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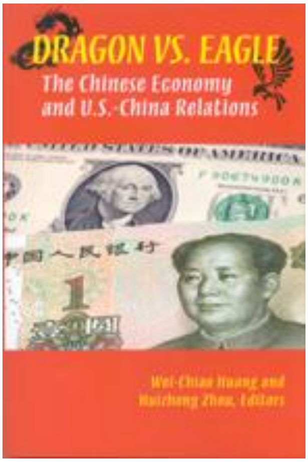
U.S.-China Economic Relations and Value Chains in Global Production Networks



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Dragon versus Eagle

The Chinese Economy and U.S.-China Relations

Wei-Chiao Huang
Huizhong Zhou
Editors

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U.S.-China Economic Relations and Value Chains in Global Production Networks

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During the past 15 years trade between the United States and China has grown substantially. This trade growth has increased the economic interdependence between the two countries, resulting in benefits for both, while also creating some economic tensions. China has experienced rapid economic growth and development with substantial decreases in poverty and increases in per capita GDP, which many academics attribute to China's market-driven economic reforms and its related integration with the world economy. Up until the 2008 financial crisis, the U.S. economy experienced a long period of relatively strong growth through increased productivity and improved integration of information and computer technologies, as well as strong consumption growth accompanied by a declining national savings rate. While U.S. consumption-led growth benefited from inexpensive goods from China such as consumer electronics and textiles, it has also resulted in growing bilateral imbalances.

U.S. import growth from China has slowed over the last several years because of weak U.S. economic growth, a drop in the value of the dollar, and a decline in imbalances. This chapter focuses on the period prior to the financial crisis, as it aligns well with recent research on value-added trade, which is discussed in a later section.

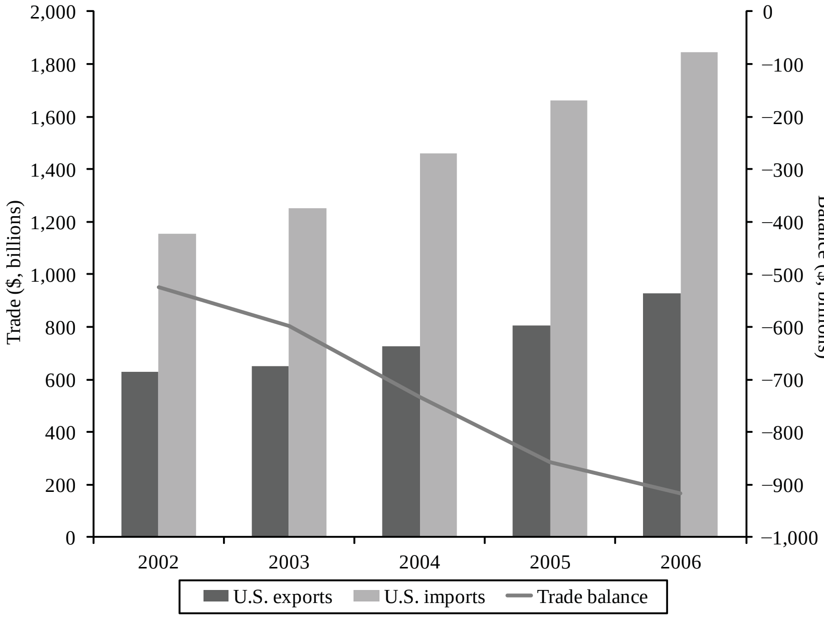
Researchers and policymakers have focused on three broad areas to explain the increasing trade imbalance between the two countries and, more recently, China's growing trade surplus with the world. The first area is China's extensive use of policy instruments to encourage its rapid economic development and transition from a centrally planned economy to a market-driven economy.[1] These policies include, among others, incentives for foreign investment and export performance, the establishment of special economic zones and substantial infrastructure investment, and a fixed exchange rate. A second explanation focuses on more macroeconomic factors, suggesting that significant imbalance in the U.S. savings and investment rates, combined with relatively rapid consumption-led economic growth in the United States compared to other developed countries, have led to an increased current account and merchandise trade imbalance.[2] A third area has been the rapid growth in fragmented global production processes, as businesses take advantage of declining information and communications technology costs, and international logistics costs to distribute pieces of their production chain based on lowest cost sources (Dean, Fung, and Wang 2011; Hummels, Ishii, and Yi 2001; Yi 2003). Although fragmentation of global production has developed independently of China's policy environment and is a widespread phenomenon, a large part of China's growth in exports to the United States has been in processing trade carried out by foreign-invested enterprises (FIEs), many of which have benefited from China's pro FIE and pro "imports for exports" policies.[3]

