Strategy, Policy, and Review Department

Changing Patterns of Global Trade

Nagwa Riad, Luca Errico, Christian Henn, Christian Saborowski,
Mika Saito, and Jarkko Turunen

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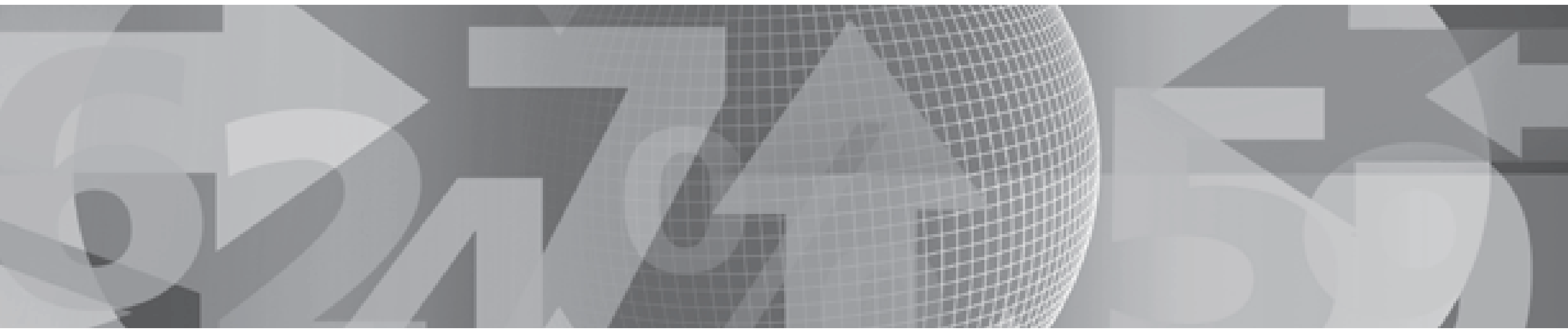

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Acknowledgments

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Executive Summary

The past few decades have seen important shifts that have reshaped the global trade landscape. As a share of global output, trade is now at almost three times the level in the early 1950s, in large part driven by the integration of rapidly growing emerging market economies (EMEs). The expansion in trade is mostly accounted for by growth in noncommodity exports, especially of high-technology products such as computers and electronics. It is also characterized by three important trends: the rise of EMEs as systemically important trading partners; the growing role of global supply chains; and an ongoing shift of technology content toward dynamic EMEs. These developments in global trade have been associated with increased trade interconnectedness and carry important implications for trade patterns, in particular in response to relative price changes. The aim of this paper is to outline the factors underlying these changes and analyze their implications for the outlook for global trade patterns.

Several factors underlie the expansion in global trade and increased interconnectedness. Although trade liberalization since the early 1950s has certainly contributed by lowering trade barriers first in advanced economies and more recently in many developing countries, an equally important factor was the growth in vertical specialization in production and the emergence of global supply chains. Technology-led declines in transportation and communication costs allowed the fragmentation of production processes along vertical trading chains that stretch across several countries. Intermediate goods therefore cross borders multiple times before being transformed into final products, as each country specializes in particular stages of a good's production sequence. Regional production networks thus emerged whose reach eventually became global. An important implication of this phenomenon is that countries that are part of a global supply chain are expected to have a higher share of imported content in their exports because their exports rely on importing intermediate inputs from other supply chain partners. The extent of imported inputs in a country's exports is a useful indicator of whether it is "downstream" (i.e., engaging heavily in assembly and processing activities) or "upstream" in the supply chain (i.e., hub).

Advanced countries and EMEs play different roles in global supply chains. Advanced economies tend to be upstream in the supply chain. This position is reflected in relatively small foreign contents in their exports and relatively large contributions toward other downstream countries' exports. In contrast, EMEs tend to be downstream in the supply chain, with relatively large shares of imported content in their exports. The extent of foreign content in exports of advanced countries and EMEs has important and contrasting implications for the sensitivity of trade patterns to relative price changes.

The Asian supply chain is more dispersed compared to those in North America or Europe. In the Asian supply chain, goods-in-process cross borders several times, including through the hub (Japan), before reaching their final destination. In contrast, in other regions, almost all foreign input is imported directly from the hub—the United States in NAFTA and EU15 in Europe. The greater dispersion of production in the Asian supply chain renders it potentially more vulnerable to disruptions of trade flows, whether policy induced, such as preferential trade agreements, or naturally caused, such as the recent earthquake in Japan.

The emergence of global supply chains has allowed EMEs to enhance the technology content of their exports, including as inputs embedded in high-technology exports of advanced countries. The share of high-technology exports has increased remarkably in China since 1995, boosted by processing trade and with significant imported contributions from Japan and other Asian countries. China is also moving upstream in the value added chain, with imports from China contributing significantly to advanced countries' high-technology exports. Moreover, with China and other EMEs increasing their presence in sectors traditionally dominated by advanced economies, the similarity in export structures has increased over time and so has competitive pressure. Given ongoing product and quality upgrading, the quality level of exports in several EMEs exceeds that expected based on their GDP per capita. Analysis based on Hausmann, Hwang, and Rodrik (2007) suggests that dynamic EMEs with higher-than-expected income value of exports can expect another growth push in the future.

In addition to rebalancing effects, changes in relative prices result in important adjustments in sectoral trade patterns. A partial equilibrium approach is used to examine the impact of relative price changes on trade structures of four key players in global trade, namely China (downstream country), the euro area, Japan, and the United States (upstream countries). The results suggest the following. First, a downstream (as opposed to upstream) position in a supply chain cushions the impact of a relative price change on both exports and imports. This reflects the higher foreign content in the downstream country's exports, which mitigates the impact of exchange rate changes because the appreciation also implies that imports become relatively cheaper.

Sectors that respond the most to the exchange rate changes differ across countries. An appreciation induces an increase in the share of high-technology exports in China and (to a lesser extent) the euro area, whereas a depreciation results in an increase in the share of medium-high-technology exports in Japan and the United States, largely driven by changes in the auto sector. This result again reflects the relatively higher proportion of imported inputs in high-technology products compared to medium-high-technology products which have higher domestic content. Finally, adjustment in the trade balance takes place mainly outside of the supply chain, as exports to supply chain partners are more resilient to relative price changes. This likely reflects two interrelated factors. First, the cost of breaking up a trade relationship may be particularly large in a supply chain, which expresses itself in relatively lower substitution elasticities in supply chain countries. Second, the simulation countries are dominant players in their regional supply chains in terms of both volume and value of their exports going to these destinations, which makes substitution for their trading partners more difficult.

The growing role of global supply chains is associated with increased trade interconnectedness. Network-based analysis illustrates several trends taking place over the past decade, most notably the emergence of China, along with the United States, as major systemically important trading hubs. This not only reflects the size of trade but also the increase in the number of its significant trading partners. Importantly, there is almost a perfect overlap between countries hosting both systemically important trade and financial centers. These countries could constitute a natural focus for risk-based surveillance on cross-border spillovers and contagion.

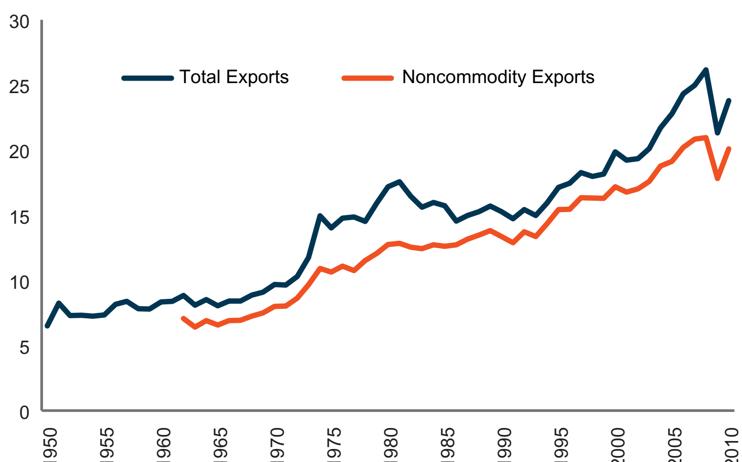
Chapter

1 Introduction

The global trade landscape has witnessed dramatic shifts over the past several decades. World trade has grown steadily since World War II, with the expansion accelerating over the past decade. Despite a post-crisis dip, the current level of world gross exports is almost three times that prevailing in the 1950s (Figure 1). With the exception of commodity price booms in the 1970s and more recently in 2004–2008, commodity trade accounted for a declining share of this growth, with the share of noncommodity trade rising to more than 20 percent of global gross domestic product (GDP) in 2008. The expansion in global trade was characterized by three important trends: the rise of emerging market economies (EMEs) as systemically important trading partners; the growing importance of regional trade; and the shift of higher-technology exports toward dynamic EMEs.

Figure 1. World Exports Relative to Production

(Percent of GDP)



Sources: IMF, Direction of Trade Statistics and World Economic Outlook database; UN Comtrade.
Note: The ratio for 1949–61 is calculated based on 15 major exporters.

Trade expansion was further associated with growing trade interconnectedness. Not only has the number of systemically important trading nations increased over time, their trade links have also multiplied. A chief contributor is the growing role of global supply chains in overall trade, facilitated by lower tariffs and technology-led declines in transportation and communication costs. With vertical specialization, production of certain goods is fragmented into several stages, with each stage produced in the most cost-effective location or country. As a result, goods cross borders several times before being transformed into final products, further increasing trade interconnectedness. Outsourcing of production stages from advanced "upstream" countries to neighboring EMEs has also supported a shift in the technology content of exports toward the latter.

The aim of this paper is to examine the evolution of these trade patterns and explore the implications of sectoral linkages for the outlook for global trade. Three approaches are used to investigate trade interconnectedness and the evolution of sectoral trade patterns: network analysis to determine systemically important trading countries; input-output-based analysis to examine the growth of global supply chains at the aggregate and sectoral levels; and, finally, a partial equilibrium approach to analyze the implications of sectoral trade patterns on global rebalancing and the outlook for global trade. The analysis complements ongoing work within the IMF that looks at the adjustment of trade and global balances at the aggregate level.

The paper is structured as follows. Chapter 2 presents a historical analysis of the evolution of global trade patterns over the past several decades and their implications for trade patterns going forward.[1] It examines the change in key players in global trade, the increase in trade interconnectedness, the growing role of global supply chains, and the change in technology content and export structures across countries.[2] The likely impact of rebalancing by key players

[1] While recognizing the growing contribution of services to global trade, the focus of this paper is on merchandise trade. Much of our analysis attempts to shed light on trade patterns and necessitates trade flows on a bilateral basis, which are generally not available for services. The focus of the paper is on noncommodity (manufacturing) trade, which was more impacted by the recent trends, whereas commodity trade was generally less impacted and is less affected by changes in relative income.

[2] This paper makes reference to different concepts of Europe in part reflecting data availability limitations but also appropriateness to the scope of the underlying analysis. The concepts used include euro area, EU15, and EU accession. In some sections, the analysis relies on sources that include European countries as three blocks—EU15, EU accession, and European Free Trade Association (EFTA) countries—without allowing for analysis of individual European countries. In other sections, reference is made to Europe's largest economy, namely Germany (with no assumption of representation for Europe), whereas analysis on trade structures and interconnectedness is done at the individual country level. Different groupings include: *euro area* (Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovak Republic, Slovenia, and Spain); *EU15* (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom); and *EU accession* (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, and Slovenia).

on trade patterns at the sectoral level is explored in Chapter 3 through the use of a partial equilibrium approach based on highly disaggregated trade data and sectoral elasticities. The exercise considers a hypothetical change in relative prices in four systemically important trading partners—China, the United States, Japan, and the euro area—without explicitly modeling the specific drivers that could induce such relative price changes. Chapter 4 concludes with policy implications.

CHAPTER

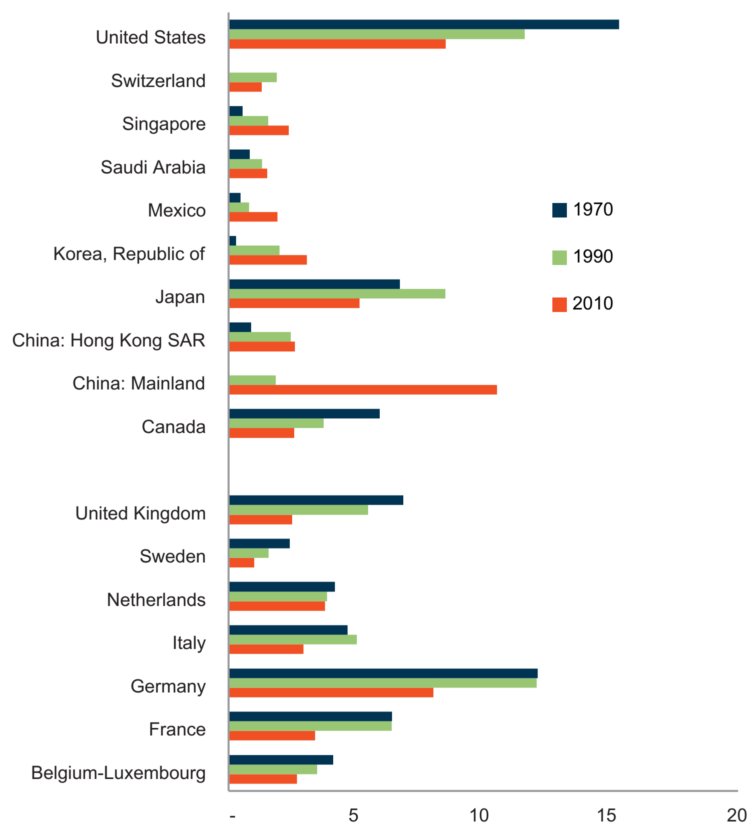
2 The Evolving Structure of Global Trade

A. The Diffusion of Key Players in Global Trade

Emerging market economies have moved from peripheral players to major centers of global trade. Figure 2 shows the evolution of key players in global

Figure 2. Exports of Key Players in International Trade

(Percent of world trade)



Source: IMF, Direction of Trade Statistics.

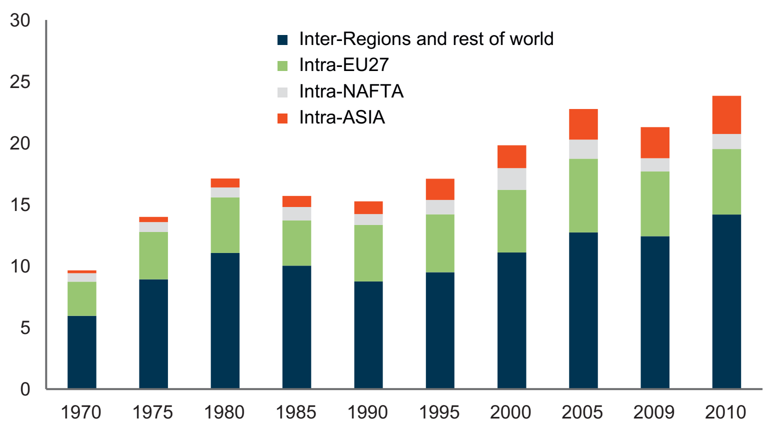
trade, defined as countries whose trade (exports plus imports) represented at least 2 percent of world trade. In the early 1970s, trade was largely confined to a handful of advanced economies, notably the United States, Germany, and Japan, which together accounted for more than a third of global trade. By 1990, the global trading landscape had become more diversified to include several EMEs, especially in East Asia. By 2010, China became the second largest trading partner after the United States, overtaking Germany and Japan. China's emergence reflects its rapid industrialization and growing trade openness—trade was 57 percent of GDP in 2008 in China, almost triple the ratio of the United States.

Growth in trade was strongest for Europe and Asia. The expansion in global trade took place against growing regional concentration. Figure 3 plots the evolution of intraregional trade measured in terms of exports, as well as interregional trade, which includes trade among countries in the rest of the world. Whereas interregional trade was virtually unchanged at about 12 percent of world GDP between 1980 and 2009, growth in intraregional trade was particularly strong in Europe and Asia.

The structure of trade has been characterized by a rising share of higher-technology goods (Figure 4). The contribution of high-technology and medium-high-technology exports such as machinery and transport equipment increased, whereas that of lower-technology products such as textiles declined. Technology-intensive export structures generally offer better prospects for future economic growth. Trade in high-technology products tends to grow faster than average, and has larger spillover effects on skills and knowledge-intensive activities. The process of technological absorption is not passive but rather "capability" driven and depends more on the national ability to harness and adapt technologies rather than on factor endowments.

Figure 3. Inter- vs. Intraregional Connectedness of Major Exporters

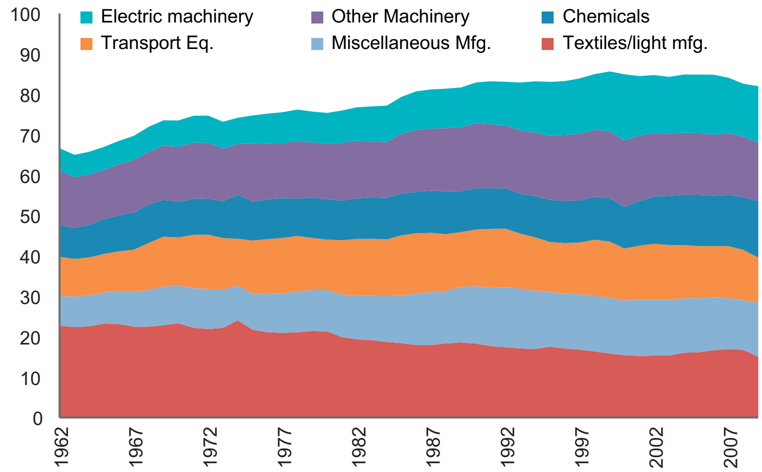
(Percent of world GDP)



Sources: IMF, Direction of Trade Statistics, World Economic Outlook database, and staff estimates.

Figure 4. World Manufacturing Exports and Their Composition

(Percent of total world exports)



Source: UN Comtrade.

In this setting, country-specific policies for technology learning and technology import, including those aimed at attracting foreign direct investment (FDI), can create a comparative advantage between countries with otherwise similar endowments of labor, capital, or skills (Lall, 2000).

The changes in global and regional trade patterns were driven first by trade liberalization, then by vertical specialization and income convergence.

- *Trade liberalization.* A key factor has been the multilateral and bilateral trade liberalization since World War II, which resulted in a significant decline in trade barriers (Krugman, 1995). Among major western European and North American countries, average tariffs fell from 15 percent to 4 percent during 1952–2005, with the bulk of this decline occurring during the 1950s and 1960s (World Trade Organization [WTO], 2007). Tariffs increased or remained very high until the 1980s in many major developing countries but have since come down sharply as well.

- *Increase in vertical specialization in production.* Along with lower trade barriers, technology-led declines in transportation and communication costs also allowed fragmentation of production processes along vertical trading networks that stretch across several countries. Technological advancement in communications reduces the cost of oversight and coordination, making it easier to separate different stages of production across countries. In addition, lower tariffs and transportation costs facilitate the flow of intermediate goods across countries in the global supply chain, as each country specializes in particular stages of a good's

Table 1. Share of Foreign Value Added (FVA) in Gross Exports

	HIY (2001)[1]		Update[2]	
	1970	1990	1995	2005
FVA share of gross exports	0.18	0.24	0.27	0.33
Growth in FVA share		31.3		21.5
Contribution of FVA exports to growth in exports/GDP		32.5		55.9

Source: IMF staff estimates using OECD Input-Output Tables.
[1]Hummels, Ishii, and Yi (2001). Twenty-eight countries are included in HIY: Australia, Canada, China, EU15, Hong Kong SAR, Indonesia, Japan, Korea, Mexico, Taiwan Province of China, Malaysia, Singapore, Thailand, and the United States.
[2]The 34 countries included in the update are EU15, Australia, Brazil, Canada, Switzerland, China, Czech Republic, Hungary, Indonesia, India, Israel, Norway, New Zealand, Poland, Russian Federation, Slovak Republic, Taiwan Province of China, Turkey, and the United States.

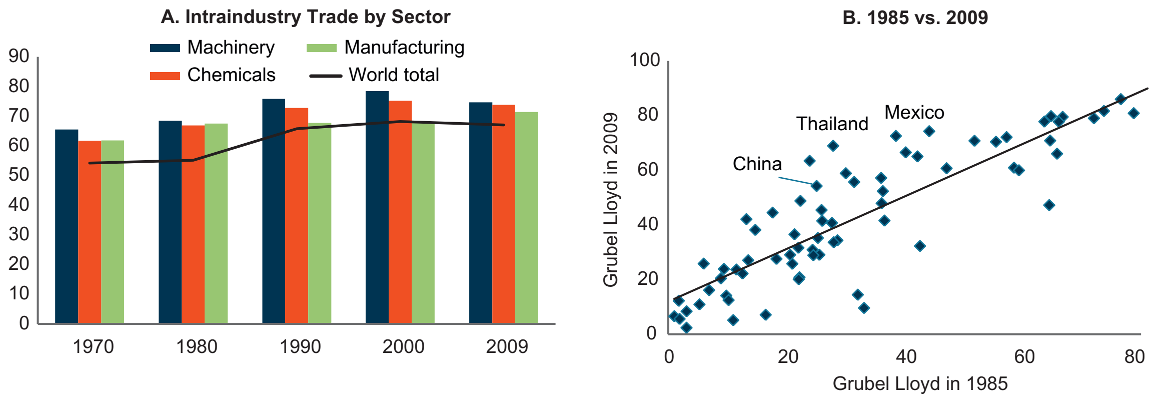
production sequence. Work by Hummels, Ishii, and Yi (2001) and staff estimates show that the foreign content imbedded in gross exports, also referred to as foreign value added (FVA) exports as opposed to domestic value added (DVA) exports, has almost doubled since 1970, to 33 percent in 2005 (Table 1). Growth in vertical specialization has accelerated more recently, increasing by more than 20 percent in the 10-year period up to 2005.

- *Convergence in income levels.* As countries converged in income levels and in the composition of their factor endowments, the volume of trade in relation to GDP increased (Helpman, 1987; Hummels and Levinsohn, 1995), and took the form of intraindustry trade, as firms produced differentiated goods with increasing returns-to-scale technology. As shown in Figure 5A, intraindustry trade as a share of overall trade has increased steadily over time and is highest for products such as machinery, chemicals, and manufactures.[3] Countries that experienced higher changes in intraindustry trade between 1985 and 2009 are those integrated in a supply chain, such as China, Thailand, and Mexico (Figure 5B).

With rising vertical specialization and intraindustry trade, gross exports may not appropriately capture the extent of DVA exports. Official trade statistics are measured in gross terms, which include both intermediate inputs and

[3] Intraindustry trade is defined as two-way exchange of goods within the same product category and can take the form of: (i) horizontal trade in similar products with differentiated varieties; (ii) trade in vertically differentiated products; or (iii) vertical specialization of production that gives rise to trade in similar goods at different stages of production (Organization for Economic Cooperation and Development [OECD], 2002).

Figure 5. Grubel Lloyd Index



Source: IMF staff estimates using UN Comtrade data at the 2-digit HS classification.
Note: The index takes the value zero when no products in the same category are both imported and exported, and 100 if all trade is intraindustry trade. World index is calculated based on a limited sample of 32 countries (including the G7) reporting data for all years.

final goods. Given the rising import content in exports, aggregate trade data are increasingly affected by intermediate goods' trade flows that cross borders several times. Tracking the extent of FVA in a country's exports has thus become common in the trade literature to gauge the extent of trade and policy spillovers across countries (Chen, Kondratowicz, and Yi, 2005; Daudin, Rifflant, and Schweisguth, 2009; Johnson and Noguera, 2010; Wang, Powers, and Wei, 2009; Yi, 2003). For instance, for countries that engage heavily in assembly and processing trade, such as Singapore, gross exports can be more than twice as high as DVA exports (Koopman and others, 2010) (Figure 6).

