in foreign supply chains are summed up as supply-chain-related losses.

Annex 2. Global Value Chains and Real Effective Exchange Rates

This annex and the analysis in Chapter 4 draw on Bems and Johnson (2017), which contains more detailed derivations. This annex provides a very brief description of the main features of the model and the approach used to measure the effects of a tariff on gross output and value-added prices and demand for gross and value-added exports.

Modeling Demand for Trade

Assume that countries produce and consume both intermediate and final goods. Each country indexed by $i, j \in \{1, \ldots, N\}$ produces an aggregate good Q_i

$$Q_i = \left((\omega_i^v)^{\frac{1}{\gamma}} V_i^{\frac{(\gamma-1)}{\gamma}} + (\omega_i^x)^{\frac{1}{\gamma}} X_i^{\frac{(\gamma-1)}{\gamma}} \right)^{\frac{\gamma}{(\gamma-1)}}, \tag{1}$$

with V_i denoting domestic value added. X_i is a constant elasticity of substitution (CES) composite intermediate good with elasticity of substitution (EoS) ρ that aggregates varieties X_{ji} imported from countries j. Demand for final goods is modeled the same way as in the original Armington (1969) framework as a CES aggregation of final goods varieties produced by all countries j.

$$F_i = \left(\sum_j \left(\omega_{ji}^f\right)^{\frac{1}{\sigma}} F_{ji}^{\frac{(\sigma-1)}{\sigma}} \right)^{\frac{\sigma}{(\sigma-1)}}. \tag{2}$$

The market clearing condition requires $Q_i = \Sigma_{i=1}^{N} \left[F_{ij} + X_{ij}\right]$. This contrasts with the original Armington specification with only demand for final goods fully specified by equation (2).

The above equations also illustrate the role played by the three underlying elasticity parameters: γ, ρ, and σ. The conventional framework models only one source of demand, with an elasticity parameter σ that governs substitutability across final goods varieties. Instead, Bems and Johnson's value-added framework includes two types of goods and three elasticities that can take different values. The effective EoS for value added can be calculated as the weighted average of the three parameters. There is only sparse evidence on the relative size of these parameters, but there is some empirical support for the assumption that elasticity in final demand σ is higher than for production inputs γ and ρ. It is important to note that, qualitatively, the results presented in this paper rely on the assumption that final demand is the more elastic. Bems and Johnson show that the results are sensitive to this assumption and can even reverse if the relative size of elasticities is revised.

Impact of Tariffs

The tariffs are assumed to apply to countries' gross exports. For simplicity, we assume full pass-through of the tariff to the price paid by buyers.[1] Using international relative price indices, this assumption implies for instance that a 5 percent tariff on the gross exports of country *i* to country *j* leads to a relative price change between 100 and 105. Equation (13) from Bems and Johnson characterizes how such changes in the price of gross output translate into changes in value-added prices.

$$\hat{p}^{VA} = [1 - \Omega^{``}] \left[diag\left(s_i^{VA}\right) \right]^{-1} \hat{p}^{GO}.$$

This equation means that value-added price changes are a weighted average of gross output price changes in all countries where the weights are the inverse of total cost shares.

The effect of a relative value-added (gross output) price change on a country's demand for value added (gross output) is modeled sequentially since the paper's framework has only a single price per country. The single price assumption also precludes the analysis of trade diversion.[2] First, the effect of a US tariff increases the relative price of gross and value-added exports of partner countries and decreases relative US prices. Equation (15) in Bems and Johnson shows how value-added demand for the United States can be

[1]Assuming a different pass-through would rescale the effects of tariffs on trade but would not lead to qualitatively different results since demand is linear in prices.

[2]A derivation of the value-added demand equations that relaxes the assumption of unique prices per country is beyond the scope of this paper.

calculated from changes in value-added prices using the following expression (and holding overall demand $\hat{F}_i^w$ constant):

$$\hat{V}_{US} = -\sum_j T^{US,j}\hat{p}_j^{VA} + \hat{F}_{US}^w, \tag{3}$$

in which $T^{US,j} \equiv \sigma T_\sigma^{US,j} + \rho T_\rho^{US,j} + \gamma T_\gamma^{US,j}$ are the value-added weights given by a linear combination of the underlying structural elasticities σ, ρ, and γ.[3]

Given the demand for gross and value-added exports of the United States, this decreases the exports of partner countries and increases domestic output for the United States. Retaliation is then modeled separately for partner countries in a parallel manner. A 5 percent retaliatory tariff decreases each country's demand for US exports and increases demand for their own and others' products in a way that mirrors equation (3). Given the size of the US economy and the fact that it is much more closed to international trade in relative terms, the impact of retaliation is on average about 10 times smaller than the impact of the US tariff.

[3]Equation (6) in Bems and Johnson shows that demand for gross output in the conventional framework without intermediate trade is a function of σ and export market shares.

Annex 3. A Two-Step Method for Estimating Growth Spillovers

Principal components analysis: The first step purges the effects of common shocks for cross-country growth dynamics, which then yields country-specific growth shocks. We estimate three principal components, which account for much of the cross-country commonalities in growth. Country-specific shocks are then calculated as the residual growth after purging the effects of these estimated common components. The model is estimated using GDP (quarter-over-quarter) growth for a balanced panel of 68 economies during 1995:Q1 and 2018:Q3. It covers advanced Europe, emerging Europe, and other major advanced as well as emerging market and developing economies, thus providing global representation.