In this chapter I present a summary of the U.S.-China trade relationship prior to 2008 and describe some of the driving factors underlying the rapid growth in U.S.-China trade. I then present data on the World Trade Organization (WTO) and U.S. import injury cases that support the notion that, from the U.S. perspective, trade relations with China are treated much like those with our long-term historical economic and political partners such as the European Union (EU) and North American Free Trade Agreement (NAFTA) countries. Finally, I discuss current research on value-added trade that could be important from a future policy perspective in understanding global value chains and China's position in them.

AN OVERVIEW OF THE U.S.-CHINA TRADE RELATIONSHIP

Figures 2.1 and 2.2 summarize U.S. merchandise trade shifts with the world and with China between 2002 and 2006. The overall U.S. merchandise trade deficit increased to $915.6 billion in 2006. The long-term trend in the U.S. trade deficit remains a key policy concern for the

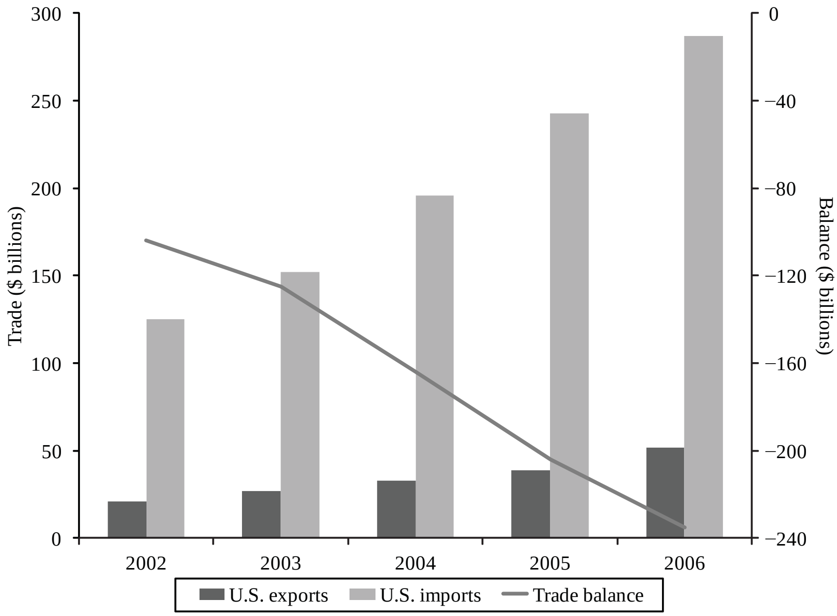
Figure 2.1 Overall Shifts in U.S. Merchandise Trade through 2006



SOURCE: USITC.

United States and its global trading and financial partners. China's rapidly increasing share in the merchandise trade deficit—it reached $235 billion in 2006—has raised particular concern. The factors and trends driving U.S. merchandise trade were numerous. Economic growth in the United States and its major trading partners contributed to increased bilateral merchandise trade flows in 2006, while strong growth in consumer spending, business structures investment, and exports supported the economic performance of the United States.[4] The rate of increase in the U.S. merchandise trade deficit slowed from 17 percent in 2005 to 7 percent in 2006, even as the deficit grew from $858.4 billion in 2005 to a record $915.6 billion in 2006. Total U.S. exports increased to a record $929.5 billion, a 16 percent increase. Aircraft, spacecraft, and related equipment; motor vehicles; and petroleum products recorded the largest sector increases for a combined $33.5 billion (27 percent)

Figure 2.2 Shifts in U.S.-China Merchandise Trade through 2006



SOURCE: USITC.

of export growth, although export increases are recorded in every merchandise sector. Meanwhile, U.S. imports for all merchandise sectors increased by 11 percent to a record $1.8 trillion. The energy products, minerals and metals, and transportation equipment sectors accounted for over half of the increase. The crude petroleum, motor vehicles, and petroleum products commodity groups recorded the largest increases in 2006, accounting for a third of import growth.