B. Growing Trade Interconnectedness

Growth in trade interconnectedness has increased the cross-border transmission of shocks through the trade channel. Table 2 presents countries with systemically important trade sectors identified using network analysis.[4] Findings suggest several important trends underlying the global trade network over the past decade. First, there has been a marked shift in the relative rankings of individual jurisdictions, with China moving to first place in 2009 up from ninth in 1999. Second, China has emerged as a major systemically important trading center along with the United States, gaining prominence not only in terms of size but also by increasing the number of its significant trading partners. Third, there has been a marked shift in the roles of China and Japan as strategic export destinations, with China surpassing Japan as a more significant regional and global consumer (Figure 7). Finally, European

[4] See Appendix 1 for details on the methodology to assess systemic trade interconnectedness.

Figure 6. Gross and Value Added Exports to the World: 2004

(Percent of GDP)

Source: Koopman and others (2010).

countries have retained their importance as "central" in the global trade network, owing more to their interconnectedness than size. Box 1 provides details.

There is strong overlap between countries with trade and financial sectors of systemic importance. Comparing the findings on trade interconnectedness with those on financial interconnectedness using the same methodology suggests an almost perfect overlap between the top 25 jurisdictions with systemic financial sectors and the top 25 jurisdictions with systemic trade sectors in 2009 (Figure 8).[5] The only exceptions are Luxembourg and Ireland, whose systemic importance is limited only to the financial sector, and Malaysia and Thailand, whose systemic importance is limited only to the trade sector.

Jurisdictions hosting both systemic trade and financial sectors would seem to be the natural focus of risk-based surveillance on cross-border spillovers and contagion.[6] The analysis underscores that these

[5] The top 25 jurisdictions with systemic financial sectors as identified in IMF (2010a).

[6] As shown in Figure 8, these would include all countries listed in Table 2 for 2009 except for Malaysia and Thailand hosting systemic trade but not financial sectors.

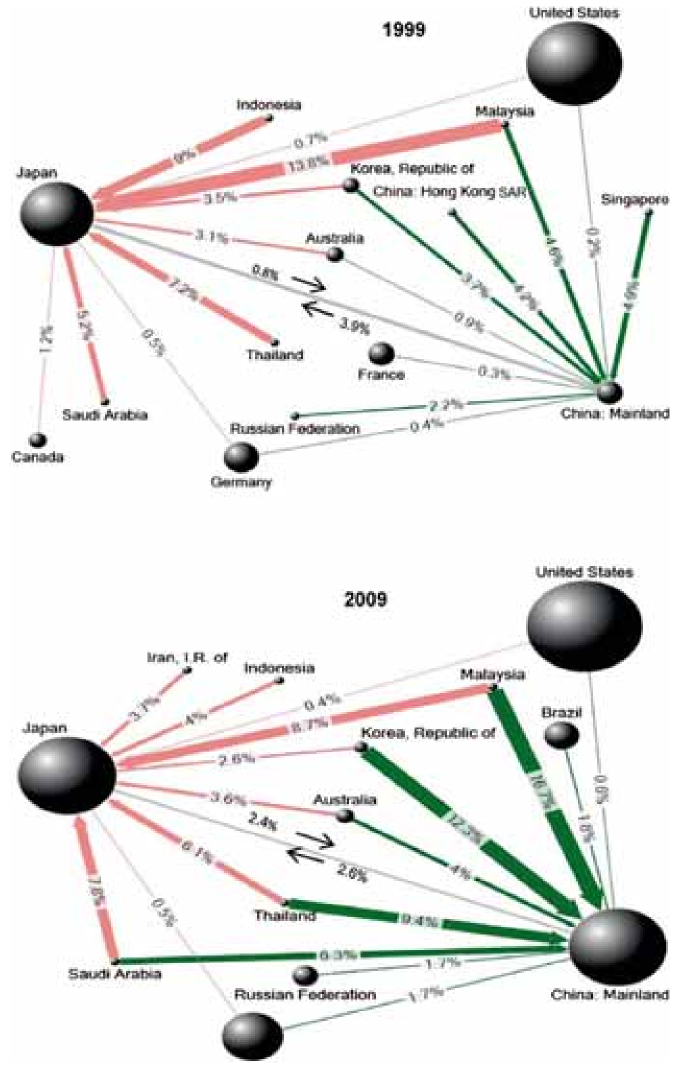
Table 2. Jurisdictions with Systemically Important Trade Sectors: 1999–2009

1999				2009			
Jurisdiction	Overall Rank[1]	Size Rank	Inter-connectedness Rank[2]	Jurisdiction	Overall Rank[1]	Size Rank	Inter-connectedness Rank[2]
Germany	1	2	2	China: Mainland	1	1	1
United States	2	1	6	United States	2	1	3
France	3	3	2	Germany	3	3	2
Japan	4	3	5	Netherlands	4	6	3
United Kingdom	5	5	2	Japan	5	4	8
Netherlands	6	8	1	France	6	5	6
Italy	7	7	7	Italy	7	7	7
Canada	8	6	12	United Kingdom	8	8	5
China: Mainland	9	9	8	Belgium	9	9	11
Belgium	10	11	9	Korea, Republic of	10	10	10
China: Hong Kong SAR	11	9	18	Canada	11	12	13
Korea, Republic of	12	13	10	China: Hong Kong SAR	12	10	20
Spain	13	14	11	Spain	13	14	11
Switzerland	14	16	13	India	14	17	9
Singapore	15	14	22	Singapore	15	13	22
Malaysia	16	16	21	Russian Federation	16	16	21
Sweden	17	18	17	Switzerland	17	18	17
Thailand	18	22	16	Thailand	18	20	15
Denmark	19	24	15	Brazil	19	22	14
Mexico	20	12	44	Malaysia	20	20	19
India	21	25	14	Australia	21	19	29
Brazil	22	23	19	Sweden	22	25	17
Austria	23	19	29	Mexico	23	15	44
Ireland	24	20	27	Austria	24	24	25
Australia	25	21	25	Turkey	25	29	15

Source: IMF staff estimates.
[1] Weighted average of the size and interconnectedness rankings using a 0.7/0.3 weight breakdown, respectively.
[2] Excludes links representing less than 0.1% of each jurisdiction's GDP.

jurisdictions display the strongest intersectoral interconnectedness to the global economy. As such, they have the highest potential for transmitting disturbances to other jurisdictions or to systemic stability via either the trade or financial channel or indeed both channels simultaneously. These jurisdictions would thus seem to warrant particular attention and further analysis on the risks associated with their activities, especially when carried out through systemically important financial institutions and nonfinancial corporations.

Figure 7. Top Ten Import Origins into China and Japan: 1999 and 2009



Sources: IMF, Direction of Trade Statistics, and staff estimates.
Note: The top ten jurisdictions from which China and Japan imported goods in 1999 and 2009. The size of the nodes represents the relative size of each jurisdiction's nominal GDP; the width of the lines indicates the volume of exports as a percentage of the exporting jurisdiction's nominal GDP. This percentage is also indicated on the labels of each line.

C. The Growing Role of Global Supply Chains

Vertical specialization has increased since the mid-1990s.[7] The increase has been particularly pronounced for China (where the share of imported content increased by 12 percentage points) and for Germany and Japan (7 percentage points), with the emergence of global supply chains contributing significantly

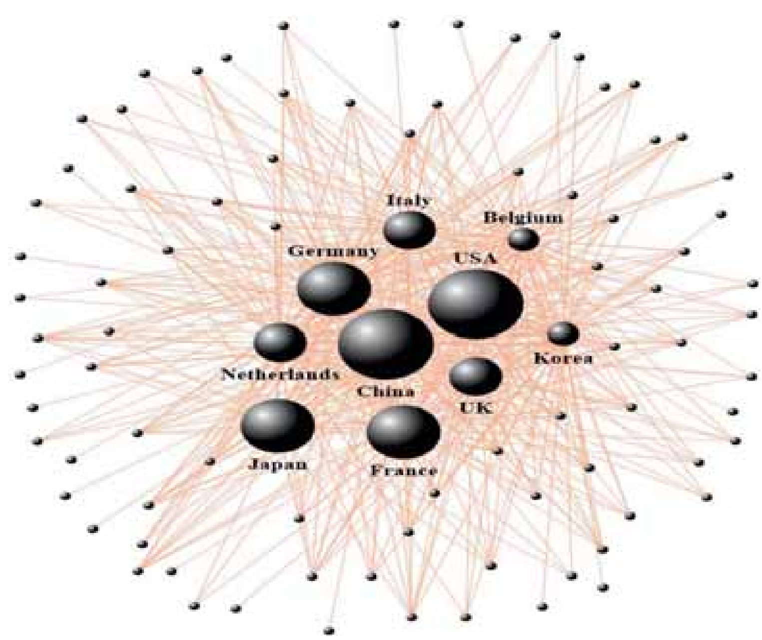
[7] Vertical specialization is one measure to characterize global supply chains. See Appendix 2 for details.

Box 1. Assessing Systemic Trade Interconnectedness

A methodology leveraging the IMF's Direction of Trade Statistics (DOTS) database is used to identify jurisdictions of systemic importance to global trade.[1] Sorting through data for the entire IMF membership, 169 jurisdictions representing almost 100 percent of total world trade in both 1999 and 2009 have been considered for a two-stage process. First, separate ordinal rankings for size and interconnectedness were created using four indicators for each ranking. Then, the indicators were combined into a single size indicator and a single interconnectedness indicator for each jurisdiction.[2] Second, a composite index was developed by combining the single size and interconnectedness indicators using a 0.7/0.3 weight split to reflect the greater relative importance of size.[3] Appendix 1 provides details on the methodology.

The findings are illustrated in Box Figure 1.1 showing the global trade network based on the 2009 rankings of the top 10 jurisdictions.[4] Straight lines between jurisdictions reflect the connections (links) between the trade centers of two jurisdictions (nodes). The interconnectedness of each jurisdiction is reflected by each node's distance from the center of the network; the size of each node reflects the size ranking of each jurisdiction. The findings reveal several underlying trends:

Box Figure 1.1. The Global Trade Network, 2009



Sources: IMF, Direction of Trade Statistics, and staff estimates.

[1] As defined in DOTS, trade refers to merchandise flows only.
[2] A materiality threshold focused the interconnectedness analysis on economically meaningful bilateral trade relationships (either exports or imports), defined as trade relationships representing 0.1 percent or more of a jurisdiction's GDP.
[3] The same 0.7/0.3 weight split was used in assessing financial sector interconnectedness (see IMF, 2010a). Sensitivity analysis carried out on various weight combinations suggests the results are robust to different weightings.
[4] The global trade network captures all active trade relationships, either exports or imports, across the top 10 jurisdictions representing 0.1 percent or more of a jurisdiction's GDP.

Box 1. (*concluded*)

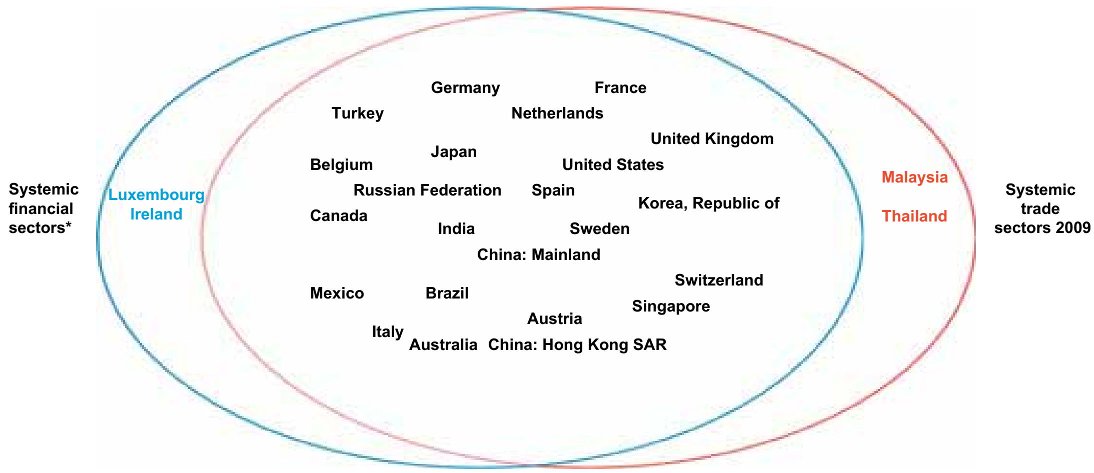
- *Although the composition of the top jurisdictions as a group has remained virtually unchanged, relative rankings of individual jurisdictions have moved markedly, with dynamic EMEs rising in importance*. With the exception of Canada, the composition of the top 10 jurisdictions in 2009 mirrored that of 1999; only two countries appear on the 2009 list that did not appear in 1999 (Russia and Turkey). At the same time, China and India rose by eight and seven positions, respectively.

- *Europe and Asia have maintained their dominance at the top of the list*. Europe has maintained its position mainly on account of its interconnectedness, whereas size was a more important factor in Asia. This suggests that although Asian countries are of importance to the absolute size of global trade, they are not (yet) "as central" in the global trade network as European jurisdictions.

- *China has become more central, along with the United States, whereas Japan appears to be losing ground*. Over a decade, China has increased its prominence in the global trade network not only in terms of size, by substantially raising its share in total world exports and imports, but also in terms of interconnectedness, by almost doubling the number of its significant trading partners, whereas Japan's rank has declined on both counts.

- *The roles of China and Japan as strategic export destinations have changed considerably over the past 10 years*. In 1999, Japan was of greater strategic importance to its largest trading partners as an importer of their products. Since then, Chinese real household consumption has more than doubled and gross fixed capital formation has increased nearly fivefold. Such rapid growth has led to a reversal in their roles as import jurisdictions. China has surpassed Japan not only as the more significant regional importer, but as a global importer as well. In addition, China's growing use of raw materials has enabled it to become a major destination for emerging market and developing economies' exports over the past decade.

Figure 8. Jurisdictions with Systemic Trade and Financial Sectors



Source: IMF staff estimates.
* As identified in IMF (2010a).

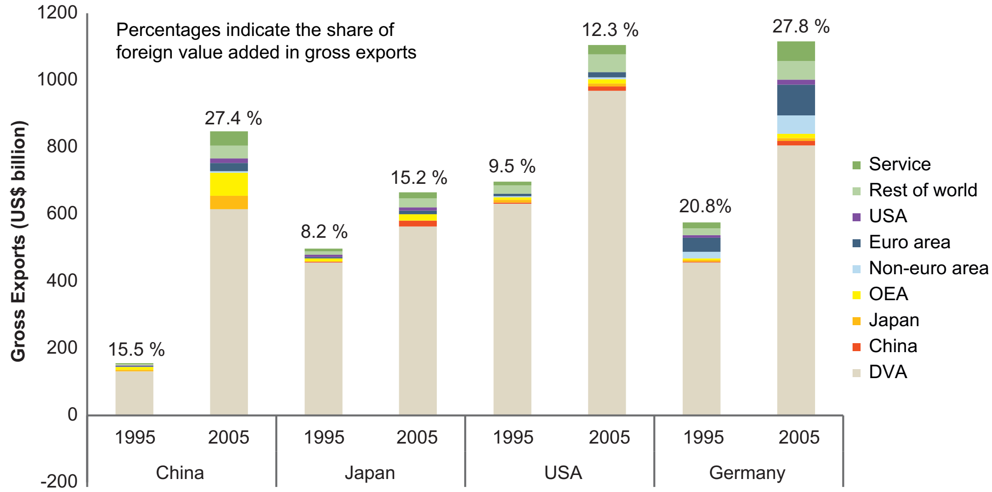
to their rise as major exporting countries (Figure 9). In comparison, the increase in imported content has been smaller for the United States. Among the group of advanced economies, the share of foreign content in gross exports is lowest for the United States, even if foreign content in Germany's exports from the euro area is treated as part of DVA.[8]

Vertical specialization has been associated with regional concentration of trade. The significant increase in FVA content of exports between 1995 and 2005 suggests that both China and Germany's exports have gained from integration within their regional supply chains. Both countries play very different roles though—the former as a downstream assembly center and the latter as an upstream hub. China's exports have high content of FVA that is from Asia: more than half of FVA is from the region, including other east Asian (OEA) economies.[9] In Germany, most of the FVA is coming from other EU countries, including EU accession countries. About 70 percent of FVA in exports of EU accession countries is from the advanced euro area countries, Russia, or European Free Trade Association (EFTA) countries.

Advanced economies tend to be upstream in the global supply chain, whereas EMEs tend to be further downstream. Estimates from Koopman and others (2010) provide a comprehensive picture of global supply chains at the

[8] If foreign content from the euro area is considered part of DVA, overall foreign content in Germany's exports declines to 19.6 percent in 2005 and to about 13.5 percent in 1995.
[9] OEA includes Hong Kong SAR, India, Indonesia, Republic of Korea, Malaysia, the Philippines, Singapore, Taiwan Province of China, Thailand, and Vietnam.

Figure 9. Foreign Contents in Gross Exports



Source: IMF staff estimates using OECD Input-Output Tables, UN Comtrade, and OECD STAN data.

aggregate level and highlight two interesting features.[10] First, compared to advanced economies, EMEs have relatively large imported contents in their exports (Table 3). Second, EMEs tend to have a smaller share of indirect exports that are sent to third countries. The ratio of these two measures provides a useful summary of a country's position in the global supply chain, confirming the downstream position of EMEs in supply chains.

The relative downstream position of some EMEs, including China, reflects an important role of processing trade. Exports of many EMEs stem from lower value added production processes that largely use imported intermediates to assemble final goods for exports. Such processing trade accounts for a significant share of exports from China, which, together with many other Asian EMEs, serves as a downstream hub in the Asian supply chain (see Box 2). Mexico has a somewhat similar role, owing to specialized duty free assembly plants that use imported intermediates and re-export final goods back to the United States. The accession of Eastern European countries with lower production costs in the European Union has also resulted in increased outsourcing of production away from the advanced EU countries.

Regional supply chains in Asia, NAFTA, and Europe can be distinguished along two key features. The first is the extent of dependence on a regional power house. The Asian supply chain extends across several countries, with

[10] The description of global supply chains in this part draws on estimates in Table 3 in Koopman and others (2010), who rely on different classifications of Europe since they use GTAP data to generate global input-output tables. Input-output tables are typically not available on an annual basis, with most recent data from GTAP referring to 2004.

Table 3. Measures of Vertical Specialization across Borders: 2004

(1) Country	(2) Imported contents embodied in gross exports	(3) Indirect exports sent to third countries[1]	(4) Upstream or downstream position, (3)/(2)
Advanced economies			
EU15	11.4	20.9	1.8
Japan	12.2	30.8	2.5
United States	12.9	26.9	2.1
Asian newly industrialized countries			
Korea	33.9	23.1	0.7
China: Hong Kong SAR	27.5	19.5	0.7
Taiwan Province of China	41.1	27.2	0.7
Emerging			
China: Mainland	35.7	12.5	0.4
EU accession countries	30.8	11.3	0.4
Mexico	48.0	10.0	0.2

Source: Koopman and others (2010).
[1] Includes indirect exports that return to home country.

goods-in-process crossing borders several times, including through the hub (Japan), before reaching their final destination (Table 4). For instance, about 15 percent of Japanese value added embodied in Chinese products goes through other countries in Asia before reaching China.[11] In contrast, almost all the FVA in other regions is imported directly from the hub—the United States in NAFTA and EU15 in Europe. The second feature relates to the extent of processed value added flowing back to the hub. A significant amount of U.S. value-added (and EU15 value added to a lesser extent) returns home after further processing abroad, which is not necessarily the case for Japan. Processing trade in Asia therefore relies heavily on the region as a whole. This finding is consistent with unique features outlined in Box 2 on Asian regional integration.

Sectoral evidence of global supply chains

The role of global supply chains for trade in high-technology goods has increased over time, especially in China. As Figure 10 illustrates, the share of imported content in exports of high-technology goods has increased for China, Japan, the United States, and the European advanced economies since the mid-1990s (see Box 3 on OECD technology classification). The increase is particularly pronounced for China—imported content of Chinese

[11] There are two ways in which Japanese value added is built into Chinese exports: one is through direct imports of intermediate inputs from Japan (6.8 percent) and the second is by importing inputs from the region that contain Japanese value added (1.2 percent).

Box 2. "Factory Asia"

Prior to the mid-1980s, east Asian trade was suppressed by the widely adopted "dual track" development strategies that blocked the imports of manufactured goods to protect infant industries while simultaneously fostering export-oriented industries (Ando and Kimura, 2005; Baldwin, 2008). Starting in the mid-1980s, however, rapid trade liberalization and a surge in intraregional trade emerged in east Asia. In response to the strong appreciation of the yen in the mid-1980s, Japanese firms first shifted labor-intensive assembly operations to newly industrialized economies (NIEs). As their own currencies started to appreciate (Korean won, Singaporean dollar, etc.), NIEs relocated lower-end, labor-intensive assembly processes to countries such as China and the ASEAN countries (Thorbecke, 2011). The off-shoring trend led to competition for investments and jobs in east Asia. This competition resulted in unilateral tariff cutting in the region and ultimately the development of what is known as "Factory Asia."

These successive relocations have allowed NIEs and then China and the ASEAN countries to develop a comparative advantage in manufacturing exports and progressively upgrade their industrial capacity, thus contributing to a "recycling of comparative advantage" that is characteristic of the Asian supply chain (Gaulier, Lemoine, and Ünal-Kesenci, 2005). In the 1990s, China's emergence heightened the competition among east Asian countries for jobs and investment linked to the ever growing "Factory Asia." As a result, unilateral liberalization accelerated in the region. Regionalism (i.e., preferential or discriminatory trade liberalization), on the other hand, was delayed. The ASEAN FTA (AFTA) and the Asian-Pacific Economic Cooperation (APEC) were established, but neither created much discrimination nor had much effect on trade flows.

In sum, Factory Asia was established without "real" regionalism. In fact, regionalism in east Asia only began in 2000 when China expressed interest in an FTA with ASEAN. It is argued that the ASEAN-Japan FTA, the Korea-ASEAN FTA, and the Japan-Korea FTA were all direct reactions to the ASEAN-China FTA (ACFTA) (Baldwin, 2008). This development of regionalism in east Asia can be a potential source of tension in the region, especially since there is neither WTO discipline locking in the unilateral tariff cutting that created "Factory Asia" nor "top-level management" to substitute for WTO discipline in east Asia.

high-technology exports increased by close to 30 percentage points from the mid-1990s to the mid-2000s.[12] This result confirms that the emergence of China as a major exporter of high-technology goods has been boosted by processing trade, with significant imported contributions from Japan and other countries in the Asian supply chain. By the mid-2000s, China had by far the

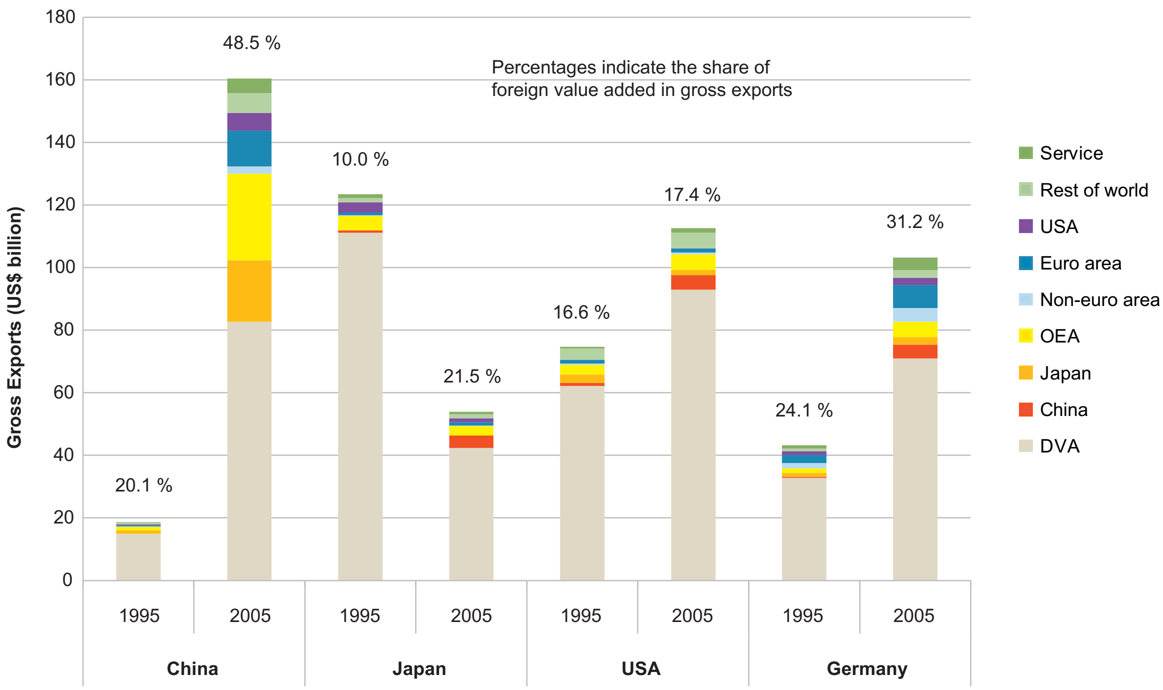
[12] These results are consistent with those in Koopman, Wang, and Wei (2008), who also find that sectors that produce relatively sophisticated goods, such as electronics, tend to have a higher foreign content than other sectors and with case studies that show that some high-technology goods exported from China include very little domestic value added (e.g., the study on iPods and portable computers by Dedrick, Kreamer, and Linden, 2010).