Local Projections Model: The second step is to trace the effects of the country-specific shocks on growth in other economies. The model is described as follows:

$$
\begin{aligned}
y_{i,t+h} &= u_{i,h} + \beta_h U_t + \theta_h\left(U_t \times GVC_{i,t-1}\right) + \psi_h(L)\, y_{i,t-1} + X_{i,t}^{\prime}\Gamma_h + \epsilon_{i,t+h} \\
\text{for } h &= 0,1, \ldots H,
\end{aligned}
$$

in which $y_{i,t+h}$ denotes (cumulative) GDP growth during time $t + h$ and t for country i. In the model that is used to estimate spillovers originating in the United States, the shock U_t refers to the US-specific growth shock, and GVC_i denotes value-added exports as percent of GDP—as a measure of trade exposure of country i to the United States. The model includes its own growth and other variables, such as oil prices, global uncertainty,[1] and controls for country fixed effects. The model is then estimated for different horizons h, which is then used to project the impact of the US shock on growth in other

[1]Measured by the stock market volatility index (http://www.cboe.com/vix).

countries h periods ahead. We use the same quarterly database as in the first step, but the spillover destinations in the local projections model are confined to the European countries. In the model for the United States, we include an additional dummy for the global financial crisis.

The local projections model yields a flexible framework to explore nonlinearities by including value-added exports as interaction terms: $U_t \times GVC_{i,t-1}$. Because of this interaction term, the marginal impact of the shock on growth in other economies depends on the level of value-added exports. In our implementation, following Iacoviello and Navarro (2018), the measure of exposure is normalized as $GVC_{i,t} = \frac{gvc_{i,t} - gvc_{50}}{gvc_{90} - gvc_{50}}$, in which $gvc_{i,t}$ (lowercase) denotes value-added exports for country i at time t ; gvc_{50} and gvc_{90} respectively denote the median and 90th percentile of value-added exports in our sample.[2] With this normalization, the marginal impact of a US-specific growth shock on a "median" economy—defined as an economy whose value-added exports are at the median in the sample—for a given horizon h is given by β_h. And the corresponding marginal impact for a "high-exposure" economy—defined as an economy whose value-added exports are at the 90th percentile—is given by $\beta_h+\theta_h$.[3] The confidence bands are calculated using the Driscoll and Kraay (1998) standard errors, which allow arbitrary correlation of the error term across countries and time. We report two standard deviation confidence bands to assess the significance of the results. To estimate spillovers from China and Germany, we estimate a similar model by appropriately changing the shocks and the value-added exports. The controls remain the same as before.

[2]See Annex Table 3.1 for value-added exports of various countries.
[3]Our results are generally robust to the inclusion of value-added exports as a separate regressor.

Annex Table 3.1. Value-Added Exports
(Percent of GDP)

	United States	China	Germany
Albania	0.4	0.1	0.9
Austria	3.3	1.4	5.4
Belgium	4.4	1.6	5.0
Bulgaria	2.5	0.6	3.4
Bosnia and Herzegovina	0.9	0.2	1.6
Belarus	0.1	0.1	0.1
Switzerland	5.7	2.3	5.3
Cyprus	0.3	0.1	0.5
Czech Republic	4.0	1.3	11.7
Denmark	3.2	1.0	1.7
Spain	1.9	0.6	2.3
Estonia	2.6	0.6	2.5
Finland	3.6	2.1	2.1
France	2.6	1.0	1.3
United Kingdom	2.8	0.8	0.9
Greece	0.7	0.2	2.6
Croatia	1.7	0.2	2.0
Hungary	3.6	0.8	6.5
Ireland	5.2	0.7	2.3
Iceland	2.8	1.2	1.2
Israel	6.4	0.7	2.4
Italy	3.3	1.1	2.4
Lithuania	1.6	0.3	2.7
Luxembourg	1.6	0.7	1.9
Latvia	1.8	0.4	2.4
Moldova	0.0	0.0	0.0
North Macedonia	3.3	0.5	4.2
Malta	3.5	0.9	4.9
Montenegro, Rep. of	0.2	0.1	0.1
Netherlands	3.7	1.2	2.6
Norway	3.2	1.0	1.9
Poland	1.5	0.4	4.4
Portugal	1.9	0.5	2.3
Romania	1.8	0.4	3.1
Russia	1.7	1.3	1.1
Serbia	1.1	0.4	0.4
Slovak Republic	1.8	0.5	6.2
Slovenia	4.1	0.9	6.9
Sweden	3.6	1.5	1.5
Turkey	1.2	0.2	1.5
Ukraine	2.0	0.9	1.6
Median	**2.5**	**0.7**	**2.3**
High-exposure	**4.1**	**1.4**	**5.4**

Sources: EORA database; and IMF staff calculations.
Note: Green denotes the median European economy with median level of value-added exports. Red refers to a “high-exposure” European economy with value-added exports at the 90th percentile of the distribution.

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