The U.S.-China trade relationship continues to evolve quickly. The U.S. merchandise trade deficit with China rose for the fifth straight year, increasing by 16 percent to $235.4 billion, reflecting the continued U.S. demand for goods produced in China. China is the fourth-largest export market for the United States and the second-leading import source in terms of absolute value. The continued rapid economic growth in China, coupled with China's increasing role as a low-cost production location, contributed to the expansion in U.S.-China trade in 2006. U.S. exports to China rose at a greater rate than the preceding years, by $12.8 billion, or 33 percent. The most significant increases in U.S. exports were in electronic products ($3.2 billion), transportation equipment ($2.5 billion), and minerals and metals ($2.5 billion). Increased demand for computer and telecommunications products by U.S. consumers contributed to continued growth in U.S. imports from China, increasing by $6.3 billion (16 percent) and $3.7 billion (26 percent), respectively. In 2006, the U.S. telecommunications market grew at the fastest rate since 2000, with demand for services such as broadband leading to increased demand for telecommunications and network equipment.

Changes in the Composition of U.S. Trade

While much attention has been paid to the increasing merchandise trade imbalance with China, it is useful to consider this trade relationship in a broader context. Table 2.1 shows the changes in the composition of U.S. non-oil imports with a number of its main trading partners between 1989 and 2007. China's share of U.S. imports increased from 2.8 percent to 20.6 percent, displacing Japan as the United States' second-largest import source after NAFTA. During this period China became the largest single import source country for the United States.

In 1989, imports from the United States' largest Asian partners (Japan, China, Korea, Taiwan, Malaysia, and Singapore) accounted for 43.9 percent of U.S. non-oil imports. By 2007, the same share had dropped slightly, to 41.5 percent of U.S. non-oil imports. During this period, the U.S. share of imports from many of its other Asian partners declined. Between 1989 and 2007, the combined share of Japan, Korea, Taiwan, Malaysia, Singapore, and other Asian countries in U.S. non-oil imports dropped from 41.1 percent to 20.9 percent. Thus, much of China's increasing share of U.S. non-oil imports came at the expense of other Asian countries, particularly Japan, which dropped from 22 percent to 8.9 percent of U.S. non-oil imports during the same period.

While the total value of non-oil imports from Asia grew substantially, its share of total non-oil imports remained fairly constant, reflecting substantial growth of imports from other regions as well. This phenomenon is particularly interesting because the composition of U.S. imports from Asia changed substantially, as more and more of the share of U.S. non-oil imports from Asia came from China.

Table 2.1 U.S. Import Shares by Country, 1989–2007

Year	Rest of world	NAFTA	Rest of Asia	Japan	China	EU15
1989	10.9	24.0	19.1	22.0	2.8	21.1
1990	11.0	24.3	18.5	20.8	3.5	21.9
1991	11.0	24.4	18.6	21.1	4.4	20.6
1992	11.3	24.5	18.4	20.1	5.5	20.2
1993	11.4	25.2	17.8	20.2	6.2	19.2
1994	11.7	26.2	17.5	19.3	6.5	18.7
1995	11.7	27.0	17.9	17.8	6.8	18.7
1996	11.9	28.3	17.4	15.9	7.3	19.2
1997	12.4	28.4	16.8	15.1	8.0	19.3
1998	12.6	28.7	16.0	14.1	8.5	20.2
1999	12.2	29.4	15.8	13.7	8.9	20.0
2000	12.6	29.1	16.1	13.4	9.5	19.3
2001	12.7	29.3	14.7	12.3	10.3	20.7
2002	12.8	28.5	14.5	11.5	12.3	20.5
2003	13.3	27.0	14.0	10.6	14.2	20.8
2004	13.7	26.5	13.7	10.1	15.9	20.1
2005	13.9	25.8	12.9	9.8	17.9	19.8
2006	14.1	25.3	12.7	9.6	19.2	19.2
2007	13.7	25.1	12.0	8.9	20.6	19.6

NOTE: U.S. imports, except Chapter 27, in percentage of total.
SOURCE: USITC and author's calculations.