Table 4. Hubs' Value Added Contained in Gross Exports

	Total	In imports from the hub[1]	In imports from the neighbors[2]
China	8.0	6.8	1.2
Mexico	31.3	31.0	0.3
EU accession	17.5	17.3	0.2

Source: IMF staff estimates using Koopman and others (2010).
[1] For China, Mexico, and EU accession countries, hubs are Japan, the United States, and the EU, respectively.
[2] For China, Australia, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, Vietnam, and the rest of east Asia are included; for Mexico, Canada, Brazil, and Latin America are included; and for EU accession countries, EFTA and Russia are included.

Figure 10. Foreign Contents in Gross Exports: High-Technology Sectors



Source: IMF staff estimates using OECD Input-Output Tables, UN Comtrade, and OECD STAN data.

largest imported content in its high technology exports. Japan and the United States make significantly less use of imported intermediates in their production of high-technology exports.[13] In Germany, if imports from euro area countries

[13] Exports of low-technology sectors have the lowest imported content in all countries. However, for countries other than China, the share of imported contents is also high in exports of medium-technology sectors (see Tables A2.2 and A2.3 in Appendix 2).

Box 3. OECD Measure of Trade by Technology Intensity

Using the OECD methodology to classify countries' industrial sectors and manufactures by level of technology, Hatzichronoglou (1997) provides four categories of technological intensity: high, medium-high, medium-low, and low technology. The technological intensity reflects to some degree a "technology-producer" aspect, measured by the ratio of research and development (R&D) expenditure to value added, and a "technology-user" aspect, measured by purchases of intermediate and capital goods.

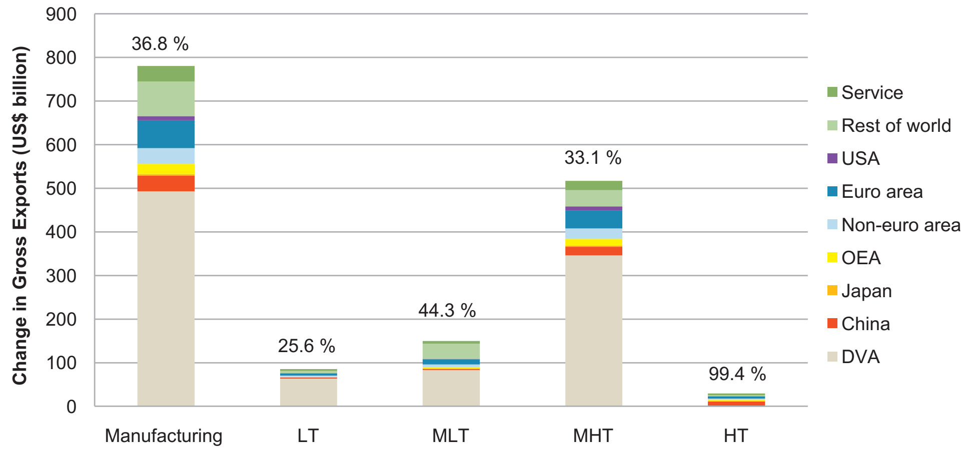
To analyze international trade flows by technological intensity requires attributing each product to a specific industry. However, products that belong to a high-technology industry do not necessarily have only high-technology content. Likewise, some products in industries of lower technological intensity may incorporate a high degree of technological sophistication. The mapping of technological intensity from industries to trade sectors may therefore in some instances be imperfect.

Box Table 3.1. Manufacturing Industries Classified According to Their Global Technological Intensity

	ISIC Revision 3		ISIC Revision 3
High-technology		**Medium-low-technology**	
1. Aerospace	353	11. Petroleum refining	23
2. Pharmaceuticals	2423	12. Rubber and plastics	25
3. Computers, office machinery	30	13. Non-metallic mineral products	26
4. Electronics-communications	32	14. Shipbuilding	351
5. Precision instruments	33	15. Basic metals	27
		16. Fabricated metal products (except machinery and equipment)	28
Medium-high-technology			
6. Electrical machinery	31		
7. Motor vehicles	34	**Low-technology**	
8. Chemicals (except pharmaceuticals)	24 excl. 2423	17. Other manufacturing industry	36, 37
		18. Wood and furniture	20
9. Other transport equipment	352, 359	19. Paper and printing	21, 22
10. Machinery and equipment	29	20. Textile, clothing, leather	17, 18, 19

Sources: Hatzichronoglou (1997); OECD (2005).
Note: List updated in 2001.

Figure 11. Source of Change in Exports of Advanced Countries: 1995–2005



Source: IMF staff estimates using OECD Input-Output Tables, UN Comtrade, and OECD STAN data.
Note: LT = low technology, MLT = medium-low technology, MHT = medium-high technology, and HT = high technology. Percentages indicate the change in foreign value added exports in the overall change in exports.

are considered part of DVA, the share of FVA in high-technology exports becomes comparable to that of Japan and the United States (about 19 percent).

Notwithstanding China's downstream position in the supply chain, its exports of intermediate products in the high-technology sector are increasingly contributing to advanced countries' high-technology exports. Together with other Asian countries, China increasingly plays a dual role in the global supply chain for high-technology products, as an assembly country and exporter of intermediate inputs to other countries' high-technology exports. Figure 11 decomposes the contribution of domestic and foreign value added by sector to the export growth of Germany, Japan, and the United States and underscores three interesting results: (i) overall, the increase in FVA contributed about 37 percent to the growth in advanced countries' gross manufacturing exports between 1995 and 2005; (ii) growth in high-technology exports was almost entirely driven by growth in FVA; and (iii) China's contribution to advanced countries' growth in manufacturing exports is significant and concentrated in high- and medium-high-technology sectors. This suggests that China may be rapidly catching up in terms of contribution to advanced countries' exports of high-technology goods.

Imports of services also contribute to advanced countries' growth in exports. Though the focus of this paper has been on trade in manufactured goods, it is worth noting that trade in services has become an important contributor to advanced countries' growth in exports. Services imports are not decomposed by country of origin due to lack of data on bilateral trade in services. Evidence on service imports by advanced countries shows that they contribute about 12 percent of the contribution of FVA in advanced countries' manufacturing exports in 2005.

The greater regional dispersion in the Asian supply chain has important policy implications. Any disruption of trade flows, particularly in intraregional trade flows in Asia, could have large negative spillover effects on domestic production in partner countries. Protecting the free flow of inputs and outputs should therefore be a top priority. This could be done by binding the region's unilateral tariff cuts under the Doha Round or including all the key players in regional FTAs such as the Trans-Pacific Partnership (TPP). An exclusion of a key player such as China in regional FTAs could create bilateral tensions that could prove potentially disruptive to supply chain trade flows.

D. The Diffusion of High-Technology Exporters

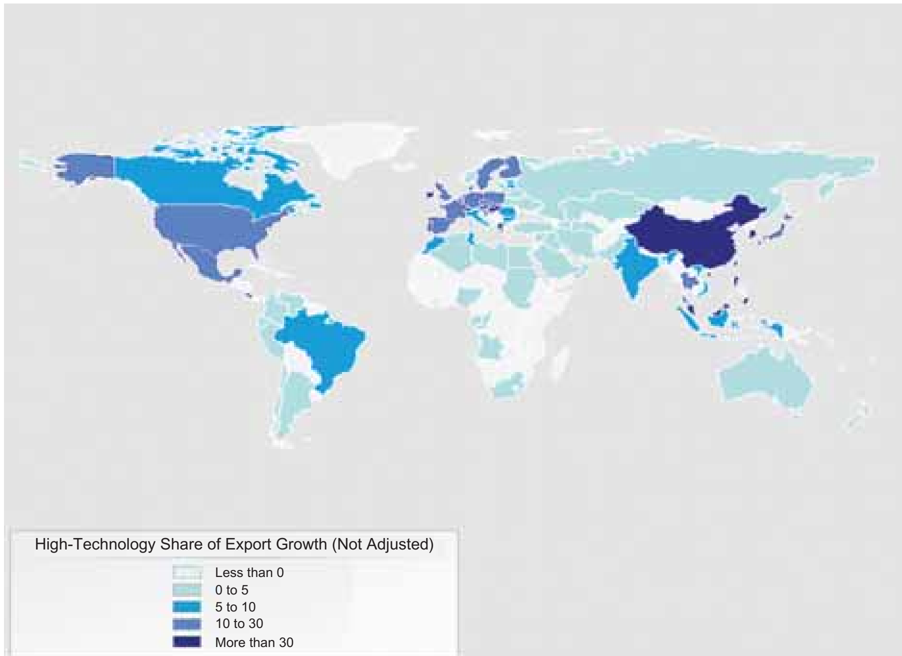
Changes in the technology composition of exports confirm the rise of emerging markets in global trade in high-technology products. Between 1995 and 2008, the contribution of high-technology exports to overall export growth was more than 30 percent for China, compared with 26 percent for the United States, 17 percent for Germany, and only 11 percent for Japan (Figure 12, top panel). Adjusting exports, however, to exclude foreign content and show more clearly the domestic content of exports yields a somewhat different picture: the contribution of high-technology exports to overall export growth is now much lower in China (24 percent), whereas that of the United States rises to 29 percent and Germany to 20 percent (Figure 12, lower panel). Of note is the increase in Mexico's contribution of high-technology exports when only DVA is considered, suggesting a more broad-based upgrading of the technology content of its export basket.

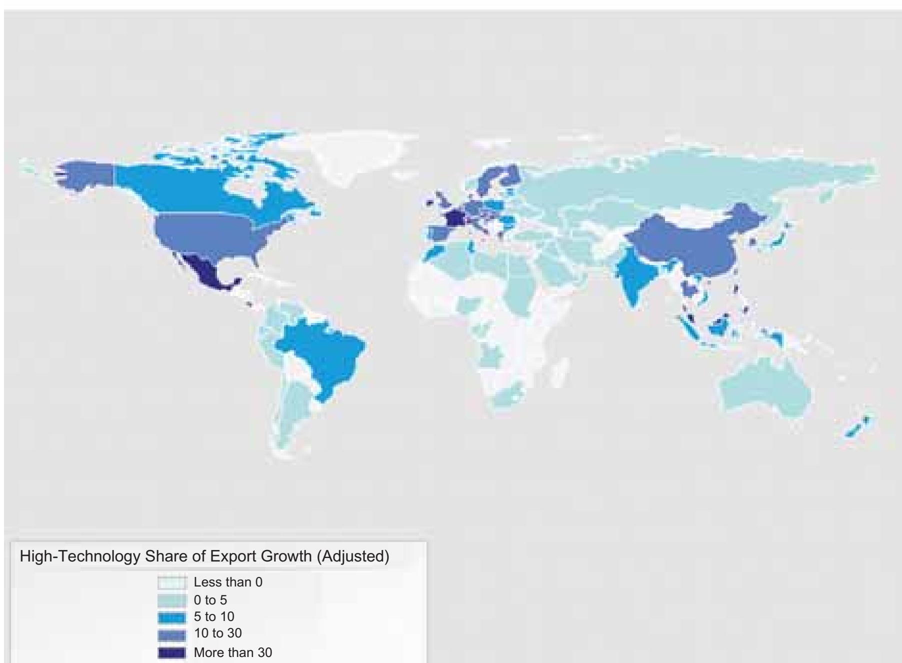
FDI has an important role in the diffusion of technology, especially across global supply chains. Evidence suggests that, whereas U.S. FDI is generally driven by market access considerations, FDI by Japanese multinationals is motivated by factor-price differentials across borders arising from relative abundance of unskilled labor in Asia (Tanaka, 2009; Wakasugi, Ito, and Tomiura, 2008). In this setting, labor-intensive stages of production such as final assembly are moved to a host country with lower cost of unskilled labor, whereas activities that are relatively intensive in skilled labor, such as marketing, patenting, and innovation, are retained in headquarters. Even though the share of Japan's high-technology exports has declined due to outsourcing to other countries, it has retained those aspects of production with the highest value added (see Box 4).

Several factors have allowed EMEs to upgrade the technology content of their exports. These include geographical proximity to advanced countries, the existence of an educated workforce, and a favorable business environment. Indeed, countries that gained most in exports of high-technology products over the last decade were those whose initial conditions in 1995 featured an intermediate level of development and some presence in high-technology

Figure 12. High-Technology Export Growth[1]

(Percent of growth)





Source: UN Comtrade.

[1]The charts reflect the contribution of high-technology exports to the change in overall exports between 1995 and 2008 across countries.

Box 4. Why Has the Share of High-Technology Sectors in Japanese Exports Fallen since the 1990s?

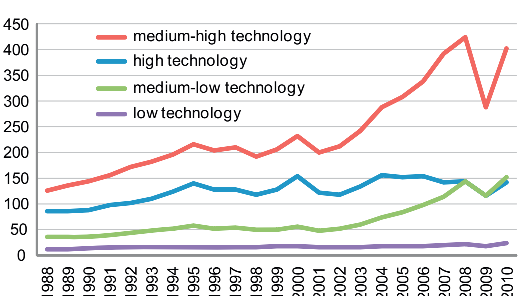
The share of Japanese exports that are attributed to high-technology sectors has fallen from 34 percent in 1995 to 23 percent in 2005. There are three potential explanations.

A rise in exports of other sectors. The share of exports of high-technology sectors has fallen because those exports have been stagnant since the mid-1990s, whereas those of other sectors have increased rapidly (Box Figures 4.1 and 4.2). Both the medium-high- and medium-low-technology sectors have increased by about 10 percentage points between 1995 and 2010, driven by a rapid increase in exports of motor vehicles, machinery and equipment, and basic metals. The rapid expansion of these exports may reflect the progressive liberalization of global trade in motor vehicles since the 1990s and strong demand growth in emerging Asia, including China, more recently.

A rise in outsourcing. As part of "Factory Asia" (see Box 2), Japanese firms in high-technology sectors have transferred production sites to countries in the region. Although R&D still takes place in headquarters, trade flows have shifted from Japan to other Asian countries. Data on R&D expenditures and on royalties and license fees seem to support this explanation (Box Figures 4.3 and 4.4). R&D expenditures have been rising since the mid-1990s and are high by international standards. Inflows of royalties and license fees in the balance of payments have also been rising steadily during the same period.

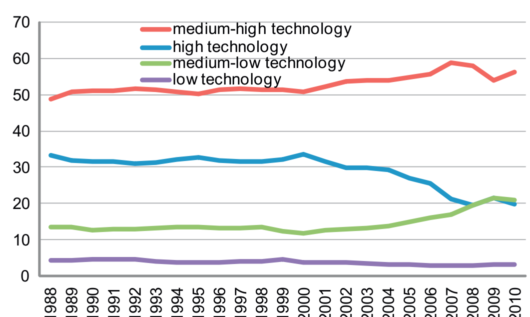
Detailed trade data also show that outsourcing is indeed part of the explanation (Box Figures 4.5 and 4.6). For instance, the decline in exports of the computers and office equipment sector is driven by a decline in exports of final products, whereas those of parts and accessories continue to increase. Outsourcing, however, does not fully explain why exports of high-technology sectors have fallen relative to those of other sectors, where incentives for outsourcing may have been equally strong.

Box Figure 4.1. Japanese Exports in Millions of U.S. Dollars



Source: World Bank, World Integrated Trade Solution (WITS).

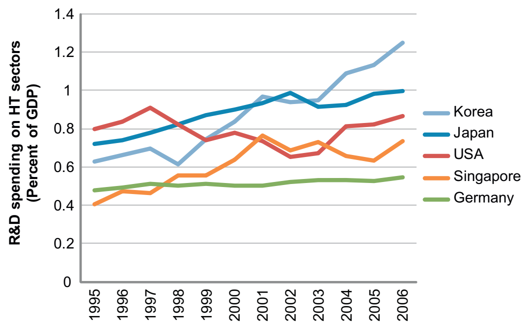
Box Figure 4.2. Japanese Exports in Percent of Total Exports



Source: World Bank, World Integrated Trade Solution (WITS).

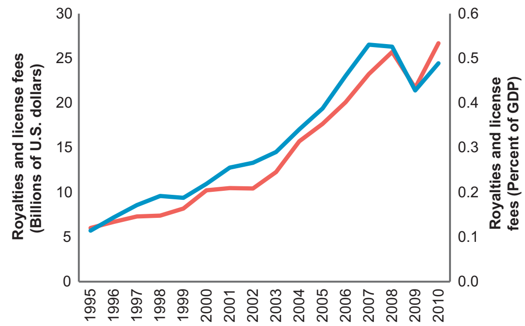
Box 4. (*concluded*)

Box Figure 4.3. R&D Spending on the High-Technology Sector



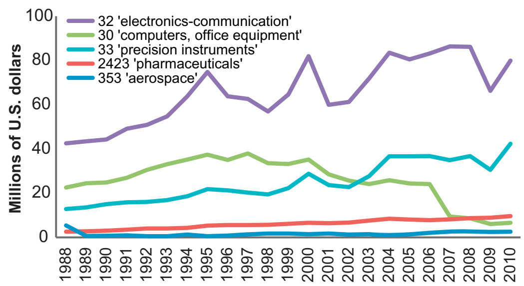
Sources: IMF, World Economic Outlook database; OECD, STAN R&D expenditure in industry.

Box Figure 4.4. Royalties and License Fees



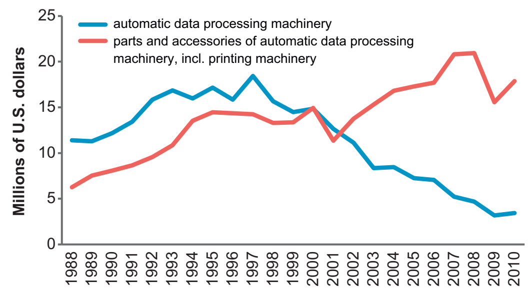
Source: IMF, International Financial Statistics.

Box Figure 4.5. Japanese Exports: High-Technology Sector



Source: World Bank, World Integrated Trade Solution (WITS).

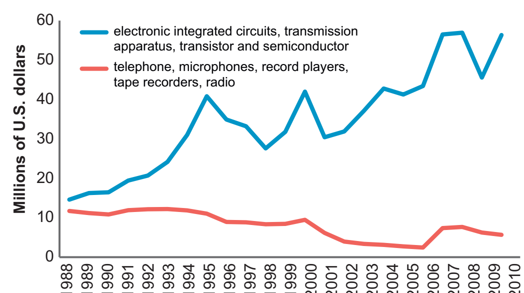
Box Figure 4.6. ISIC-30: Computers and Office Equipment



Source: World Bank, World Integrated Trade Solution (WITS).

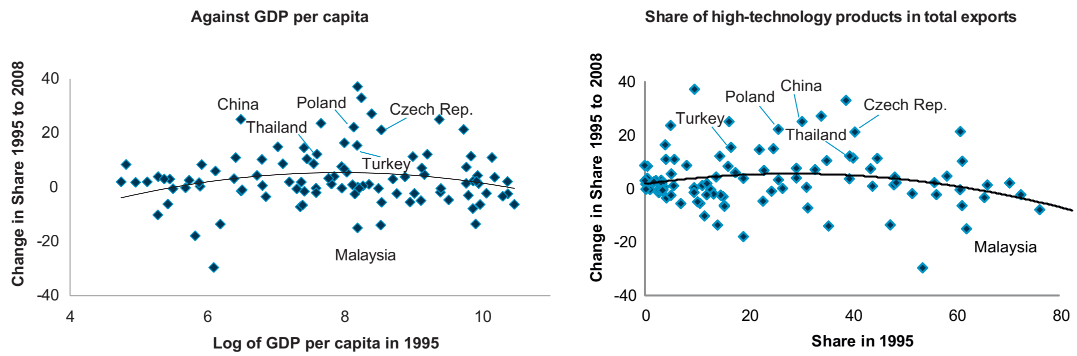
Information lost in sectoral aggregation. Products that belong to a high-technology industry do not necessarily have only high-technology content; the relative fall in high-technology exports may have been concentrated in products with a lower-technology content. Trade data on the electronics and communication sector seem to confirm this hypothesis: exports of relatively simple products such as telephones have declined, whereas products with a high-technology content such as integrated circuits have risen (Box Figure 4.7).

Box Figure 4.7. ISIC-32: Electronics and Communication



Source: World Bank, World Integrated Trade Solution (WITS).

Figure 13. Technology Content of Exports



Sources: UN Comtrade; and IMF staff estimates.

exports (Figure 13). These include countries such as China, Malaysia, and Thailand in Asia, and the Czech Republic, Poland, and Turkey in Europe.

Although many low-income countries (LICs) have not yet fulfilled these conditions, there has been some upgrade in the technology content of their exports as well. As shown in Box 5, exports of medium-high- and high-technology products have increased for LICs in all major regions, albeit from a very low level. Increased trade with dynamic EMEs such as China has provided an important impetus, although traditional partners such as the United States and Japan remain important destinations for higher-technology exports. This suggests that LICs in Asia and the Western Hemisphere could be benefiting from greater integration in global supply chains.

E. Rising Export Similarity

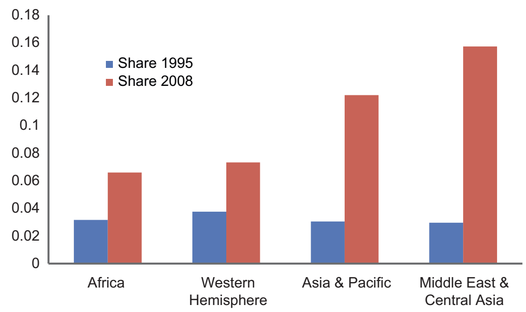
Export structures of EMEs are becoming increasingly similar to those of advanced economies, in part reflecting the growth of global supply chains. With China and other EMEs increasing their presence in sectors traditionally dominated by advanced countries, the similarity in export structures has increased and so has competitive pressure. A common indicator to gauge export competitiveness is the export similarity index (ESI), which takes higher values for country pairs with similar shares of each product (six-digit) category in overall exports.[14] As shown in Table 5, Japan competes most with Korea, the United States, and European countries, whereas the U.S. export structure continues to be similar to other advanced economies. China has traditionally competed with other Asian countries, and although large

[14] An ESI value of 1 corresponds to identical export structures and zero to completely dissimilar structures. See Appendix 3 for details.

Box 5. Structure of Export Baskets in LICs

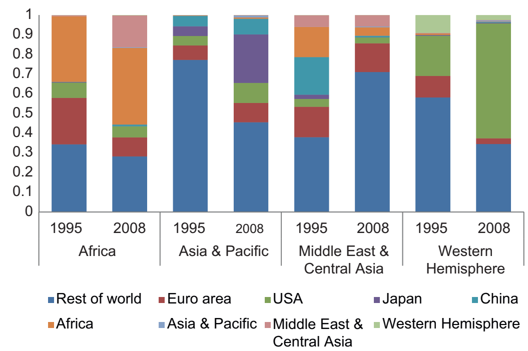
Many LICs have seen an upgrade in their export baskets in recent years, albeit from a low level. Although still lagging behind strong performing EMEs, the incidence of medium-high- and high-technology products in LIC non-oil exports has increased notably.[1] Box Figure 5.1 shows that for LICs in all major regions the share of these products in non-oil exports increased from about 3 to 4 percent in 1995 to about 7 percent in African LICs, and 12 to 16 percent for LICs in Asia and the Middle East and Central Asia in 2008.

Box Figure 5.1. LICs: High- and Medium-High-Technology Exports (Share in Total Exports, Non-Oil)



Source: UN Comtrade.

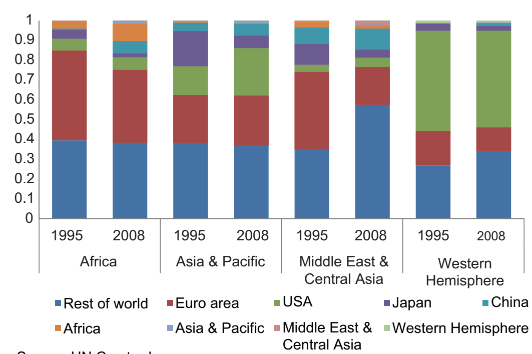
Box Figure 5.2. LICs: High- and Medium-High-Technology Exports by Destination (Non-Oil)



Source: UN Comtrade.

Decomposition of LIC exports by technology intensity and destination reveals several interesting trends (Box Figures 5.2 and 5.3). First, a significant share of trade in medium-high- and high-technology exports took place between African LICs in 2008, as opposed to other destinations. Second, EMEs are important destinations for LIC exports of medium-high- and high-technology exports. These include China, Singapore, and Thailand for Asian LICs, South Africa for African LICs, and Mexico for LICs in the Western Hemisphere.

Box Figure 5.3. LICs: Low- and Medium-Low-Technology Exports by Destination (Non-Oil)



Source: UN Comtrade.

[1] In 2008, the share of non-oil exports in overall exports was 28 percent for LICs in Africa, 35 percent in the Middle East and Central Asia, 81 percent in the Western Hemisphere, and 83 percent in Asia.

Box 5. (*concluded*)

Finally, advanced economies are important destinations for LIC exports, albeit more for lower-technology than for higher-technology products. Nonetheless, the increase in exports of medium-high- and high-technology products to Japan for Asian LICs and to the United States for LICs in the Western Hemisphere could be indicative of greater integration in the respective regional supply chains.

differences still remain, its export structure has been converging with that of advanced economies such as Germany and the United States.[15]

Rising export similarity between advanced countries and EMEs could reflect increased complementarity, as well as competition. The observed shift in technology content and corresponding convergence in export structures may reflect higher complementarity arising from the increased outsourcing of labor-intensive production to low-wage countries in the region. For instance, whereas transport equipment exports go directly to advanced countries and have held their share over time, a growing proportion of Japanese machinery exports are now assembled in China, showing up as increased Japanese exports to Asia (and, in turn, higher exports from China to the United States). This has more to do with Japan's upstream role in the Asian production chain rather than a sign of growing competitive pressure. Similarly, in Europe, technological intensity of exports has shifted from western to eastern Europe and particularly the Czech Republic, Hungary, and Poland. In North America, the United States has outsourced some high-technology activities to its NAFTA partners, especially Mexico, and to Central America.

Gross exports data would not adequately capture quality differences within the same product category. Whereas EMEs could be exporting products in categories similar to those of advanced countries, these can still be differentiated along quality and price dimensions.[16] In the particular case of China, the important role of processing trade in high-technology exports may affect aggregate indicators of export similarity. To take this into account, we further modify the ESI to distinguish products by destination market, assuming that high-income countries are likely to demand higher quality varieties of the same

[15] This is consistent with findings suggesting that China is gaining similarity with advanced economies along the extensive margin, by penetrating product markets traditionally dominated by advanced economies (Wang and Wei, 2008), as well as the intensive margin, through rising exports in product categories that China was exporting all along (Amiti and Freund, 2008).

[16] Analysis of U.S. customs micro level data suggests that a shirt imported from Japan costs on average 30 times as much as a shirt imported from the Philippines (Schott, 2004). Thus, although it may be the case that export baskets of many EMEs now look similar to advanced economies, the quality or sophistication level of their products may still be different.

Table 5. Overall Export Similarity Index: 1995 and 2008

China						Japan					
Rank	1995		Rank	2008		Rank	1995		Rank	2008	
1	Hong Kong SAR	0.510	1	Hong Kong SAR	0.510	1	Germany	0.532	1	Germany	0.544
2	Thailand	0.355	2	Malaysia	0.391	2	United States	0.515	2	Korea	0.510
3	Philippines	0.312	3	Thailand	0.388	3	Korea	0.468	3	United States	0.487
4	Korea	0.311	4	Italy	0.383	4	United Kingdom	0.451	4	United Kingdom	0.430
5	Italy	0.306	5	Czech Republic	0.377	5	France	0.434	5	France	0.421
6	Indonesia	0.303	6	Korea	0.368	6	Singapore	0.397	6	Austria	0.401
7	Malaysia	0.297	7	Japan	0.356	7	Italy	0.392	7	Italy	0.400
8	Portugal	0.291	8	Hungary	0.355	8	Sweden	0.371	8	Czech Republic	0.392
9	Hungary	0.285	9	Germany	0.345	9	Austria	0.371	9	Spain	0.381
10	Vietnam	0.276	10	Poland	0.343	10	Mexico	0.369	10	Thailand	0.368
12	India	0.272	13	United States	0.333	12	Hong Kong SAR	0.362	14	China	0.356
13	Poland	0.265	15	Vietnam	0.325	13	Malaysia	0.345	16	Singapore	0.351
20	United States	0.248	17	Spain	0.313	15	Thailand	0.315	20	Hong Kong SAR	0.327
24	Germany	0.241	19	France	0.310	20	Philippines	0.244	23	Malaysia	0.294
25	Japan	0.238	23	Indonesia	0.295	23	China	0.238	25	Philippines	0.276
Euro Area						**United States**					
Rank	1995		Rank	2008		Rank	1995		Rank	2008	
1	United Kingdom	0.619	1	United States	0.640	1	United Kingdom	0.584	1	Germany	0.587
2	United States	0.585	2	United Kingdom	0.621	2	Germany	0.553	2	United Kingdom	0.586
3	Japan	0.501	3	Sweden	0.554	3	France	0.528	3	France	0.576
4	Sweden	0.480	4	Japan	0.513	4	Japan	0.515	4	Netherlands	0.487
5	Switzerland	0.448	5	Czech Republic	0.483	5	Netherlands	0.467	5	Japan	0.487
6	Czech Republic	0.433	6	Denmark	0.477	6	Italy	0.424	6	Italy	0.467
7	Denmark	0.424	7	Poland	0.473	7	Austria	0.412	7	Austria	0.459
8	Canada	0.391	8	Hungary	0.451	8	Canada	0.398	8	Sweden	0.459
9	Hungary	0.378	9	Switzerland	0.436	9	Sweden	0.394	9	Belgium	0.452
10	Korea	0.373	10	Korea	0.429	10	Spain	0.379	10	Spain	0.428
11	Mexico	0.362	12	Mexico	0.399	11	Singapore	0.371	14	Korea	0.394
12	Hong Kong SAR	0.311	13	Turkey	0.379	13	Korea	0.349	16	Singapore	0.379
13	Poland	0.311	13	China	0.377	16	Hong Kong SAR	0.337	20	Mexico	0.359
15	Singapore	0.282	16	Singapore	0.332	18	Mexico	0.333	23	China	0.333
16	China	0.281	21	Hong Kong SAR	0.302	29	China	0.248	28	Hong Kong SAR	0.312

Sources: UN Comtrade; and IMF staff estimates.

product.[17] The increase in overlap in export structures of emerging market economies, notably China, Indonesia, and Vietnam in Asia, and Poland and Turkey in Europe and those of advanced countries persists (Figure 14), albeit to a lesser extent compared to the unadjusted ESI presented in Table 5.

Advanced countries' exports are still differentiated by price and quality characteristics. An alternative indicator due to Hausmann, Hwang, and Rodrik (2007) measuring the income level embodied in a country's exports (EXPY) is useful in gauging the extent of export sophistication. The EXPY assigns to each six-digit product category a (weighted) average income level of those countries producing the same product. Thus, a product exclusively produced by industrialized countries, and likely embodying high quality/ value added, would be assigned a higher value. Based on this indicator, Japan has consistently outperformed the G-7 countries in increasing the value of its exports (Figure 15). Despite their substantial catch-up, the income level embodied in EMEs' exports still remains below those for advanced countries. In other words, EMEs' exports are still skewed toward lower-income product categories. This is true even for China which has strongly outperformed other large emerging markets according to this metric.

Export structures suggest that dynamic EMEs can expect another growth push. In a given year a country's EXPY can deviate considerably from the value that may be predicted based on its income level. Given ongoing product and quality upgrading, the quality level of exports in several EMEs is higher than expected based on GDP per capita. As shown in Figure 16, countries with higher-than-expected EXPYs tend to grow more in subsequent years (see also Hausmann, Hwang, and Rodrik, 2007). The growth push is expected to be most pronounced for some Asian countries such as China, India, and Thailand, and somewhat less pronounced but still positive for most eastern European countries (Figure 17).[18]

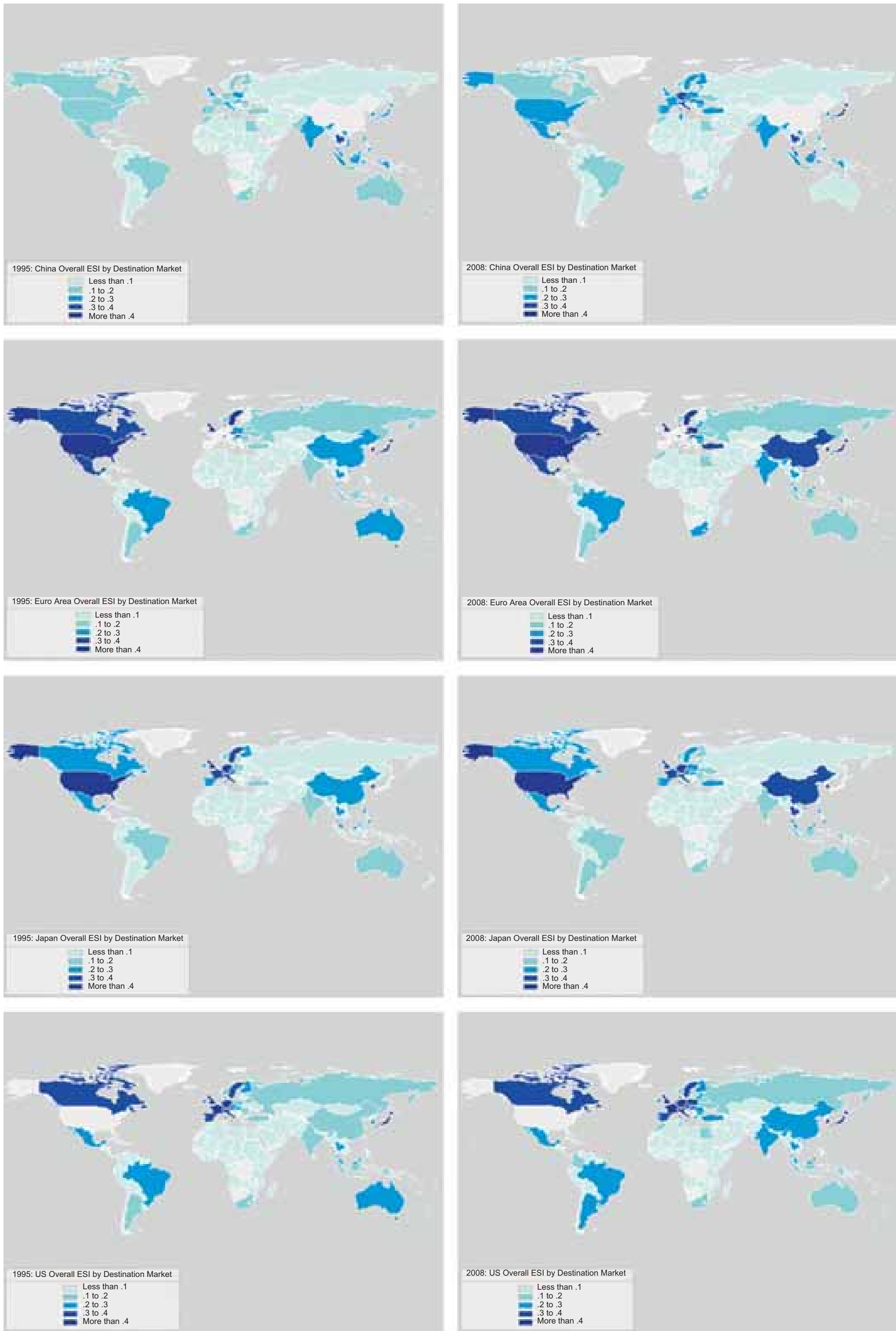
F. Past Trends and Implications for Trade Outlook

The integration of rapidly growing EMEs is likely to induce a gradual shift in the sources of global demand away from advanced economies. With China overtaking Japan as the second largest economy in the world in 2010, East Asian countries are likely to emerge as the largest trading bloc by 2015, surpassing NAFTA and the euro area (Figure 18). Global supply chains have

[17] The ESI is recalculated by distinguishing products based on five destination markets using the standard World Bank income classification: high-income OECD, high-income non-OECD, upper middle income, lower middle, and low-income. In this analysis, product "A" exported to a low-income country would be considered a different product from the same product "A" exported to a high-income country.

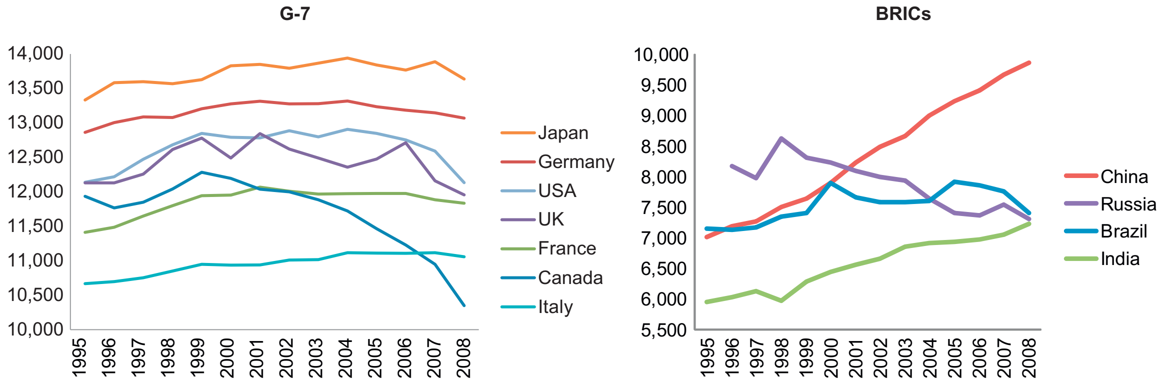
[18] In terms of Figure 17, this growth push would move these countries to the right, thus aligning their income level with the sophistication level of their exports. For countries that are closer to the regression line, the EXPY-induced growth push would be smaller.

Figure 14. Export Similarity Index (ESI) by Destination in 1995 and 2008: China, Euro Area, Japan, and the United States



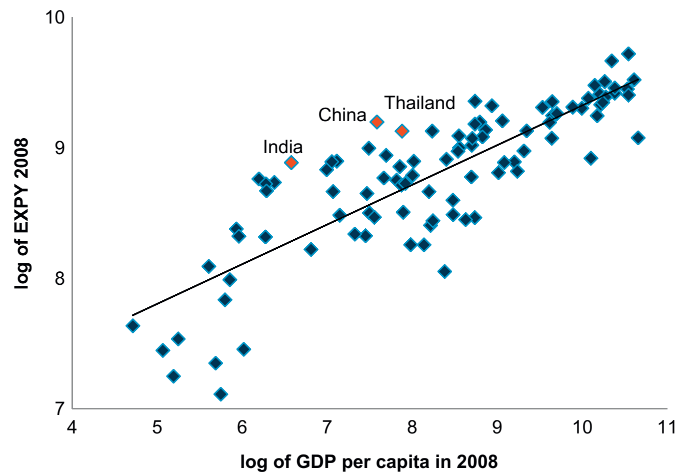
Source: UN Comtrade.

Figure 15. Income Level of Exports (EXPY)



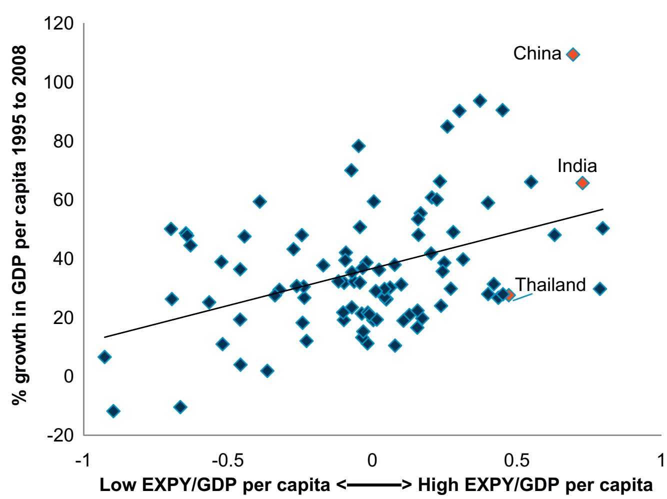
Sources: UN Comtrade; and IMF staff estimates.

Figure 16. Income Level of Exports 2008 vs. GDP per Capita 2008



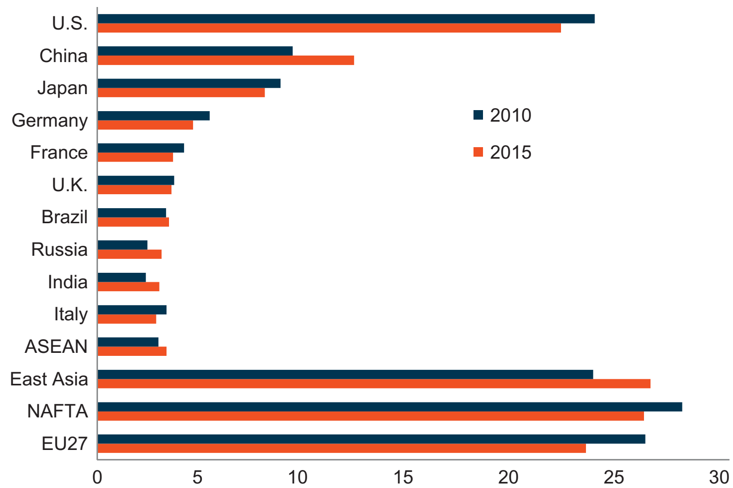
Sources: IMF, World Economic Outlook database, and staff estimates.

Figure 17. Growth in GDP per Capita 1995–2008



Sources: IMF, World Economic Outlook database, and staff estimates.

Figure 18. Three Trading Blocks and Top Export Markets by 2015
(Share of world nominal GDP)



Source: IMF, World Economic Outlook database.
Note: East Asia = ASEAN + Taiwan Province of China + Hong Kong SAR.

been an important factor in this trend and a country's position along the supply chain could have important implications for trading patterns in the future.

The emergence of global supply chains may have also changed the way trade responds to relative price changes. Higher imported content in exports is likely to lower the sensitivity of trade to changes in the exchange rate. For instance an appreciation of the domestic currency against all trading partners implies that while exports become more expensive, imported intermediates also become cheaper, mitigating the impact of relative price changes on trade flows (Koopman, Wang, and Wei, 2008).[19] Advanced countries whose exports tend to be concentrated in medium-high-technology goods are therefore likely to be more sensitive to relative price changes because of higher DVA, whereas those of EMEs are likely to be less sensitive given higher FVA in their exports.[20] The simulation results in the next chapter are consistent with these predictions.

Global supply chains may also result in closer relationships between producers in different countries and higher adjustment costs. Although this may further dampen the impact of (small) relative price changes on trade flows, it may also represent a source of vulnerability. The recent earthquake in Japan provides for a real life test of the resilience of supply chains to disruptions in production, especially in an upstream country (see Box 6 for details). And although the disruption is likely to prove temporary, it may nonetheless lead to a rethink of the "just-in-time" production framework underlying global supply chains, especially the Asian one.

[19] However, this impact is lower if the currencies of partner countries that provide imported intermediates also appreciate (see Ahmed, 2009; Thorbecke and Smith, 2010).
[20] Appendix 4 provides a brief description of the export structure of the four simulation countries.

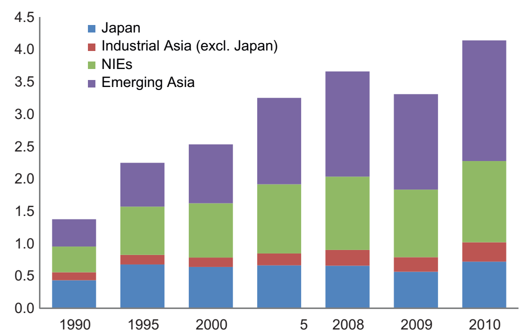
Box 6. Supply Chain Implications of the Pacific Earthquake in Japan[1]

Although the implications of the disruptions are likely to be temporary, the March 11, 2011, Pacific earthquake in Japan is likely to test the resilience of the Asian supply chain. This box elaborates on the relevant factors that are important in analyzing the possible spillover implications of a disruption in Japanese production. The analysis focuses on the semiconductor and automobile industries, which seem to be most vulnerable to a supply chain disruption.

Although its weight in global trade has been declining, Japan continues to play an important role in Asian regional trade. Asian intraregional trade has expanded rapidly since 1990, largely driven by dynamic economies such as China (Box Figure 6.1). Nonetheless, Japan's intraregional exports as a share of global GDP has remained remarkably stable—even during the crisis—and accounts for more than two-thirds of industrial countries' intraregional trade. Japanese exports to the region accounted for almost 60 percent of overall exports in 2010, mostly concentrated in machinery, chemicals, and transport equipment. Japan's deepening regional integration was in large part driven by increased outsourcing of production processes by Japanese firms to neighboring countries.

Box Figure 6.1. Intraregional Trade

(Exports in percent of world GDP)



Sources: IMF, Direction of Trade Statistics, and World Economic Outlook database.
Note: Industrial Asia: Australia and New Zealand; NIEs: Hong Kong SAR, Korea, Singapore, and Taiwan Province of China; Emerging Asia: Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

Japan's trade structure is shifting from export of high-technology final products toward export of sophisticated intermediate inputs. Whereas exports of high-technology final goods may have declined, those of sophisticated intermediate inputs have been rising (see Box 4). Japan has thus established itself as an important supplier of sophisticated manufacturing inputs at the global and regional levels, particularly in the transport and electrical machinery sectors. Even though they may not constitute an important share in its overall exports, Japan accounts for a significant share of global exports in the semiconductor and auto subsectors, and is an important source of these intermediates not only for countries in Asia but also for the United States and the European Union (Box Table 6.1).