A similar pattern arose in U.S. non-oil export shares (see Table 2.2). The NAFTA partner countries held a fairly constant share of U.S. non-oil exports between 1989 and 2007, while large Asian countries' shares declined from 29.2 percent to 25.7 percent of U.S. non-oil exports. As with imports, a fairly substantial shift occurred between exports to Japan and China. In 1989, Japan accounted for 12.1 percent of U.S. non-oil exports and China 1.7 percent. By 2007, Japan had dropped to 5.7 percent and China climbed to 6.0 percent.

Driving Factors in U.S.-China Bilateral Trade

In general, bilateral trade between the United States and China was driven by FIEs, and more recently from a growing role by private firms operating in China (see Figure 2.3). Electronic machinery (HS-84) con-

Table 2.2 U.S. Export Shares by Country, 1989–2007

Year	Rest of world	NAFTA	Rest of Asia	Japan	China	EU15
1989	17.4	28.5	15.4	12.1	1.7	24.9
1990	16.7	28.3	15.2	12.3	1.3	26.1
1991	17.9	28.0	15.6	11.5	1.6	25.4
1992	18.9	29.1	15.6	10.8	1.7	23.9
1993	19.4	30.2	16.2	10.5	2.0	21.7
1994	17.7	31.8	16.9	10.6	1.9	21.0
1995	18.0	29.0	18.4	11.2	2.2	21.2
1996	18.7	29.9	17.9	11.0	2.1	20.5
1997	19.0	31.5	17.4	9.7	2.0	20.5
1998	18.9	33.5	14.7	8.7	2.2	22.2
1999	16.6	35.2	15.5	8.5	2.0	22.2
2000	15.6	35.6	16.4	8.6	2.2	21.6
2001	16.9	34.9	15.1	8.1	2.7	22.3
2002	16.0	36.0	15.7	7.7	3.3	21.2
2003	15.6	35.3	15.9	7.6	4.2	21.5
2004	16.5	34.9	15.9	7.0	4.6	21.1
2005	17.9	34.9	15.0	6.5	5.0	20.6
2006	19.3	33.4	14.7	6.1	5.7	20.7
2007	21.7	31.4	14.0	5.7	6.0	21.1

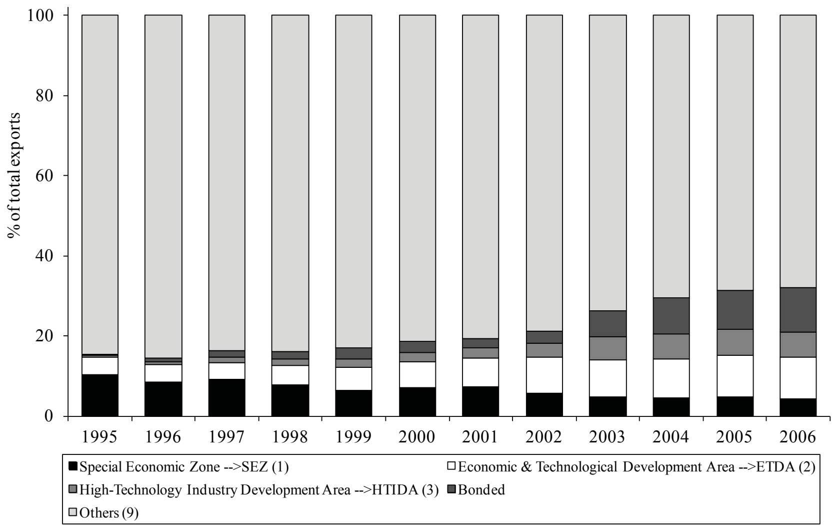
SOURCE: USITC.

stituted the largest and fastest growing product category for both imports and exports (see Tables 2.3A and B). In addition, China's government incentive schemes, such as Economic and Technological Development Zones and other specialized zones, played a dominant role in China's imports from the United States (see Figure 2.3 and Tables 2.3A and 2.3B).[5]

China's trade pattern with the United States differs in some respects from its trade pattern with the world. Yao (2008) finds that while China ran a large trade surplus with the United States in machinery and electrical products, it ran a substantial deficit with the rest of the world in these products, and that China's special economic zones played an important role in these trade flows. This, along with the general realignment of U.S. import shares from Asia discussed above, supports the argument that China is playing an important role as an assembly platform for Asia by importing electronic components and shipping final