Japan is an important source of FVA in gross exports of other Asian countries. Japan is clearly upstream in the Asian supply chain and its share of FVA in gross exports is particularly high for Asian countries engaged in assembly or processing activities (Box Figure 6.2). The chart illustrates two important points: (i) foreign content in gross

[1] With contributions from Phil de Imus of the Strategy, Policy, and Review Department.

Box 6. (*continued*)

Box Table 6.1. Japan's Share in Global Export Markets and Partner Imports, 2010

	8486	8408	8541	8703
Japan exports (percent of world exports; reporting)	34.3	10.0	15.0	17.1
Imports from Japan (percent 4-digit imports):				
China: Mainland	35.7	37.1	19.6	23.5
China: Hong Kong SAR	23.2	7.6	15.2	30.6
India	12.2	10.0	7.8	15.0
Indonesia	48.6	31.1	35.1	20.1
South Korea	40.6	34.6	25.3	18.7
United States	53.2	20.2	17.8	27.7
European Union	27.2	25.2	6.4	33.3

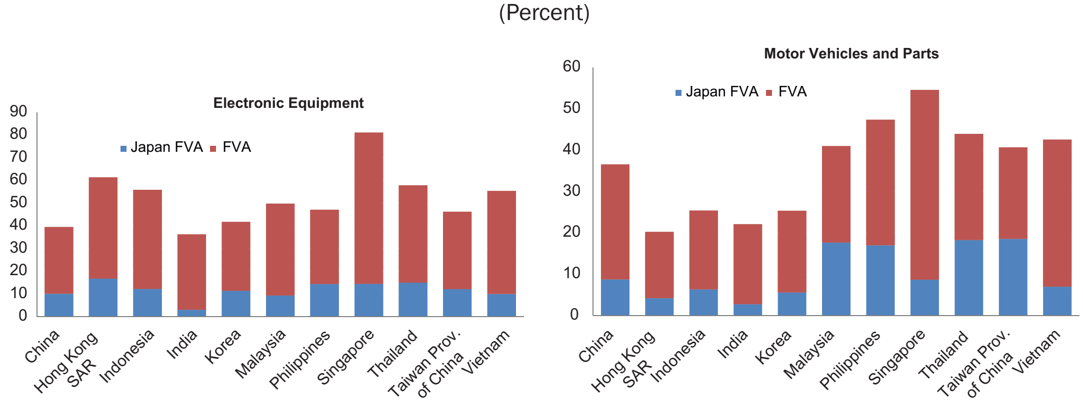
Source: Global Trade Atlas.
Note: 8486, boilers and reactors: machines and apparatus for manufacture of semiconductors; 8408, boilers and reactors: compression-ignition for combustion engines; 8541, electrical machinery: semiconductor devices; 8703, vehicles excluding railways: autos.

exports of these products of most Asian countries is relatively high (more than 80 percent in electronic equipment in Singapore); and (ii) a significant proportion of FVA comes from Japan, especially for Hong Kong SAR and China (electronic equipment), and Thailand and Taiwan (motor vehicles). A disruption in the production of key intermediate inputs in Japan due to the earthquake, therefore, has the potential to spill over to production in other countries in the supply chain.

The extent of disruption from the earthquake is gradually manifesting in the high frequency Japanese trade data. Exports plunged in April and, for the first time in

Box Figure 6.2. Japanese Contribution to FVA in Countries' Gross Exports, 2004

(Percent)



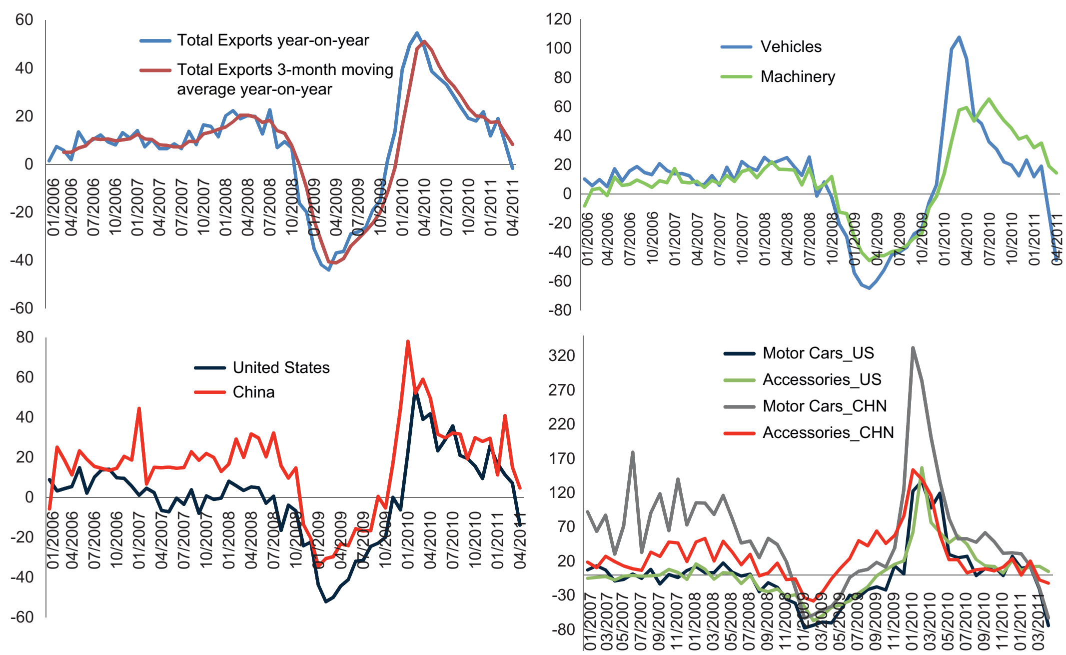
Source: Koopman and others (2010).

Box 6. (*continued*)

31 years, Japan recorded a trade deficit for the month (Box Figure 6.3). Part of this decline, however, is a correction from the sharp increase in growth rates as Japanese exports bounced back from the crisis; a similar correction in growth rates was observed after the dot-com bubble burst in 2001. Nonetheless, there is significant variation in impact across sectors, with exports of vehicles being hit particularly hard compared to those of machinery, and between upstream and downstream countries, as exports to the United States are harder hit compared to China. This differential impact is partly attributed to the relative weights of final versus intermediate goods exported to each country. Within the vehicles sector, the decline was most pronounced for exports of the final goods (cars subsector) compared to those of intermediates (parts and accessories for vehicles subsector), possibly reflecting an inventory effect. The overall impact on the United States reflects the predominance of exports of cars (final product) under the vehicles sector compared to car accessories (intermediate product) for China.

Overall, so far, equity prices and supply projections by industry analysts suggest that the overall impact of the disruption along the supply chain is likely to be short-lived. However, many of the affected Japanese firms' returns remain significantly below

Box Figure 6.3. Japanese Exports by Sector and Partner



Source: Global Trade Atlas.

Box 6. (*concluded*)

expectations.[2] Staff micro analysis of firms' equity returns data in the semiconductor industry for key upstream (input suppliers), midstream (memory makers), and downstream companies (PC and handset makers) suggests an initial impact on the market's outlook, especially during the immediate period of elevated concern regarding a potential nuclear meltdown. However, these effects did not persist for all firms in the ensuing month; in part this reflects a previous buildup in global semiconductor inventory, which may provide some cushion possibly until 2011:Q3. In the automobile sector, concerns have focused on disruptions to the supply of microcontroller units (MCUs), which are small, high-value components used in a variety of automotive applications and parts. Equity returns for Japanese MCU manufacturers have experienced significantly negative abnormal returns (ARs) since March, coinciding with weak returns for Japanese auto manufacturers, suggesting markets expect them to bear the brunt of any parts bottlenecks. Indeed, these manufacturers have scaled back their production across the globe. Equity markets also suggest that some of their competitors are expected to substitute for lost production.

The supply chain implications of the Pacific earthquake are likely to be transitory, although downside risks remain. In the short term, substitution may be harder in subsectors in which Japanese exporters have a high market share. Firms may be initially willing to endure some losses as Japanese production recovers, either through inventory adjustment or temporary shutdown of facilities. Moreover, exports of sophisticated subproducts may be protected by patent rights, making substitution of Japanese suppliers difficult in the short term.[3] However, if the supply of key products from Japan is disrupted for a prolonged period and inventories run out, firms may be forced to replace Japanese exports from other sources.

[2] A firm's performance is measured against its expected return derived from a standard capital asset pricing model (CAPM) to calculate AR. Returns on the MSCI World Free index represent the market return and the 3-month U.S. Treasury bills the risk free rate. ARs are summed up since March 2011 to derive a cumulative abnormal return.

[3] As suggested by the analysis on R&D spending and royalties in Box 4.

CHAPTER

3 Global Trade and Relative Prices: A Sectoral Elasticities Approach

A highly disaggregated sectoral level approach is used to examine the impact of relative price changes on trade flows and structures. The impact of such macroeconomic policies is often analyzed at the level of the overall economy or for highly aggregated sectors, using multicountry computable general equilibrium (CGE) models that rely on modeling complex interactions among a large number of variables in various economies. As a complement to such analysis, a simple model that combines a partial equilibrium approach with input-output table analysis is used here to analyze the response of sectoral trade flows to changes in relative prices.[21] The framework models the impact of a hypothetical change in relative prices in two steps. The first step focuses on the import market of each economy. Changes in relative prices result in demand responses and shifts in the structure of trade at the product level, reflecting differences in import demand and substitution elasticities as well as the amount of imported intermediate inputs used in the production of exports.[22] The second step of the analysis uses input-output tables to determine the change in the composition of import demand as a result of the shift in the structure of exports (as determined in the first step). Appendices 5 and 6 provide details on the methodology.[23]

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[21] Data on imports at the six-digit level is used for the full set of 162 countries available in UN Comtrade.

[22] These exchange rate changes are assumed to be entirely exogenous without regard for the origin of the shock and any other implications this shock may have on macro variables and trade balances. The analysis also abstracts from any potential possible responses to the exogenous shock.

[23] The model is based on two sets of micro-level trade elasticities with a high level of product detail (demand elasticity: HS six-digit; substitution elasticity: HS two-digit). For each import market and for a hypothetical increase in relative prices, the exporter *substitution effect* (between suppliers) quantifies the extent consumers switch demand away from country A toward countries producing the same good. The *demand (income) effect* then quantifies the extent to which the importing country reduces its import demand overall, given that it now faces higher international price levels. Because our country sample covers nearly all of world trade, changes in the level and the composition of every country's export basket can be determined on the basis of changes in trading partners' imports.

The greater product detail and transparency of this modeling approach comes with a cost. Our approach offers two key advantages. First, by allowing for a high level of product detail, the aggregation bias implicit in CGE models using aggregate trade flows is avoided. The high level of sectoral detail allows reactions to relative price changes to vary across goods and countries. The model thus provides a useful framework for analyzing sectoral and supply chain linkages in international trade. Second, the model is simple and transparent in its assumptions allowing the flexibility to adjust the key parameters, including accounting for the effect of global supply chains on the response of trade flows. On the downside, each product is modeled as a separate market and in isolation from other markets, and inter- and intrasectoral linkages or economy-wide impacts of changes in relative prices that are likely to take place are not fully captured. These limitations need to be kept in mind when examining the model's predictions at the aggregate level.

The simulations focus on the four key players in global trade. The analysis essentially focuses on the impact of a change in relative prices in China and the United States on their trade structures, by assuming an exogenous 10 percent increase in relative prices in the former and a similar decline in the latter. The increase (decrease) in relative prices can be interpreted as a real appreciation (depreciation) against all trading partner currencies. The direction of change in relative prices in each country is consistent with policy recommendations to reduce global imbalances through a lower current account surplus in China and deficit in the United States (Blanchard and Milesi-Ferretti, 2009). For purely illustrative purposes, we also assume a 10 percent relative price increase in the euro area and a similar decline in Japan. The baseline for the analysis is 2008, being a largely precrisis year.[24]

A. Aggregate Results

Changes in relative prices result in sizable long-term responses in trade flows and rebalancing effects. Table 6 presents a summary of the results under different assumptions of pass-through of exchange rates to import prices. Assuming full pass-through in the long run, the results suggest that a 10 percent depreciation for the United States would result in a 14 percent expansion in exports and a 7 percent contraction in imports. Together these translate into a 40 percent improvement in the trade balance and roughly a halving of the U.S. current account deficit-to-GDP ratio. These results are

[24] The financial crisis caused trade flows to contract disproportionately in 2009 and thus is likely to provide a distorted picture of long-run structural patterns. At the same time, earlier years such as 2006–2007 may be distorted by the oil and food price surges.

Table 6. Simulated Long-Term Impacts of Relative Price Shocks on External Balances Based on 2008 Trade

(Percent of national GDP, unless otherwise noted)

		Post-shock[1]		Simulated impact (Percent change)	
	Pre-shock	Perfect pass-through	Imperfect pass-through[2]	Perfect pass-through	Imperfect pass-through[2]
Simulation 1: China ***(Assumption: 10 percent appreciation)***					
Current Account Balance	9.6	5.9	7.1		
o/w Merchandise Trade Balance	8.0	4.2	5.4		
Exports	31.7	28.9	30.0	–10.9%	–7.7%
Imports	–23.8	–24.7	–24.6	1.7%	1.3%
Simulation 2: Euro Area ***(Assumption: 10 percent appreciation)***					
Current Account Balance	–1.7	–4.7	–3.9		
o/w Merchandise Trade Balance	–0.6	–3.6	–2.8		
Exports[3]	17.0	15.1	15.7	–12.7%	–8.9%
Imports[3]	–17.5	–18.6	–18.5	4.5%	3.7%
Simulation 3: Japan ***(Assumption: 10 percent depreciation)***					
Current Account Balance	3.2	6.3	5.6		
o/w Merchandise Trade Balance	0.8	3.9	3.2		
Exports	15.3	17.5	16.7	17.0%	12.0%
Imports	–14.5	–13.5	–13.5	–4.5%	–4.5%
Simulation 4: United States ***(Assumption: 10 percent depreciation)***					
Current Account Balance	–4.7	–2.4	–3.3		
o/w Merchandise Trade Balance	–5.8	–3.5	–4.4		
Exports	9.1	10.2	9.9	13.7%	10.4%
Imports	–14.9	–13.8	–14.3	–6.7%	–2.7%
Memorandum items (in billions of U.S. dollars):					
Nominal GDP[4]					
China	4,520	4,417			
Euro Area	13,616	13,374			
Japan	4,887	4,992			
United States	14,369	14,519			

Sources: IMF, World Economic Outlook database, Direction of Trade Statistics, and staff estimates.

[1] Trade levels implied in the long term by simulated relative international price shocks are in absence of other shocks.

[2] Calculated using exchange rate to domestic price pass-through elasticities estimated by Goldberg and Campa (2005) and restricted to range from 0 to 1. The elasticity for simulation countries on the export side is calculated as a weighted average of import partners' individual elasticities.

[3] Euro area trade data was obtained from the IMF Direction of Trade Statistics database.

[4] Post-shock GDPs reflect changes due to changes in exports under perfect pass-through (see Appendix 6 for more detail).

broadly consistent with findings by Obstfeld and Rogoff (2005) and Dekle, Eaton, and Kortum (2007), among others, suggesting that a 20 percent fall in relative prices in the United States would be sufficient to close the current account deficit. The results for China suggest that a 10 percent real exchange appreciation would lead to a 50 percent reduction in its merchandise trade surplus.[25]

A downstream position in a supply chain is likely to cushion the impact of a relative price change on both exports and imports. The response of Chinese exports to a 10 percent exchange rate appreciation is smaller in absolute magnitude compared to that of Japanese exports to a 10 percent exchange rate depreciation. To a large extent, this result reflects China's downstream position in the Asian supply chain and the relatively high share of foreign intermediates that mitigate the impact of exchange rate changes on its exports. The large foreign share in Chinese final exports also implies that import growth is relatively small: a given decline in exports leads to a larger decline in intermediate imports. On the other hand, the relatively large impact on Japanese exports is driven not only by Japan's upstream position in the supply chain but also by its strength in exports of consumer discretionary goods such as vehicles and transport equipment with low foreign content and high price sensitivity.

Imperfect exchange rate pass-through to import prices and pricing-to-market are likely to mitigate the adjustment in trade flows to exchange rate changes.[26] In reality, trading firms absorb part of the exchange rate changes rather than pass them on to importing consumers. In particular, in trading relationships with flexible exchange rate regimes, exporters may delay price adjustments given the possibility of an unwinding of the initial exchange rate shock. Exporters may also be pricing-to-market, in which case the change in relative prices would not be (fully) reflected in import prices. As shown in Table 6, accounting for less than perfect pass-through reduces the exchange rate impact on both exports and imports in all simulations significantly.[27]

[25] The aggregate impact on China's exports is on the lower side of the spectrum of results typically found in the literature. Ahmed (2009) shows that exchange rate appreciation dampens Chinese export growth, both for nonprocessed and processed exports, with the estimated cumulative price elasticity being greater than unity. Thorbecke and Smith (2010), using dynamic ordinary least squares estimation and quarterly data over the 1993–2008 period, argue that a 10 percent appreciation of the renminbi alone would reduce processed exports by 14 percent.

[26] Pass-through analysis is based on results by Campa and Goldberg (2005) estimating exchange rate pass-through to be about 0.6 in the short run and 0.75 in the long run (amidst significant cross-country variation). Interestingly, their results showed the lowest pass-through elasticity to be observed for the U.S. import market (0.25 in the short run and 0.4 in the long run), suggesting a potentially more limited impact on the U.S. trade balance from exchange rate changes.

[27] This implies that a bigger change in the nominal exchange rate would be needed to generate a 10 percent shift in international relative prices.

Overall, the results for advanced economies are in line with historical responses of trade flows to exchange rate changes (Box 7).

Adjustment in trade flows is also likely to be gradual given high fixed costs in production and trade relationships. Fixed production costs and constraints to factor mobility make it burdensome and often unprofitable to move production facilities across countries once they are established. Furthermore, there is a large and growing literature outlining the high fixed costs of establishing export relationships, such as costs of establishing distribution networks or adapting to local regulations (Freund, 2009). On average, the analysis suggests that about half of the long-run adjustment in trade balances in response to a real exchange rate appreciation would materialize within the first 2 years, and 80 percent within 6 years.[28]

B. Sectoral Effects

An appreciation results in an increase in the share of high-technology exports in China and to a lesser extent in the euro area. In China, the share of machinery and electronics (a high-technology sector) in overall exports increases in response to the appreciation, whereas that of textiles (a low-technology sector) falls. This result reflects both limited price sensitivity of high-technology goods, which are typically more differentiated (Rauch, 1999), and the larger contribution of imported intermediate inputs (Figures 19 and 20).[29] It suggests that an appreciation would support a continued upgrading of Chinese exports in terms of technology content and reduce the reliance on low-skill manufacturing. This may also lead to increasing convergence with advanced countries' exports in terms of quality (Schott, 2004). Box 8 further illustrates the impact on the Chinese export structure under an alternative assumption that other supply chain countries also allow their currencies to appreciate. The qualitative results remain broadly unchanged. On the other hand, the response in the euro area is more muted, reflecting the lower contribution of FVA in high-technology exports.

A depreciation results in important shifts in the share of medium-high-technology exports in Japan and the United States, largely driven by the auto sector. Medium-high-technology exports are generally more sensitive to relative price changes, reflecting both higher DVA and the largely discretionary consumer character of this sector, which is subject to higher

[28] Adjustment paths for external balances are derived based on the relationship between short-run and long-run elasticities suggested by the literature, which tend to vary between 2 and 5 (Goldstein and Khan, 1985; Senhadji and Montenegro, 1999).

[29] Supply chain analysis in Chapter 2 has shown that foreign content tends to be highest in the high-technology sector.

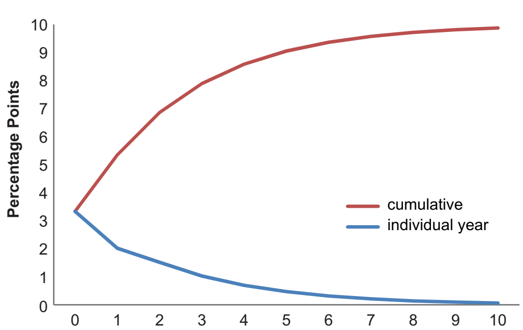
Box 7. Impact of Exchange Rate Changes and Trade Flows—A Historical Perspective

The simulation results are broadly consistent with responses observed during historical episodes of exchange rate changes. A dynamically adjusted REER (DAREER) is used to account for the gradual realization of the impact on trade flows of changes in the real exchange rate. There are several reasons why trade flows would only respond gradually to exchange rate changes. Export relationships are costly to establish and production facilities are hard to redeploy in the short run. In the case of an appreciation, exporting firms may initially attempt to maintain market share at the cost of profits until cost savings can be realized, or a hoped-for offsetting exchange rate movement takes place.

A simple autoregressive model is used to trace the dynamic adjustment of trade flows to exchange rate shifts, based on the relationship between short-run and long-run elasticities. Following Goldstein and Khan (1985) and Senhadji and Montenegro (1999), the ratio of long-run to short-run impact is in the range of 2 to 5. A midpoint of 3 as the key parameter determining the speed of adjustment is thus used as a reasonable ratio for likely outcomes. This implies that a third of the impact of 10 percent change in the REER would manifest in the first year of the shock, with the remaining impact (6.5 percent) unfolding asymptotically (Box Figure 7.1). The DAREER is thus a weighted average of realized REER shocks, with weights obtained as shown in Box Figure 7.1 and more recent shocks given higher weights.

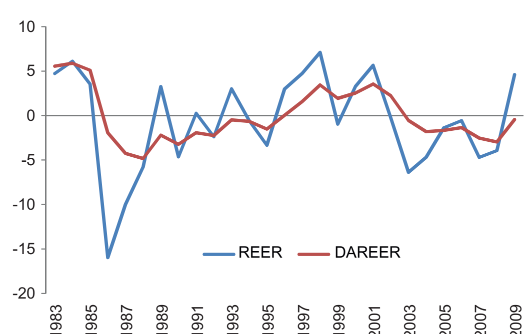
The DAREER has historically been less volatile compared to the unadjusted REER, given that exchange rate fluctuations in proximate years often offset each other (Box Figure 7.2). The analysis focuses on the United States and Japan, given their flexible exchange rate regimes and availability of long time series, but for expositional brevity, only the results of the United States are discussed.

Box Figure 7.1. Pass-Through of 10 Percent Shock in REER per Year



Source: IMF staff estimates.
Note: Chart assumes a ratio of long-run to short-run pass-through of 3 in a first-order autoregressive model.

Box Figure 7.2. United States

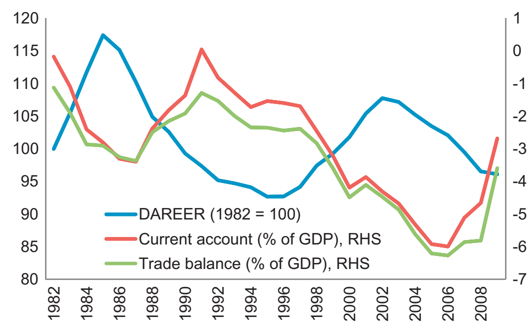


Sources: IMF, Information Notice System (INS), and staff estimates.

Box 7. (*concluded*)

The historical analysis confirms the negative relationship between external balances and movements in the DAREER (Box Figure 7.3). For the United States swings of 10 percent or more in the DAREER were relatively infrequent; the DAREER exhibited only two long waves of appreciation and depreciation since the 1980s, with attendant worsening and improvement in trade and current account balances.

Box Figure 7.3. US DAREER and External Balances



Sources: IMF, World Economic Outlook database, INS, and staff estimates.

The historical response of external balances to changes in the DAREER is closely aligned with the simulation results. Box Table 7.1 presents results based on peak-to-trough analysis of changes in external balances and the DAREER. Peak-to-trough analysis is based on 2-year averages because the DAREER for the United States moved only gradually. On average, the trade balance improved (deteriorated) by 0.17 percent of GDP for every percentage point depreciation (appreciation) of the DAREER. These values are close to the simulation results suggesting a 1.4 percentage point of GDP improvement in the trade balance in the United States in response to a 10 percent real depreciation (assuming partial pass-through).

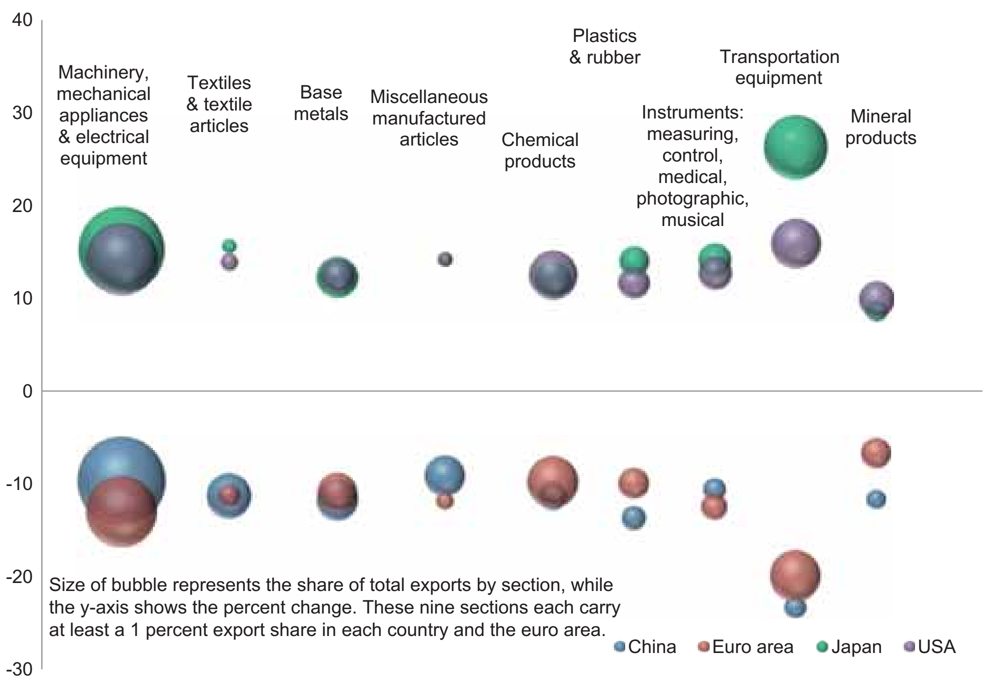
Box Table 7.1. Response of External Balances to Exchange Rate Changes: Historical and Simulation

United States		Historical episodes					Simulated Scenario[1]
	from	1982–83	1986–87	1994–95	2005–06		
	to	1986–87	1991–92	2000–01	2008–09	Mean	
Change in dynamically adjusted REER (percent)		9.7	–14.6	10.9	–7.7		–10.0
Current account adjustment (percent of GDP)		–2.7	3.0	–2.4	1.9		1.4
Ratio: CA change/DAREER change		–0.3	–0.2	–0.2	–0.3	–0.2	–0.1
Trade balance adjustment (percent of GDP)		–1.8	1.9	–1.9	1.5		1.4
Ratio: TB change/DAREER change		–0.2	–0.1	–0.2	–0.2	–0.2	–0.1

Sources: IMF, World Economic Outlook database, and staff estimates.

[1] We use the current account and trade balance adjustments resulting under the assumption of imperfect exchange rate pass-through (Table 6). This ensures the consistency of the analysis given that changes in the DAREER are inherently exchange rate changes (derived from the REER), not changes in relative prices in destination markets.

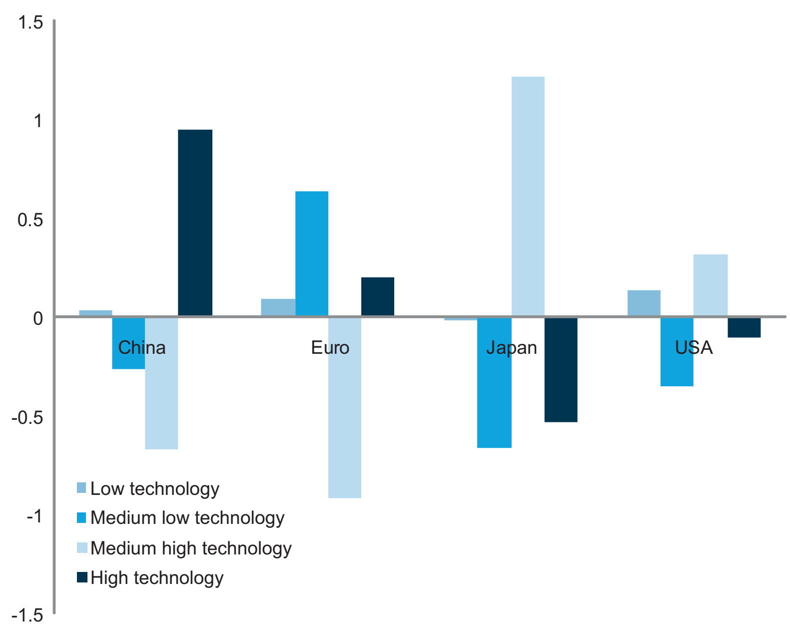
Figure 19. Exports by Section: Percent Change and Share



Sources: UN Comtrade; and IMF staff estimates.

Figure 20. Responses of Exports by Technology Content

(Percentage point change in share)



Sources: UN Comtrade; and IMF staff estimates.

Box 8. Appreciation within the Asian Supply Chain

Alternative simulation. Regional integration in Asia suggests that an appreciation of the Chinese nominal exchange rate is likely to result in revaluations of other regional currencies. An appreciation along the Asian supply chain would result in a further increase in prices of Chinese exports through higher costs of imported intermediate inputs, potentially contributing to lower exports and further global rebalancing.[1] The alternative simulation therefore reflects the trade impact of changes in relative prices stemming from a 10 percent appreciation in the Chinese nominal exchange rate and a concurrent 5 percent appreciation of the nominal exchange rates of countries in the Asian supply chain.[2] The aggregate results are presented in Box Table 8.1.

Box Table 8.1. China: Baseline and Alternative Simulations[1]

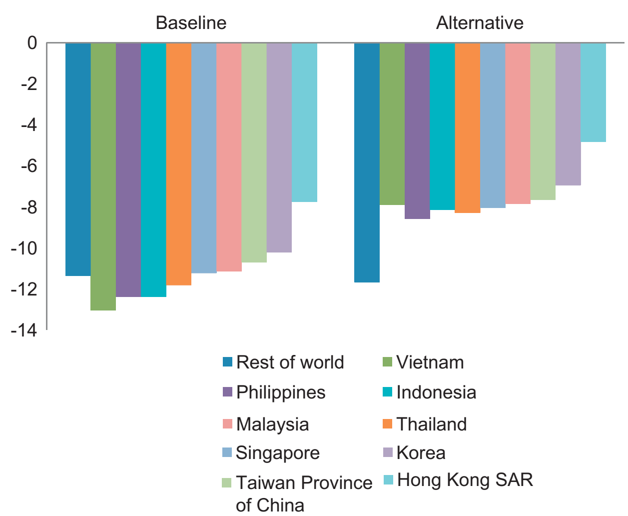
	Simulated impact (percent change)	
	Baseline	**Alternative**
Exports	–10.9	–10.2
Imports	1.7	1.3

Sources: UN Comtrade; and IMF staff estimates.
[1] Assumes perfect pass-through.

Additional effects on Chinese exports. There are three additional effects on Chinese exports compared to the baseline simulation. First, imported intermediate inputs from upstream supply chain partners become more expensive, making Chinese exports based on processing trade more expensive and contributing to lower exports. Second, Chinese exports to countries in the Asian supply chain become less expensive and therefore exports to these countries decline less. Finally, higher import prices from countries in the Asian supply chain lowers overall imports in third

Box Figure 8.1. Exports to Supply Chain Countries

(Percent change)



Sources: UN Comtrade; and IMF staff estimates.

[1] Thorbecke and Smith (2010) estimate that an appreciation of the renminbi and other east Asian currencies by 10 percent would result in a decline in processed exports by 10 percent (compared to a fall of only 4 percent if the renminbi appreciates alone).

[2] Countries in the Asian supply chain are: Hong Kong SAR, Indonesia, Republic of Korea, Malaysia, the Philippines, Singapore, Taiwan Province of China, Thailand, and Vietnam.

Box 8. (*concluded*)

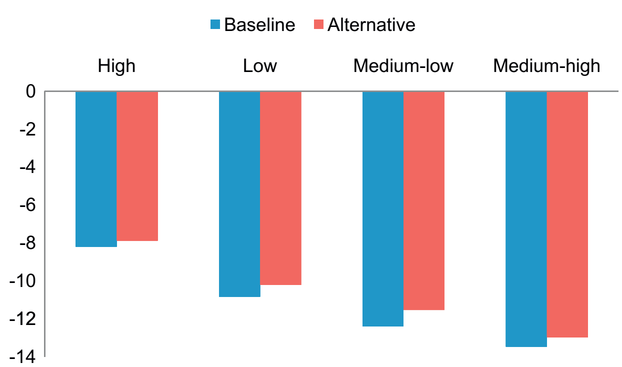
markets through the income effect, leading to a larger decline in exports from China, whereas substitution between importing countries results in a smaller decline in exports from China.[3]

Supply chain effects on Chinese exports. The additional appreciation amplifies the role of the region as a destination for Chinese exports (see Box Figure 8.1). Exports to the Asian supply chain countries—including Hong Kong SAR and Korea among the top 10 largest export destinations—decline substantially less compared to the baseline scenario. Despite higher export prices, the decline in Chinese exports to the rest of the world, including to Japan, is not significantly higher compared to the baseline simulation.

Sectoral effects. Despite the larger share of imported intermediate inputs in Chinese exports of high-technology sectors, the alternative simulation does not fundamentally change the picture of an upgrading in Chinese exports in terms of their technology content (see Box Figure 8.2). As in the baseline simulation, exports of high-technology goods decline the least, resulting in a further increase in their share in total exports (especially for machinery and electronics exports).

Box Figure 8.2. Exports by Technology Content

(Percent change)



Sources: UN Comtrade; and IMF staff estimates.

Aggregate effects and rebalancing.
The aggregate effects on Chinese trade are somewhat smaller than in the baseline simulation (Box Table 8.1). For exports, the gain from more exports to Asian countries and relative competitiveness gains in third markets outweigh the loss from higher export prices resulting from higher prices of imported intermediate inputs. Overall, the alternative simulation suggests a 3.6 percentage point fall in the Chinese current account surplus (compared to 3.8 percent in the baseline). The smaller decline reflects less rebalancing vis-à-vis the supply chain countries, with limited additional rebalancing impact with the rest of the world. Exports to euro area countries fall somewhat more (by 12.4 percent instead of 12 percent in the baseline), whereas the impacts on Chinese exports to Japan and the United States are similar to the baseline simulation.

[3] Although this box focuses on exports, imports to China can also change. First, imports from Asian supply chain countries become more expensive, resulting in a smaller increase in Chinese imports. Second, a smaller decline in Chinese exports has a smaller dampening impact on imports of both intermediate and final goods.

income elasticities. In Japan, where the transport sector accounts for a sizable share of overall exports (23 percent in 2008), a depreciation would reinforce its comparative advantage in medium-high-technology exports. In fact, Japan's relative specialization in the motor vehicles subsector would exceed that of France, Germany, and Spain, which had overtaken Japan after 1995 (Box 9). The response in the United States is relatively more muted given the higher FVA in its auto sector compared to Japan—26 percent versus 13 percent, respectively.

Imports of intermediate goods in the four economies are affected differently by a relative change in prices (Figure 21).[30] In China, intermediate goods imports fall by more than 6 percent in response to the appreciation, reflecting the overall decline in exports and its downstream position in the Asian supply chain.[31] Similarly, a depreciation of the yen would lead to an increase of more than 3 percent in Japan's intermediate goods imports, reflecting the significant expansion on the export side. In the United States, however, a depreciation of the dollar would lead to a drop in imports of intermediates because exports would not react as much as in Japan. A similar effect is visible in Europe: the assumed appreciation of the euro would result in a net increase in import of intermediates because exports do not react as much as in China or Japan.

Exports to supply chain partners are resilient to relative price changes but suppliers of intermediates can be impacted severely when exports fall in response to exchange rate appreciation. Figure 22 presents simulated export changes by destination as well as import changes by origin for each simulation, highlighting supply chain partners. For all four simulations, *exports* to supply chain partners are affected less by relative price shocks.[32] This could reflect two interrelated factors. First, the cost of breaking up a trade relationship may be particularly large in a supply chain, which would express itself in lower substitution elasticities in supply chain countries.[33] Second,

[30] Note that in response to an exchange rate depreciation, the demand for imports falls as a result of imports becoming more expensive (*price effect*). At the same time, an increase in exports leads to an increase in both GDP and the demand for imported goods, especially intermediates (*demand effect*). Although the *price effect* is substantially larger for consumer and capital goods, the *demand effect* has a larger impact on intermediates in China and Japan.

[31] Goods classified as "intermediate inputs" are by "product type" and not by "use" as in input-output tables. The former is used to approximate the latter since the latter is not available at the six-digit HS commodity level.

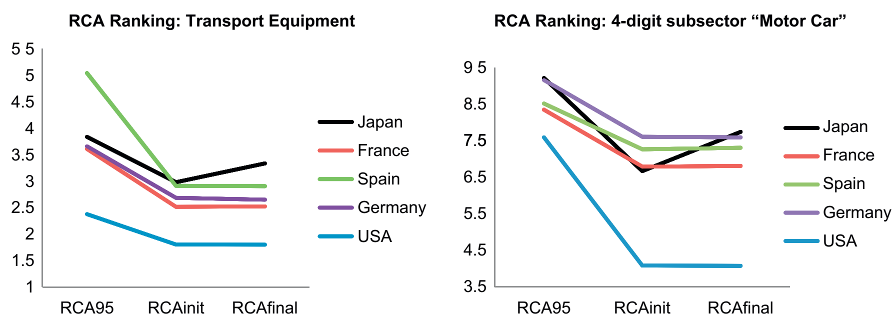
[32] In Japan, the difference in magnitude between the impact on exports to Asian supply chain partners compared to the rest of the world is particularly large. This is driven not only by Japan's dominant position in the production chain but also its upstream position which results in significant high-technology exports to these partners (which tend to be less responsive).

[33] We also carried out simulations that assume constant elasticities across products and markets. Although less pronounced in this alternative setup, exports to supply chain countries continue to be relatively less responsive to relative price changes. This suggests that in addition to the lower substitution elasticities in supply chain import markets, the dominant market position of our simulation countries is an important reason for the limited responsiveness of exports to the supply chain.

Box 9. Revealed Comparative Advantage (RCA) Analysis in Japan

The impact of the depreciation on the transport sector can be further gauged through the RCA index. The RCA index is a complementary construct to the ESI and measures the extent to which a country specializes in a certain product relative to other countries exporting the same product. The RCA therefore gives an indication of the products/sectors in which a given country has comparative advantage (to the extent that trade patterns internalize intercountry differences in relative costs as well as noncost factors). As shown, Japan regains part of its comparative advantage after the exchange rate change, driven by changes in the motor cars subsector.

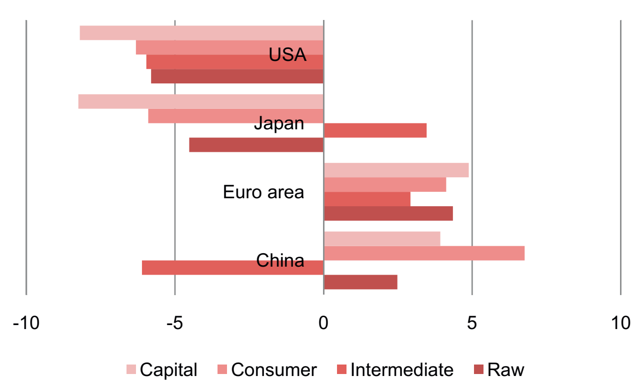
Box Figure 9.1. Impact of a 10 Percent Japanese Depreciation on the Country's Revealed Comparative Advantage (RCA)



Sources: UN Comtrade; and IMF staff estimates.

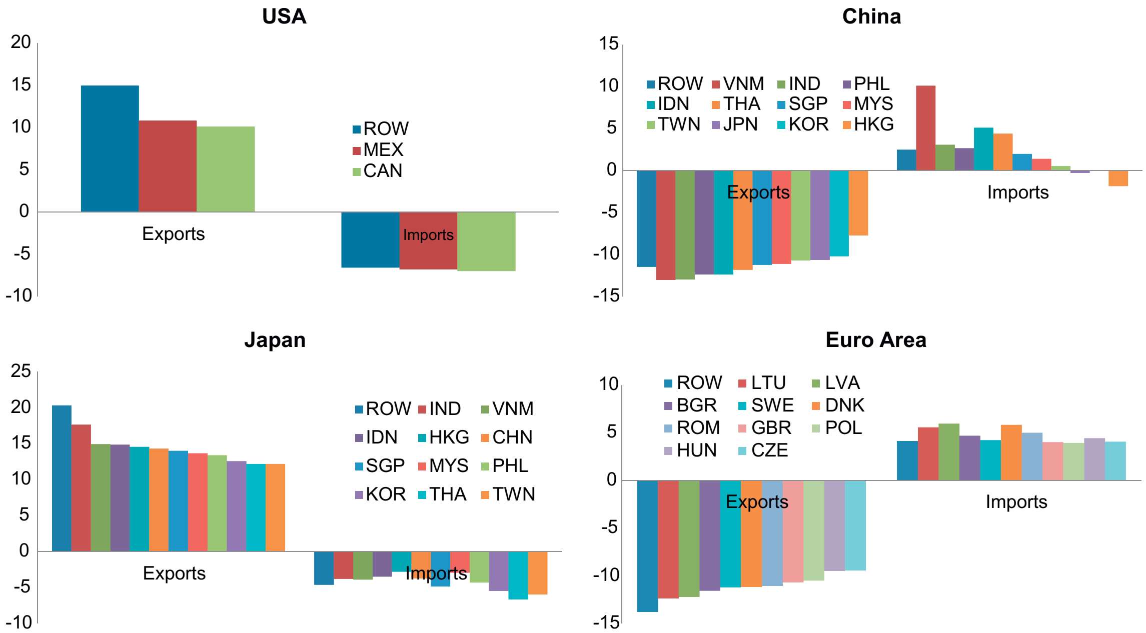
Figure 21. Import Responses by Type of Good

(Percent)



Sources: UN Comtrade; and IMF staff estimates.

Figure 22. Responses of Exports and Imports: Supply Chain vs. Rest of World
(Percent change)



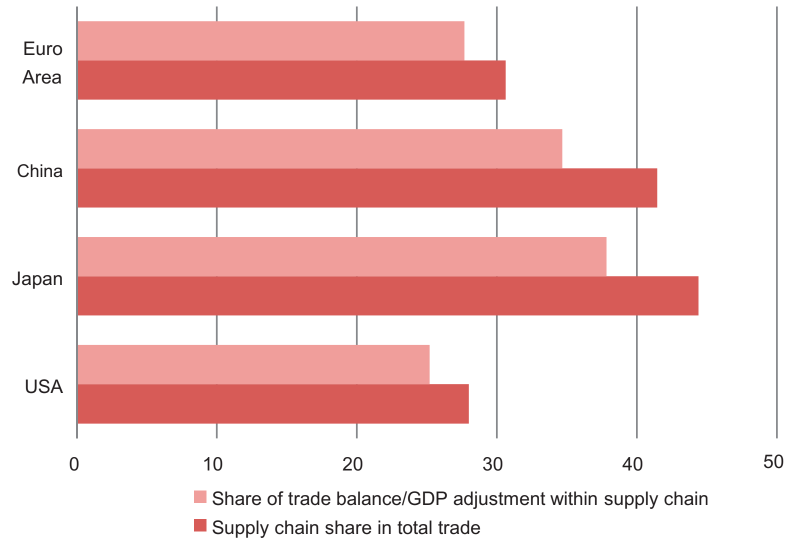
Sources: UN Comtrade; and IMF staff estimates.
Note: BGR, Bulgaria; CAN, Canada; CHN, China; CZE, Czech Republic; DNK, Denmark; GBR, United Kingdom; HKG, Hong Kong SAR; HUN, Hungary; IDN, Indonesia; IND, India; JPN, Japan; KOR, Republic of Korea; LTU, Lithuania; LVA, Latvia; MEX, Mexico; MYS, Malaysia; PHL, Philippines; POL, Poland; ROM, Romania; ROW, rest of world; SGP, Singapore; SWE, Sweden; THA, Thailand; TWN, Taiwan Province of China; VNM, Vietnam.

our simulation countries are dominant players in their regional supply chains in terms of both the volume and the value of their exports going to these destinations. This makes substitution for their trading partners more difficult. It is important to bear in mind, however, that supply chain partners are more strongly affected than other trading partners to the extent that they export a high share of intermediates to the hub country. A large exchange rate shift will not only result in a significant response of exports but also of the intermediate goods imports used in their production.

Trade balance adjustment in response to exchange rate changes takes place mainly outside the supply chain. In response to an appreciation exports to supply chain partners fall by less than exports to the rest of the world. At the same time, imports from the supply chain countries increase less than imports from the rest of the world. Taken together, this implies that trade balance adjustment in response to a relative price change is weaker within the supply chain than outside it (Figure 23).

Figure 23. Contribution to Adjustment in Trade Balance
(Percent)

Supply chain contribution to adjustment in trade balance is smaller than its importance as a trading partner would suggest...



Sources: UN Comtrade; and IMF staff estimates.

Chapter

4 Conclusion and Policy Implications

Shifts in the global trade landscape over the past few decades have resulted in increased interconnectedness and strengthened trade spillover channels. The expansion in global trade has been underpinned by a diffusion of key systemic players, both in size and in links. Not only has the number of key players increased, but there has been a shift in relative importance in global trade, from large advanced economies such as Japan and the United Kingdom to EMEs such China and India. Importantly, China is now on par with the United States—ranking first in systemic importance not only in terms of size but also in terms of significant bilateral trade relations. This has important implications on trade spillovers as the sources of demand shift in the process of rebalancing.

There is a high correlation between trade and financial interconnectedness. There is a strong overlap between countries hosting both systemically important trade and financial sectors, implying a heightened potential for these countries to transmit disturbances via either the trade channel or the financial channel, or both channels simultaneously. These countries would constitute a natural focus of risk-based surveillance on cross-border spillovers and contagion.

Changes in relative prices result in substantial responses in trade flows in Japan, the euro area, and the United States, and less so in China. Although still important, rebalancing effects are relatively small in China due to its downstream position in the production chain and greater content of imported intermediates in its exports. China's role as an assembly hub for the region's high-technology exports mitigates the impact emanating from relative price changes. The alternative simulation suggests the rebalancing impact is likely to be larger in the case where other countries in the supply chain also appreciate. Notwithstanding the stylized nature of the simulation exercise, the results for China are broadly consistent with findings of the April 2011 *Regional Economic Outlook* for the Asia and Pacific Region suggesting the impact in third markets to be more muted if only the currency of the final supplier appreciates as opposed to when other intermediate suppliers also appreciate. Exports of the three advanced economies—and in particular Japan—are significantly more sensitive to relative price changes given that these countries are located upstream in the production process.