Figure 2.3 Disaggregating China-U.S. Trade by Enterprise Type, Customs Regime, and Incentive Scheme

China's Exports to the U.S. by Incentive Scheme



China's Imports from the U.S. by Incentive Scheme

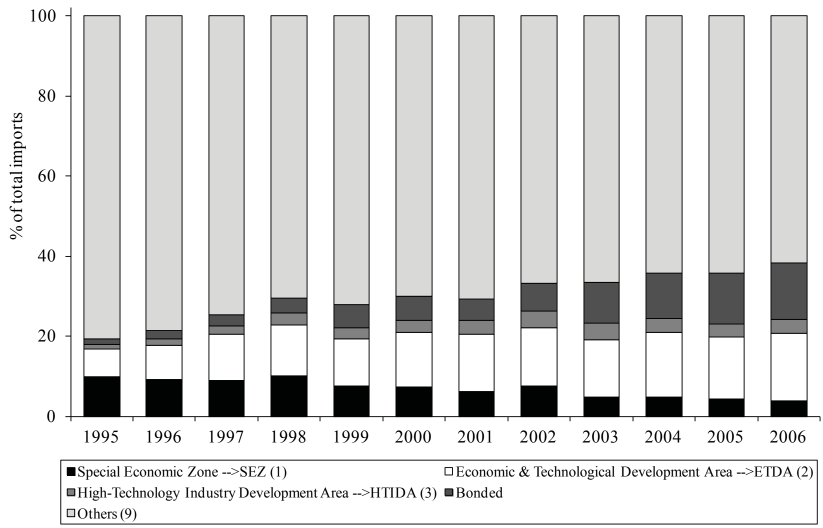
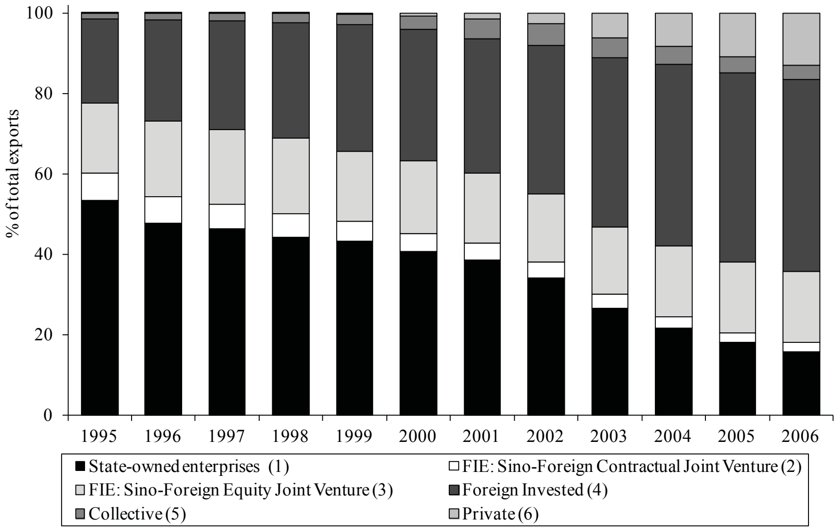
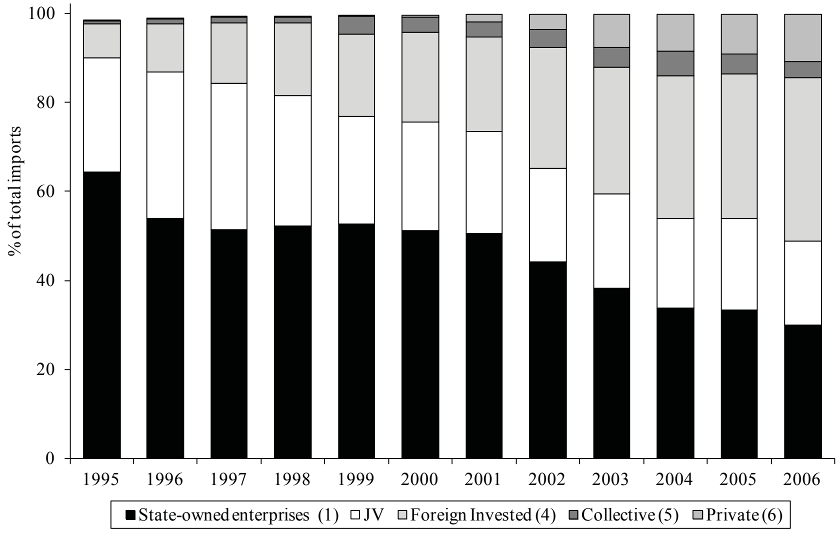