Trade with supply chain partners is generally more resilient to exchange rate changes and rebalancing takes place predominantly outside the supply chain. The reason is not only the position of market power our simulation countries enjoy in their respective supply chain partners but also the perceived higher cost of breaking up a trading relationship. Imports from supply chain partners upstream in the production process also tend to increase less or even fall in response to an exchange rate appreciation in the simulation country. This is especially the case in China, a downstream country in the production process.

Real exchange rate shifts of the magnitude considered would not result in a substantial reorganization of trading networks and production chains. The simulations suggest that the magnitude of the trade response to exchange rate shifts differs by sector but the overall structure of export and import baskets remains broadly unchanged in the countries under consideration. Although subsectors react asymmetrically to exchange rate shifts, these differential impacts are not large enough to alter sectoral export shares significantly. This finding is generally consistent with the notion that export structures are path-dependent and reflect the outcome of long cumulative processes of learning, agglomeration, institution building, and business culture. Moving from a low-technology structure to a high-technology structure typically involves a broad and integrated set of economic policies conducive to technological absorption and adaptation.

Exchange rate appreciation may lead not only to an increase in a country's share of high-technology exports but also to quality upgrading. The simulation results have shown that an exchange rate appreciation may lead to an increase in the share of a country's high-technology exports. Although not captured in our model, this effect is likely to be further strengthened, namely via intraproduct quality upgrading. Since high quality goods are less sensitive to price shocks, exporting firms are more likely to be able to withstand competitive pressures emanating from shifts in relative prices. In the case of China and other EMEs with potential to appreciate in the near future, this effect may lead to increasing convergence not only in the types of products exported but also in terms of quality levels from the currently very disparate values.

The growing importance of global supply chains further increases the international transmission of shocks, including policy-induced ones. Compared to Europe or North America, global supply chains in Asia are more integrated regionally and their export structure is more intertwined. This makes them more vulnerable to country- or product-specific disruptions. Any disruption of trade flows, particularly in intraregional trade flows in Asia, could jeopardize the positive development observed in the past two decades. Protecting the free flow of inputs as well as outputs should be a top priority. This could be done in terms of binding the region's unilateral tariff cuts in the WTO by concluding Doha, but could also be done by including all the key players in regional FTAs such as the TPP. An exclusion of a key player such as China in regional FTAs could create bilateral tensions and potentially undermine the free flow of goods underpinning the Asian supply chain.

The resilience of supply chain relations may be tested by the recent earthquake in Japan, although substitution away from Japanese exporters may be difficult in the short term. A disruption in the supply of sophisticated intermediate manufacturing inputs by an upstream exporter such as Japan is unprecedented and provides for a real-life experiment on supply chain resilience. In the short term, substitution away from Japanese exporters may be difficult given their dominant market position in key sophisticated intermediate inputs and possibly patent-related constraints. Nonetheless, a prolonged disruption in supply and a rundown of inventories may force firms to replace Japanese exports from other sources. A rethinking of the "just-in-time" production model may result in a reorientation of production and sourcing networks in global supply chains.

To increase resilience to international price shocks, policy makers should create an environment enabling firms to undertake quality upgrading of products. The aggregate impact of an exchange rate shock on trade flows is shown to be large in the long run and domestic firms' profits will begin to be compressed in the short run as they struggle to retain export market share. With sectors experiencing a symmetric relative price shock, the most promising strategy for policy makers may be enabling firms to respond to unfavorable exchange rate movements via quality upgrading. Apart from providing a reliable macroeconomic environment, policy makers should therefore aim to lower costs of doing business and those of establishing trade relationships.

Appendix 1: A Methodology for Assessing Systemic Trade Interconnectedness[34]

The cross-border transmission of shocks takes place through two main channels: the financial channel and the trade channel. The global crisis has drawn renewed attention to the former with recent IMF Executive Board papers discussing financial sectors of "systemic importance" and their interlinkages in the context of IMF surveillance, underscoring financial interconnectedness.[35] Less emphasis has been placed on the trade channel—that is, the real side of the equation.[36] Nonetheless, understanding the impact that changes in domestic demand exert through the trade channel, especially in the case of systemically important trade sectors, is important in informing the analysis of cross-border spillovers and contagion.

Typically, considerations about the "systemic" importance of a trade sector have been based on its absolute (within jurisdiction) or relative (within the global trade system) size. Interconnectedness has, however, more recently emerged as a critical complementary consideration to gauge the systemic risk that may arise through direct or indirect interlinkages among sectors in the global system. The idea is that the more linkages a given sector has to the global system, the higher the risk that distress in that sector may have repercussions on other jurisdictions or systemic stability.

Against this background, we develop a methodology for assessing systemic trade interconnectedness by defining "systemic" trade sectors and identifying the jurisdictions hosting them. The methodology draws from recent work on financial interconnectedness[37] and leverages the IMF's Direction of Trade Statistics (DOTS) database. The use of DOTS lends robustness to the analysis by providing data that are not only uniform, but also available for the entire IMF membership. Additionally, the regular updating of DOTS by the IMF's Statistics Department allows for dynamic analysis and recalibrations of the findings tracking global trade developments on a timely basis. This methodology naturally complements financial interconnectedness analysis, providing a holistic view of the potential for spillovers and contagion at the bilateral, regional, and global levels.

[34] Prepared by Luca Errico and Alexander Massara (both from the Statistics Department).
[35] For example, see IMF (2010b).
[36] In this analysis, trade includes goods/merchandise, but excludes services.
[37] IMF (2010a).

Methodology

The methodology entails a two-stage approach. In the first stage, jurisdictions are ranked based on trade size and interconnectedness indicators. In the second stage, the rankings of trade size and interconnectedness are combined into a composite index of systemic trade importance.

First Stage

Size indicators

Three measures of the absolute size of a trade sector (in nominal U.S. dollars), namely: (i) total exports (X); (ii) total imports (M); and (iii) total turnover ($X + M$) are used to capture the importance of a jurisdiction's trade sector in the global trade system. One measure of the relative size of a trade sector—namely, total turnover relative to nominal GDP (in U.S. dollars)—is used to gauge the relative importance of the trade sector within a given jurisdiction. The four trade size indicators then are combined into a single ranking for size by ranking all jurisdictions in each of the four trade size indicators separately and taking the median rank of the four indicators for each jurisdiction as the single ranking for trade size.

Interconnectedness indicators

Similar to the approach used for financial interconnectedness analysis, the idea is to infer from the pattern of cross-border linkages among trade sectors the extent to which a trade sector in a jurisdiction is "central" in the global trade network. The global trade network is defined as a set of bilateral trade relationships (links), either exports or imports, of different jurisdictions (nodes). A materiality threshold ensures that the analysis focuses only on economically meaningful links—that is, trade relationships representing less than 0.1 percent of a jurisdiction's GDP are excluded.

The network is expressed in matrix form where Aij represents the value of total turnover between jurisdiction i and jurisdiction j. The matrix has dimension n equal to the number of jurisdictions. Diagonal elements are zero. Off-diagonal elements are zero for jurisdiction pairs that have no link either as exporter or importer. The indicators are based on whether a link exists, that is, they are based on the indicator $Nij = 1$ if $Aij > 0$, and 0 otherwise.

Applying network analysis, four measures of "centrality" of a jurisdiction's trade sector within the global trade network are used:[38]

[38] Because we consider both exports and imports, the network is "undirected" and because we assign equal weights to the four measures of centrality, the network is "unweighted" with binary values (0, 1).

1. "In-degree" is the number of links that point to a node. It is given by the sum $\sum j \; \mathrm{N}ji$;

2. "Closeness" is the inverse of the average distance from node i to all other nodes. The distance between i and j, δij equals the shortest path. The average distance from i to all other nodes is given by $\sum j\delta ij/(n-1)$. Closeness is the inverse of this measure;

3. "Betweenness" looks at the nodes that the shortest path goes through. Let $\mathrm{g}\,jk$ denote the number of shortest paths between j and k, and $\mathrm{g}\,jk(i)$ denote the number of such paths that go through node i. The probability that node i is on the shortest path from j to k is given by $\mathrm{g}\,jk(i)/\mathrm{g}\,jk$. "Betweenness" of node i is the sum of these probabilities over all nodes excluding i, divided by the maximum that the sum can attain: $(\sum j{\neq}i\sum k{\neq}igik(\mathrm{i})/\mathrm{g}\,jk)/(n-1)(n-2)$; and

4. "Prestige" (or eigenvector centrality) considers the identity of counterparties. It is a measure of the importance of a node in the network. It assigns relative scores to all nodes in the network based on the principle that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The "prestige" of jurisdiction i (vi) is obtained by taking the "prestige" of its exporters, weighted by a matrix of relationships with i, that is, $vi = \sum j\mathrm{R}ji\; vj$. This defines a linear system $v = R'v$ where R is the matrix of relationship. The solution to the system is the eigenvector associated with the unit eigenvalue.

As with the ranking for trade size, a single ranking for trade interconnectedness is calculated from these four different indicators. All jurisdictions are ranked in each of the four interconnectedness indicators separately, taking the median of the four rankings as the single ranking for trade interconnectedness.

Second Stage

An overall composite index of trade systemic importance is calculated as a combination of the trade size and trade interconnectedness rankings calculated in the first stage. The rankings of size and interconnectedness are combined into a weighted average "baseline" index to allow the analysis of the relative significance of size and interconnectedness in systemic importance. Sensitivity analysis of the composite index suggests that while weight changes affect some of the individual country ratings at the margin, they do not introduce significant changes in the listing of the jurisdictions in the upper echelons of the ranking.[39]

[39] The following combinations of size and interconnectedness breakdowns were tested: 0.8/0.2 (0.8 for size and 0.2 for interconnectedness), 0.7/0.3, 0.6/0.4, and 0.5/0.5, respectively.

Appendix 2: Measures Used to Characterize Global Supply Chains

Various measures can be used to characterize global supply chains. Hummels, Ishii, and Yi (2001) were the first to measure the value of imported contents embodied in a country's exports. Their measure, referred to as vertical specialization (VS) share of gross exports or to foreign value added (FVA) share in gross exports, is calculated as follows:

$$\textit{FVA share in exports} = u \cdot A_M \cdot L \cdot E / E_k$$

where u is a row vector of ones, A_M is the imported inputs coefficients matrix, L is the Leontief matrix, E is a column vector of gross exports in each sector, and E_k is the total exports. By multiplying the column vector of gross exports E by the Leontief matrix, $(I–A_D)^{-1}$ where I is the identity matrix and A_D is the domestic input coefficient matrix, one can compute the gross output needed to produce those exports. By multiplying those by import inputs coefficients, one can compute the total foreign inputs contained in gross exports. Finally, by dividing it by total exports, one can compute the FVA content share of gross exports.

The main source of data used is, as in Hummels, Ishii, and Yi (2001), the input-output tables from STAN/OECD. The input-output data are available for 36 emerging and advanced countries. The FVA shares in gross exports are computed for 36 countries (Table A2.1). The FVA contents in billion U.S. dollars (not shown) are aggregated to compute the VS share of world exports shown in Table 1 in the main text.

Note that imported intermediates are both the imported intermediates used directly in output and the intermediates used to produce the domestic intermediate inputs that are then used in output. While the focus is on manufacturing exports, imported intermediates also include inputs from agriculture, services, and mining sectors. FVA shares are calculated by assuming that the same ratio of intermediates to output holds for exports.

To further decompose foreign value added by source country, following Koopman and others (2010), bilateral sectoral trade data from COMTRADE are supplemented for Japan, China, the United States, and Germany.[40] Tables A2.2 and A2.3 show the FVA content in gross exports in billion U.S. dollars and in percent of gross exports, respectively. These results are summarized in two figures in Chapter 2.

[40] There are no data on bilateral trade in services and therefore foreign services are not decomposed into their countries of origin, but are included as a separate imported input.

Table A2.1. FVA Share in Gross Exports
(Percent of gross exports)

	Total		Manufacturing									
			Total		LT		MLT		MHT		HT	
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
AUS	13.9	14.1	18.7	20.2	15.1	15.0	16.5	21.7	27.5	25.9	32.2	22.5
AUT	30.5	35.4	35.2	41.4	29.3	34.0	32.8	41.9	40.5	45.9	33.4	34.4
BEL	41.3	44.4	48.3	53.5	43.8	44.4	48.3	58.2	52.2	56.4	39.0	40.2
BRA	10.8	14.4	12.0	17.1	8.8	8.6	13.9	19.1	14.8	21.6	21.8	33.2
CAN	27.0	27.9	33.9	37.9	16.6	21.7	26.0	35.7	45.9	46.4	32.3	46.2
CHE	19.6	22.1	24.2	29.0	19.8	23.5	35.5	48.7	34.1	29.8		
CHN	15.5	27.4	16.6	30.4	15.6	19.6	15.2	26.6	17.5	29.6	20.1	48.5
CZE	29.8	48.2	34.8	53.7	28.2	42.3	36.5	49.2	37.1	53.4	46.4	75.7
DEU	20.8	27.8	23.2	30.9	22.4	25.4	26.1	37.6	22.5	30.1	24.1	31.2
DNK	27.7	35.7	30.7	38.0	27.1	36.8	36.3	38.4	32.1	39.2	34.0	37.4
ESP	26.6	34.2	32.5	42.6	23.5	28.5	29.3	42.9	37.5	47.3	32.9	50.2
FIN	28.7	38.3	31.4	41.2	21.0	26.2	39.5	51.9	35.3	41.7	46.0	46.4
FRA	19.8	27.2	24.6	33.3	18.5	23.6	27.0	40.3	25.5	34.9	29.1	29.2
GBR	22.4	19.9	27.8	29.9	24.2	22.0	24.7	31.4	27.7	30.7	33.6	32.3
GRC	15.8	26.0	24.9	35.2	16.5	18.5	38.3	50.4	25.9	31.3	31.6	21.3
HUN	47.7	56.1	53.8	63.2	33.5	43.6	42.6	50.4	57.5	60.9	72.8	79.6
IDN	14.9	18.1	22.8	24.4	18.2	18.4	21.2	24.0	36.3	37.3	42.9	32.9
IND	10.4	13.4	13.0	19.7	8.3	10.4	20.5	28.7	15.5	19.0	19.7	26.8
IRL	45.5	51.2	50.2	58.5	45.9	53.8	46.7	37.9	42.9	56.6	62.0	67.4
ISR	16.0	37.9	16.3	50.7	9.9	76.7	16.4	45.6	20.4	33.3	24.5	30.0
ITA	23.4	29.0	27.0	34.1	24.1	28.7	27.1	38.8	28.2	34.3	32.1	36.6
JPN	8.2	15.2	9.1	17.4	9.0	16.6	13.7	23.9	7.6	15.7	10.0	21.5
KOR		38.1		41.0		27.3		48.1		36.0		46.3
LUX	40.5	58.5	42.7	52.0	36.8	52.5	45.5	54.0	37.9	50.7	37.7	37.7
MEX		36.7		47.5		33.2		25.9		42.9		71.1
NDE	35.8	38.9	43.4	48.9	38.8	36.9	48.5	57.8	43.0	47.0	47.6	54.8
NOR	21.7	16.5	33.6	32.1	25.0	24.0	39.9	47.1	33.1	27.6	38.2	36.5
NZL	18.3	18.8	21.2	21.9	18.6	20.2	28.1	24.5	27.8	27.3	25.4	
POL	15.3	30.9	17.6	38.4	14.5	29.6	21.1	38.9	18.8	42.2	12.9	54.0
PRT	35.7	39.0	39.9	45.9	31.5	32.9	45.0	49.9	49.4	52.9	56.4	66.6
RUS	10.6	10.9	13.6	15.2	18.9	21.2	10.2	12.2	18.3	21.1		
SVK	35.2	48.7	43.7	57.7	30.9	42.9	46.9	53.0	47.6	64.0	42.5	71.4
SWE	28.9	33.4	32.7	39.4	22.8	29.4	38.7	51.6	34.3	38.8	36.9	33.9
TUR	14.1	22.7	19.6	29.5	16.5	25.6	25.4	33.4	23.4	30.5	21.4	46.7
TWN	34.9	48.5	39.7	54.5	32.5	41.6	33.6	58.8	36.9	55.6	48.8	54.4
USA	9.5	12.3	12.6	17.3	8.7	10.3	13.5	23.7	12.5	17.9	16.6	17.4

Source: IMF staff estimates using OECD Input-Output Tables.
Note: LT = low technology; MLT = medium-low technology; MHT = medium-high technology; HT = high technology (see Box 2 for more detail). AUS, Australia; AUT, Austria; BEL, Belgium; BRA, Brazil; CAN, Canada; CHE, Switzerland; CHN, China; CZE, Czech Republic; DEU, Germany; DNK, Denmark; ESP, Spain; FIN, Finland; FRA, France; GBR, United Kingdom; GRC, Greece; HUN, Hungary; IDN, Indonesia; IND, India; IRL, Ireland; ISR, Israel; ITA, Italy; JPN, Japan; KOR, Republic of Korea; LUX, Luxembourg; MEX, Mexico; NDE, Netherlands; NOR, Norway; NZL, New Zealand; POL, Poland; PRT, Portugal; RUS, Russian Federation; SVK, Slovak Republic; SWE, Sweden; TUR, Turkey; TWN, Taiwan Province of China.

Table A2.2. FVA Content in Gross Exports by Countries of Origin

(Billions of U.S. dollars)

Country	Year	Item	Total	Agr. and mining	Manufacturing Total	Manufacturing LT	Manufacturing MLT	Manufacturing MHT	Manufacturing HT	Services
China	2005	FVA	232.50	2.13	211.15	43.57	21.04	68.79	77.75	19.22
		Service	43.05	0.47	23.36	7.43	2.92	8.34	4.67	19.22
		EU27	29.29	0.20	29.09	4.44	1.68	9.20	13.78	–
		Japan	40.01	0.24	39.77	5.99	2.12	11.97	19.69	–
		China	–	–	–	–	–	–	–	–
		USA	13.75	0.12	13.63	2.92	0.72	4.39	5.60	–
		OEA	68.40	0.53	67.87	14.42	4.90	20.87	27.68	–
		Rest of world	38.01	0.57	37.43	8.38	8.70	14.02	6.33	–
		DVA	615.23	15.11	483.62	178.90	58.20	163.83	82.69	116.50
Japan	2005	FVA	100.98	0.08	92.43	3.23	17.44	60.19	11.57	8.47
		Service	17.73	0.01	9.25	0.32	1.46	6.68	0.79	8.47
		EU27	9.99	0.01	9.99	0.30	0.90	7.64	1.15	–
		Japan	–	–	–	–	–	–	–	–
		China	17.77	0.01	17.76	0.65	1.45	11.67	3.99	–
		USA	9.23	0.01	9.22	0.28	0.81	6.83	1.30	–
		OEA	15.52	0.01	15.51	0.49	2.65	10.07	2.31	–
		Rest of world	30.74	0.03	30.71	1.19	10.17	17.32	2.03	–
		DVA	563.09	0.71	438.51	16.28	55.48	324.39	42.36	123.87
USA	2005	FVA	136.38	4.02	113.02	11.56	21.13	60.72	19.60	19.33
		Service	28.09	0.40	8.36	1.57	1.19	4.17	1.42	19.33
		EU27	20.91	0.64	20.27	2.04	2.88	13.44	1.91	–
		Japan	8.50	0.13	8.37	0.47	0.60	5.66	1.65	–
		China	12.98	0.16	12.82	1.38	1.00	5.81	4.63	–
		USA	–	–	–	–	–	–	–	–
		OEA	13.14	0.27	12.87	1.17	1.02	5.68	5.00	–
		Rest of world	52.76	2.42	50.33	4.93	14.45	25.97	4.99	–
		DVA	968.55	32.12	539.45	100.18	67.93	278.34	93.00	396.97
Germany	2005	FVA	310.00	1.96	287.24	32.56	61.73	160.77	32.18	20.80
		Service	58.15	0.41	36.94	4.79	6.37	21.75	4.04	20.80
		EU27	146.52	0.91	145.61	16.81	27.06	90.02	11.72	–
		Japan	8.31	0.03	8.28	0.32	0.50	5.11	2.34	–
		China	13.47	0.05	13.42	2.08	1.06	5.88	4.41	–
		USA	14.59	0.09	14.50	1.11	1.65	9.43	2.31	–
		OEA	12.93	0.04	12.89	1.38	0.84	5.73	4.93	–
		Rest of world	56.03	0.44	55.59	6.07	24.25	22.85	2.42	–
		DVA	805.57	8.53	641.75	95.39	102.39	372.96	71.01	155.29

Source: IMF staff estimates using OECD Input-Output Tables, UN Comtrade and OECD STAN data.
Note: FVA = foreign value added (= service + EU27 + Japan + China + USA + OEA + rest of world); DVA = domestic value added; OEA = other east Asia (Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan Province of China); LT = low technology; MLT = medium-low technology; MHT = medium-high technology; HT = high technology (see concordance table for more detail); gross exports (not shown in the table) = FVA + DVA.

Table A2.3. FVA Share in Gross Exports by Countries of Origin

(Percent of gross exports)

Country	Year	Item	Total	Agr. and mining	Manufacturing Total	LT	MLT	MHT	HT	Services
China	2005	FVA	27.4	12.4	30.4	19.6	26.6	29.6	48.5	14.2
		Service	5.1	2.8	3.4	3.3	3.7	3.6	2.9	14.2
		EU27	3.5	1.1	4.2	2.0	2.1	4.0	8.6	–
		Japan	4.7	1.4	5.7	2.7	2.7	5.1	12.3	–
		China	–	–	–	–	–	–	–	–
		USA	1.6	0.7	2.0	1.3	0.9	1.9	3.5	–
		OEA	8.1	3.0	9.8	6.5	6.2	9.0	17.3	–
		Rest of world	4.5	3.3	5.4	3.8	11.0	6.0	3.9	–
		DVA	72.6	87.6	69.6	80.4	73.4	70.4	51.5	85.8
Japan	2005	FVA	15.2	9.5	17.4	16.6	23.9	15.7	21.5	6.4
		Service	2.7	1.1	1.7	1.6	2.0	1.7	1.5	6.4
		EU27	1.5	0.8	1.9	1.5	1.2	2.0	2.1	–
		Japan	–	–	–	–	–	–	–	–
		China	2.7	1.0	3.3	3.3	2.0	3.0	7.4	–
		USA	1.4	1.2	1.7	1.4	1.1	1.8	2.4	–
		OEA	2.3	1.2	2.9	2.5	3.6	2.6	4.3	–
		Rest of world	4.6	4.3	5.8	6.1	14.0	4.5	3.8	–
		DVA	84.8	90.5	82.6	83.4	76.1	84.3	78.5	93.6
USA	2005	FVA	12.3	11.1	17.3	10.3	23.7	17.9	17.4	4.6
		Service	2.5	1.1	1.3	1.4	1.3	1.2	1.3	4.6
		EU27	1.9	1.8	3.1	1.8	3.2	4.0	1.7	–
		Japan	0.8	0.4	1.3	0.4	0.7	1.7	1.5	–
		China	1.2	0.5	2.0	1.2	1.1	1.7	4.1	–
		USA	–	–	–	–	–	–	–	–
		OEA	1.2	0.7	2.0	1.0	1.1	1.7	4.4	–
		Rest of world	4.8	6.7	7.7	4.4	16.2	7.7	4.4	–
		DVA	87.7	88.9	82.7	89.7	76.3	82.1	82.6	95.4
Germany	2005	FVA	27.8	18.7	30.9	25.4	37.6	30.1	31.2	11.8
		Service	5.2	3.9	4.0	3.7	3.9	4.1	3.9	11.8
		EU27	13.1	8.6	15.7	13.1	16.5	16.9	11.4	–
		Japan	0.7	0.3	0.9	0.3	0.3	1.0	2.3	–
		China	1.2	0.5	1.4	1.6	0.6	1.1	4.3	–
		USA	1.3	0.8	1.6	0.9	1.0	1.8	2.2	–
		OEA	1.2	0.4	1.4	1.1	0.5	1.1	4.8	–
		Rest of world	5.0	4.2	6.0	4.7	14.8	4.3	2.3	–
		DVA	72.2	81.3	69.1	74.6	62.4	69.9	68.8	88.2

Source: IMF staff estimates using OECD Input-Output Tables, UN Comtrade and OECD STAN data.
Note: FVA = foreign value added (= service + EU27 + Japan + China + USA + OEA + rest of world); DVA = domestic value added; OEA = other east Asia (Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan Province of China); LT = low technology; MLT = medium-low technology; MHT = medium-high technology; HT = high technology (see concordance table for more detail); gross exports (not shown in the table) = FVA + DVA.