Figure 2.3 (continued)

China's Exports to the U.S. by Enterprise Type



China's Imports from the U.S. by Enterprise Type



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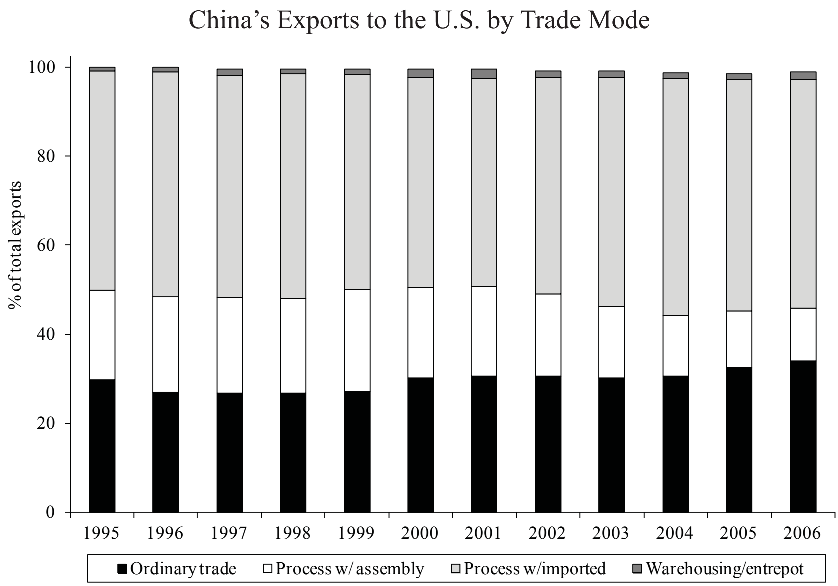
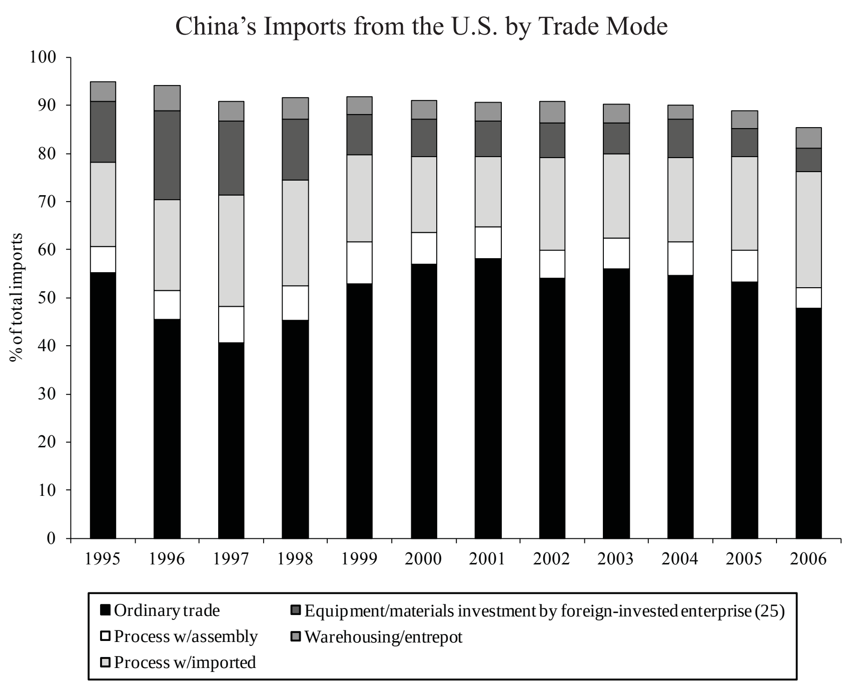




SOURCE: Ferrantino et al. (2010).

Table 2.3A Decomposing China's Top 20 Traded Products with the United States: U.S. Exports to China ($, millions)

			1995		2006	
Rank (2006)	HS[a]	Product	Value	% of total	Value	% of total
1	85	Electrical machinery and associated parts	1,270	11	10,178	18
2	84	Machinery and associated parts	2,190	19	7,704	14
3	88	Aircraft, spacecraft, and associated parts	1,176	10	6,090	11
4	90	Optical/photographic, medical, or surgical instruments and parts	450	4	2,941	5
5	39	Plastics and articles thereof	351	3	2,716	5
6	12	Oil seeds, grains, and fruits	56	0	2,585	5
7	52	Cotton, including yarns and woven fabrics	834	7	2,082	4
8	72	Iron and steel	141	1	1,800	3
9	74	Copper and associated articles	146	1	1,774	3
10	76	Aluminum and associated articles	147	1	1,735	3
11	47	Wood pulp; recovered (waste and scrap) paper and paperboard	184	2	1,474	3
12	29	Organic chemicals	263	2	1,418	3
13	87	Vehicles, nonrailway	172	1	1,291	2
14	41	Raw hides, skins, and leather	111	1	876	2
15	28	Inorganic chemicals; organic or inorganic compounds of precious metals	39	0	687	1
16	81	Base metals, cermets, and associated articles	10	0	677	1
17	38	Miscellaneous chemical products	105	1	669	1
18	44	Wood and articles of wood; wood charcoal	29	0	551	1
19	98	Special classification provisions, nesoi	148	1	483	1
20	48	Paper and paperboard; articles of paper pulp, paper or paperboard	142	1	466	1
		Subtotal	7,963	68	48,198	87
		Total	11,748		55,224	

Table 2.3B Decomposing China's Top 20 Traded Products with the United States: U.S. Imports from China ($, millions)

			1995		2006	
Rank (2006)	HS[a]	Product	Value	% of total	Value	% of total
1	85	Electrical machinery and associated parts	7,886	17	64,906	23
2	84	Machinery and associated parts	3,624	8	62,266	22
3	95	Toys, games, and sports equipment	6,222	14	20,892	7
4	94	Furniture; bedding, cushions, and lamps	1,979	4	19,358	7
5	64	Footwear	5,824	13	13,890	5
6	62	Articles of apparel and clothing accessories	3,277	7	11,858	4
7	73	Articles of iron or steel	556	1	8,367	3
8	61	Articles of apparel and clothing accessories	1,376	3	8,010	3
9	39	Plastics and articles thereof	1,623	4	7,465	3
10	42	Articles of leather	2,536	6	6,835	2
11	87	Vehicles, nonrailway	501	1	5,134	2
12	90	Optical/photographic, medical, or surgical instruments and parts	1,274	3	4,787	2
13	63	Textile articles	645	1	4,628	2
14	44	Wood and articles of wood; wood charcoal	225	0	2,997	1
15	83	Miscellaneous articles of base metal	324	1	2,982	1
16	71	Natural or cultured pearls, stones, precious metals	248	1	2,564	1
17	99	Special import reporting provisions, nesoi	202	0	2,502	1
18	40	Rubber and articles thereof	138	0	2,472	1
19	29	Organic chemicals	360	1	2,258	1
20	72	Iron and steel	198	0	2,176	1
		Subtotal	39,018	86	256,348	89
		Total	45,555		287,773	

[a] HS = Harmonized system code.
SOURCE: USITC Dataweb. This is an update from a table in Hammer (2006).

assembled goods to the United States. Hummels, Ishii, and Yi (2001) and Dean, Fung, and Wang (2011) show that a significant share of China's export values reflect content imported from other countries and reexported after some transformation.

There has been a broad debate on the driving factors behind the rapidly growing U.S.-China trade relationship (Ahearne et al. 2007; Fosler and Bottelier 2007; Branstetter and Lardy 2006; Dean, Fung, and Wang 2011; Hummels, Ishii, and Yi 2001; and Yi 2003). An extensive discussion of that debate is beyond the scope of this chapter. Instead I will discuss how this rapidly growing economic relationship generated trade tensions between the two countries, as represented by the United States' use of international WTO dispute settlement panels and national antidumping (AD) cases, and then present a summary of a novel method for looking more closely at this trade relationship that better reflects global supply chains.