Appendix 3: Definition of Concepts Related to Export Analysis

The Export Similarity Index (ESI) measures the extent of overlap in countries' export structures and thus provides a sense of the competitive pressures faced by countries at different points in time. The ESI after Finger and Kreinin (1979) is calculated as:

$$S(ab, c) = \{\textstyle\sum_i \mathit{Minimum}\ [X_i(ac), X_i\ (bc)]\}100.$$

It measures the similarity of export patterns of countries "a" and "b" to market "c" (world) and takes the value of one if the commodity distribution of a's and b's exports is identical.

A complementary construct is the Revealed Comparative Advantage (RCA) index, which measures the intrinsic advantage of a particular export sector/product consistent with changes in an economy's relative factor endowment and productivity. The RCA index is based on Balassa's (1965) measure of relative export performance by country and sector/product. The RCA index is calculated as:

$$RCA_{ij} = (X_{ij}/X_{jw})/(X_i/X_w)$$

where X_{ij} is exports of country i of product j, X_{jw} is global exports of product j, X_i is total exports of country i, and w is total global exports. A value greater than one indicates the country has a revealed comparative advantage in that product. The assumption here is that trade patterns reflect intercountry differences in relative costs as well as nonprice factors, and therefore "reveal" the comparative advantage of trading countries.

Appendix 4: New Drivers of Global Trade: Key Stylized Facts

Changes in export composition by trading partner strongly reflect the emergence of EMEs (Figure A4.1). As a consequence, those countries more strongly exposed to EMEs generally experienced higher trade growth. Some, though not all, of China's rapid export growth can be explained by a higher exposure to EMEs. With EMEs also expected to spearhead economic expansion going forward, deepening trade relationships with EMEs would further aid countries' export performance.

- *United States:* Among our simulation countries, the United States is the one with the most stable export structure by destination during the last decade and a half. NAFTA partners remain by far its largest trading partners. Interestingly, Asia's importance for U.S. exporters has declined, despite the region's strong growth performance. Yet China's share in U.S. exports has increased at the expense of other Asian countries, chiefly Japan. Although the United States may benefit from stronger expansion in Latin American countries, it remains a relatively closed economy. With a lackluster domestic medium-term outlook, its firms may renew efforts to exploit export opportunities in dynamic regions.

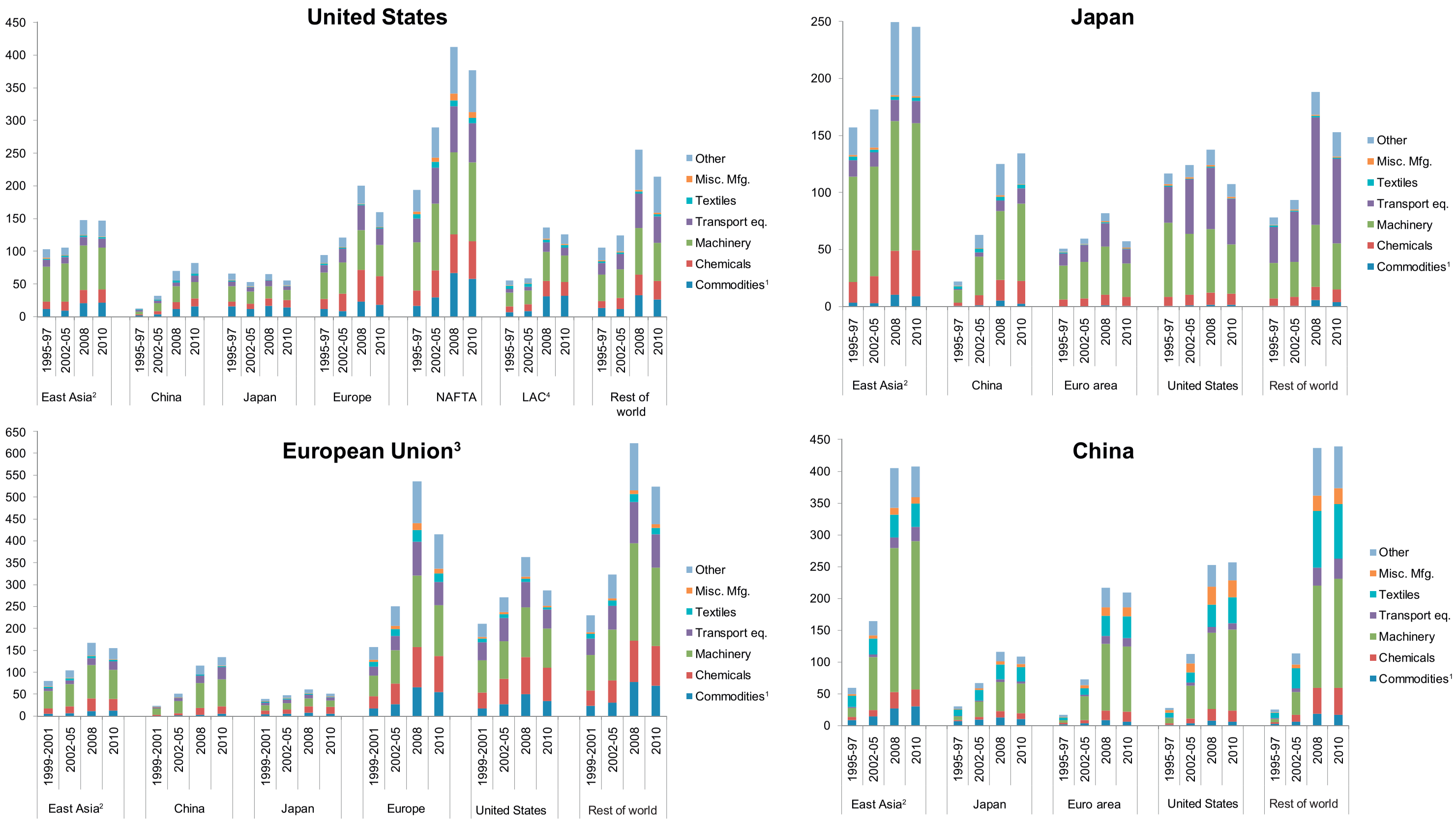
- *Japan:* Japan clearly reoriented its trade during the last 15 years by outsourcing production processes to other Asian countries, mainly China, from where in turn exports are shipped to more traditional trade partners in Europe and North America. Consequently, Japan's exports to Asia have increased at the expense of those to the United States and Europe.

- *Euro area:* European countries were able to take somewhat better advantage of Asia's emergence than the United States, although unexploited potential likely remains. The main reorientation of the European Union's external trade was toward its (production chain) partners in eastern Europe, whereas the share of exports shipped directly to the United States declined. EU countries also fortified their role in proximate emerging markets in Central Asia and the Middle East and North Africa (MENA) region.

- *China:* During the last 15 years, Chinese exports not only expanded extraordinarily but also their composition became much more diversified, with exports to the euro area and particularly to EMEs outside east Asia gaining share. In the latter markets, the attractive pricing of their products may have helped Chinese firms gain market share. The share of Chinese exports shipped to the United States stayed constant. Outsourced Japanese production compensated for what would otherwise have been a decline in U.S. share given the strong expansion of Chinese exports in other markets.

Figure A4.1. Export Composition of Simulation Countries by Destination

(Current US$ billions)



Source: Global Trade Atlas.
[1]Includes agricultural products.
[2]ASEAN countries plus Hong Kong SAR, Republic of Korea, and Taiwan Province of China.
[3]EU27 external trade.
[4]Latin America and the Caribbean, excluding Mexico.

Historically, price competitiveness has been an important determinant of export success. Over the past 20 years, the emergence of EMEs imposed a natural downward trend in advanced countries' export market shares. The analysis shows that this decline could often be halted by real effective exchange rate (REER) depreciations. Appreciations in turn accelerated this decline, whereas impacts mostly materialized with a lag (Figure A4.2).[41] Price competitiveness has remained an important determinant of export performance.

- *United States:* The 25 percent REER appreciation experienced by the United States between 1995 and 2001 resulted, after some lag, in a large loss of export market share between 2000 and 2004. Thereafter it was able to stabilize its export market share even despite EME's forceful expansion, largely due to the favorable effects of an offsetting REER depreciation.

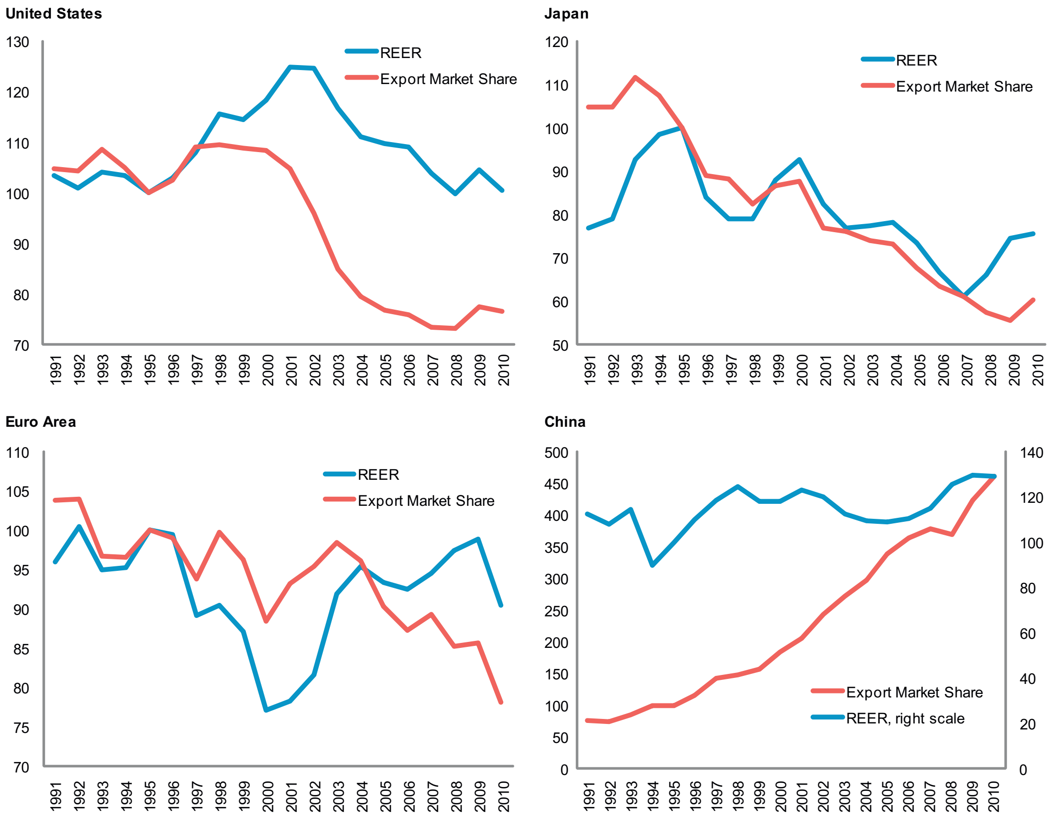
- *Japan:* Japan's export market share cannot be well explained by changes in REER-based price competitiveness. Its price competitiveness was broadly stable in the 1990s and improved during the 2000s. Nevertheless, the country lost more than 40 percent of its export market share during the past two decades. The reason behind this divergence can largely be attributed to Japanese firms' outsourcing of many downstream production processes to other Asian countries, which then came to serve as export platforms (European Central Bank, 2005).

- *Euro area:* The export market share of the euro area registered only a small decline until 2003 given help from a 20 percent euro depreciation at the end of the 1990s, just as EMEs started to take center stage. Following a considerable appreciation of the euro at the beginning of the 2000s, the euro area's export market share began to plummet.

- *China:* For China, a relationship between its REER and its export market share is hard to identify. Its rapid integration into the world economy, particularly post-WTO accession in 2001, is clearly the overwhelming driver of its rising export market share. China's REER was relatively stable over most of the period. The only exception occurred between 1995 and 1998 in the form of a 20 percent appreciation, which may have dented the country's growth in export market share between 1997 and 1999.

[41] Our analysis of external balances in Box 7 constructs a dynamically adjusted REER to account for these lagged effects.

Figure A4.2. Export Market Shares and Real Effective Exchange Rates, 1990–2010
(1995 = 100)



Appendix 5: Data and Modeling Strategy

The objective of this exercise is to quantify at a high level of product detail the implications of sectoral and supply chain linkages on the trade impact of relative price changes. The model employed for the analysis uses a comprehensive data set including information on imports by trading partner at the HS2002 six-digit level sourced from UN Comtrade. We have chosen the year 2008 for our analysis because (i) a larger number of countries have to date reported data for 2008 at this level of disaggregation than for 2009 and (ii) trade flow composition was presumably less distorted by the crisis-induced collapse in trade.

We model trade response to changes in relative prices in two stages. In the first stage, a partial equilibrium model is used to determine change in consumer demand for import in every import market. The second stage uses the input-output tables discussed in the main text to adjust imports in response to the trade-induced change in aggregate demand.

This modeling approach offers three key advantages: (i) the aggregation bias implicit in CGE models using aggregate trade flows is avoided; (ii) the model is simple and transparent in its assumptions; and (iii) the simulation exercise illustrates changing trade patterns at a high level of product detail which allows quantifying sectoral and supply chain linkages and their importance for changes in trade patterns. In response to a change in relative prices in a given economy, the model produces the impact on global trade flows at the HS six-digit level. The results can then be aggregated to any given level of product detail and used to compute ex ante and ex post indicators of RCA, export similarity (ESI), and the technology content in a country's exports and imports.

The greater product detail and transparency of this modeling approach comes with a cost that renders the model useful primarily for the analysis of sectoral and supply chain linkages. Each product is modeled as a separate market and in isolation from other markets, and inter- and intrasectoral linkages or economy-wide impacts of changes in relative prices that are likely to take place are not fully captured. These limitations need to be kept in mind when examining the model's predictions at the aggregate level.

First stage: A partial equilibrium model of import demand

In determining the change of export prices as a result of a real exchange rate shift, we take account of the fact that these are not affected symmetrically across sectors. We reiterate the argument made in the main text, namely that the foreign content (intermediates and value added) in exports differs not only by exporting country but also by sector. In particular, we highlighted that the foreign content in Chinese exports is higher in sectors that are commonly associated with high-technology goods. This implies that exports in these sectors are relatively less affected by an exchange rate shift. We integrate this argument into our methodology by assuming that export prices in a given sector change by the share of domestic content in the export value multiplied by the exchange rate shift. For instance, a 10 percent exchange rate depreciation leads to a 5 percent fall in export prices in a sector with 50 percent domestic content in exports, and by 8 percent in a sector with 80 percent domestic content.[42]

We utilize a simple partial equilibrium setup that is similar to the model used in Brenton and others (2011) and Lim and Saborowski (2010) and extend it to a multicountry setting. The framework allows analyzing the response of trade flows to changes in relative prices in a transparent way and at a high level of product detail. Our analysis therefore refrains from using a multicountry CGE model which would require modeling complex interactions for a large number of variables and countries and sacrifice our high level of product disaggregation. Our approach has the advantage that it requires only a limited set of parameters to be determined, namely the trade elasticities involved.

The model focuses on the import market of every product in every economy in isolation. The setup is based on a representative consumer with Armington (1969)-style preferences, who makes choices over imported goods in response to price changes in two consecutive steps: first, she substitutes between different exporters' national varieties following relative price changes, and second, she changes her overall demand for the good in question as a result of the change in the average price of the product.[43] The ex ante price of all product varieties is normalized to unity. Thus, if the percentage change in relative prices is x, the consumer price of each variety becomes $1 + x$.[44] A similar setup has been widely adopted in applied trade models, including single- and multicountry CGE models.

The model relies on six core assumptions. First, as is standard in consumer demand theory, sector-level elasticities are used to determine the magnitude of the demand response of trade flows to relative price changes. Second, the calculations are based on the standard Armington (1969) assumption of imperfect substitutability between imports from different trading partners

[42] We do not adjust the magnitude of the import price change in the country under consideration by the share of intermediates in its imports and in other countries' value added embodied therein, due to lack of reliable data on this phenomenon. This limitation is likely not to distort the results severely as long as this intermediate content is relatively small.

[43] The calculation steps are detailed in Appendix 6. A complete model derivation in a similar setup can be found in Lim and Saborowski (2010).

[44] The total price change for a given good is computed as a weighted average (by market share) of the price changes of the different product varieties.

(within each product category). Third, a change in relative prices is defined as a change in relative prices facing the consumer in each importing economy.[45] Fourth, no direct substitution between different products is allowed (i.e. each product is modeled as a separate market and in isolation from other markets). Fifth, our parameterization of the model is aimed at computing long-term impacts of relative price changes. Finally, and given the partial equilibrium nature of the exercise, inter- and intrasectoral linkages (e.g., factor reallocation) or economy-wide impacts of changes in relative prices cannot be considered.[46]

Sector-level *elasticities of substitution* are used to determine the magnitude of substitution between exporters of a given good in each import market. The literature on elasticities of substitution is rich but provides estimates that differ widely in magnitude. Broda and Weinstein (2006) and Broda, Greenfield, and Weinstein (2006) provide the most comprehensive set of elasticities by importer and at the five-digit SITC product level. However, a more recent literature that allows for firm heterogeneity in structural models (e.g., Crozet and Koenig, 2010) suggests that elasticities may be lower on average and may lie in the range of –2 to –3. This range is also suggested by Obstfeld and Rogoff (2005) who use these values for their analysis of the exchange rate change needed to close the U.S. current account deficit. In general, this range of values is more consistent with what is typically found in studies focusing on aggregate impacts of changes in relative prices (Gagnon, 2007). In the light of these findings, we use the Broda and Weinstein (2006) and Broda, Greenfield, and Weinstein (2006) elasticities scaled to a mean of 2.25 as attained in Crozet and Koenig (2010).[47] This results in an import-weighted mean elasticity of 2.4.[48]

[45] In other words, a change in relative prices is not the same as an exchange rate change whenever pass-through is incomplete.

[46] Implicit in our model is one additional technical assumption: since demand responses are based on elasticities, there will never be market entry by new exporters as a result of price changes (zero trade flows will always remain unchanged at zero).

[47] We remove outliers by capping the elasticities at a value equal to the mean plus 2 standard deviations. We then scale all elasticities to arrive at the desired mean of –2.25.

[48] The literature on substitution elasticities (e.g., Broda and Weinstein, 2006) has shown that estimates tend to be significantly higher when estimated at a higher level of product detail. These elasticities provide correct changes in import quantities at the high level of disaggregation at which they are estimated. However, changes in a country's total imports obtained via simple summation of these changes at high disaggregation levels would be considerably biased upward. This is because the summation cannot account for cross-product substitution in response to relative price changes. To minimize this possible bias, we therefore work with elasticities estimated at the more aggregate SITC three-digit level at which cross-product substitution is likely to be minimal. Crozet and Koenig (2010) find a mean elasticity of –2.25 at the three-digit level in a theory framework with heterogeneous firms set out by Melitz (2003), whereas Broda and Weinstein (2006) find one of –4. The values found in Crozet and Koenig (2010) also lie closer to what is typically found in time series estimation (Gallaway, McDaniel, and Rivera, 2003; Saito, 2004) and to the values used in Brenton and others (2011) and Lim and Saborowski (2010).

Country-specific *import demand elasticities* at a high level of product detail are used to determine the magnitude of the demand response to relative price changes in each import market. Kee, Nicita, and Olarreaga (2008) provide a comprehensive set of price elasticities of import demand by import market and six-digit HS level of product detail. Notwithstanding the fact that their estimates are somewhat larger than is typically found in the literature, their study provides a carefully estimated and comprehensive set of elasticities unmatched in its high level of product detail. We therefore use their elasticities but scale them to a mean of –1 which results in an import weighted mean of –0.79.[49] This value lies within the consensus range established by the empirical literature.[50]

Second stage: Adjusting imports for the trade-induced change in aggregate demand

Changes in exports have an impact on total value added and aggregate demand. In the first stage of our modeling framework, an exchange rate shock in a given country affects both imports and exports. But an important link is missing, namely the impact of changes in aggregate demand (resulting from falling or rising exports) on imports. We account for this shortcoming in the second stage of the analysis. The predicted changes in imports and exports from the first stage are used as a starting point.

We use input-output tables to determine how changing exports affect value added as well as imports of intermediates and final goods (see Appendix 3). We first use input-output tables to determine the fall in value added that is consistent with the change in exports resulting from the first stage of the analysis. The same tables are then used to determine the change in imports of intermediates and final goods (by sector) that results from falling/rising aggregate demand. The input-output tables distinguish two-digit ISIC sectors in the analysis as well as intermediate and final goods therein. Since the level of disaggregation of our trade data is higher, the resulting sectoral impacts are then split up across subsectors according to market share.

[49] We initially remove outliers by capping the elasticities at a value equal to the mean plus 2 standard deviations and fill in missing observations using product elasticities at higher aggregation levels, at the country level, where available. We then scale all elasticities to arrive at the desired mean of –1.

[50] Goldstein and Khan (1985) give a comprehensive survey of the early literature on price elasticities of import demand. Their conclusion is that the average long-run import demand elasticity lies somewhere between –0.5 and –1. Reinhart (1995) estimates long-run import demand elasticities for 12 developing countries from 1970 to 1991 using cointegration techniques. She obtains an average elasticity of –0.6. Aziz and Li (2007) find an import demand elasticity of –0.9 for China. They use quarterly data from 1995 to 2006 on total Chinese imports (from all trading partners and products) as the dependent variable. Hong (1999) provides sample import price elasticities used in the LINK modeling system for different countries. They range between –0.4 and –1. Brenton and others (2009) and Lim and Saborowski (2010) use an elasticity of –0.5, albeit in a short-term setup.

Appendix 6: Measuring the Impact of Relative Price Changes on the Current Account Balance

Changes in a country's exports obtained in the simulation described in Appendix 2 are fed back into the current account balance relative to GDP in two ways. First a fall in exports in each sector for example would lead to a fall in the DVA by a certain fraction. That is, the denominator will fall. The extent of the fall in GDP can be computed using the input-output tables as follows:

$$dY = v \cdot L \cdot dE$$

where dY is the change in GDP, v is a row vector of value added in each sector, L is the Leontief matrix, and dE is a column vector of changes in exports in each sector.

The second channel is through a fall in imports of intermediate inputs and final (capital and consumption) goods. A fall in exports would lead to a fall in imports of intermediate inputs. The extent of the fall in intermediate imports is:

$$dtntM = A_M \cdot L \cdot dE$$

where $dtntM$ is a column vector of the change in imports of intermediate inputs by sector and A_M is the imported inputs coefficients matrix. The extent of the fall in final goods imports are:

$$dfinM = mpm \cdot dY$$

where $dfinM$ is a column vector of the change in imports of final goods by sector and mpm is a column vector of marginal propensity to imports by sector.

The overall effect of the simulation results is summarized in Section A in Chapter 3.

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