The United States, China, and the WTO

As part of an internal U.S. political economy debate and compromise, Congress and the president agreed to changes in U.S. import safeguard mechanisms such as AD and import surge protections, as the United States committed to reduced tariffs in the Kennedy Round of General Agreement on Tariffs and Trade (GATT) negotiations in 1967. As a result of that round and later GATT and WTO rounds, bilateral free trade agreements, and nonreciprocal tariff preference agreements, the U.S. average trade weighted tariff rate dropped significantly from roughly 12 percent to 5 percent between 1967 and the mid 1970s, and continued to drop to 1.3 percent for 2007 (Irwin [2005] and author's calculations). With the creation of the WTO in 1995, the United States has also made use of, and been the recipient of, formal dispute panels to resolve disagreements with its trading partners. These mechanisms are viewed as integral components of normal U.S. trade relations. In the next section I summarize data regarding the United States' use of WTO dispute panels and national AD cases during this period to illustrate the fact that trade disputes between the United States and China are not much different from those between the United States and its other large trading partners.

It is important to note some important differences between WTO dispute panels and the AD mechanism discussed below. World Trade Organization dispute cases are brought by one or more governments against another government, and the cases are heard in Geneva, Switzerland, by WTO dispute panels with three members chosen by the WTO. Antidumping cases in the United States are brought by one or more U.S. firms, or other nongovernmental interested parties, against one or more foreign firms. The cases are argued by private parties in Washington, DC, before two U.S. government agencies—the Department of Commerce to determine whether dumping is occurring, and the U.S. International Trade Commission to determine whether that dumping injures the U.S. firms. Thus it is inaccurate in the AD context to refer to U.S. cases against China, as the cases are brought by private parties before U.S. government panels.

U.S.-China Trade Tensions

The growing bilateral trade deficit between the United States and China has generated concern among policymakers in both countries. Numerous sources in China have expressed concern that the U.S. government is making extensive use of WTO dispute panels, that U.S. firms are making extensive use of AD injury cases, and that the use of these mechanisms has a negative impact on the two countries' "harmonious trade relations" (see, for example, China State Council [2005] and *China Daily* [2007a,b]). Many U.S. lawmakers and interest groups have called for the government to make more extensive use of WTO dispute panels and to make import injury mechanisms, such as AD, easier for U.S. firms to file, or to prove, and thus help slow the bilateral deficits' growth.[6]

Below I briefly review the use of these mechanisms in the United States vis-á-vis China and its firms and put them in a broader context for U.S. trade relations. Through 2008 the U.S. government's use of WTO cases and private firms' use of import injury cases (and the U.S. government's determinations in those cases) appear to not single out China or its firms. Instead, the broad data appear to show that China and its domestic firms were treated similarly to the United States and its other major trading partners and general political allies, such as its NAFTA partners and the EU.

WTO Dispute Settlement Cases

Between 1995, when the WTO was created, and 2008, the United States was a complainant in 86 dispute settlement consultations (see Table 2.4). The top five respondent countries are the European Economic Community, Mexico, Korea, Japan, and Canada—countries long considered U.S. political and economic partners. China ranks sixth, followed by India, Brazil, and Argentina. The pattern that emerges from this data is that the United States views WTO consultations as part of its normal trade relationship with its major political and economic partners, and that China and other developing countries with significant U.S. trade relations are treated similarly. This suggests that from a U.S. perspective, utilizing the WTO dispute settlement mechanism is a natural part of a robust economic relationship.

Since China joined the WTO in 2001, it has ranked second to the EU in terms of number of panels with the United States as a complainant, followed by Canada and Mexico (see Table 2.5). This probably reflects a combination of China's rapid growth to become a major trading partner for the United States. Recall that China's share of U.S. imports has risen dramatically, roughly doubling since its accession to the WTO, and surpassing the EU as the United States' second-largest trading partner. If we compare the rankings in Table 2.5 with the import shares in Table 2.1, the data suggest that from a U.S. perspective our trading tensions with China appear normal and on par with our main economic and political allies. While China has expressed that it desires harmonious trade relations with its partners, including the United States, from the U.S. perspective it would appear that through 2008, at the WTO, the United States has treated China as it would any other large trading partner.

Import Injury (AD) Cases

Firms in China remain a major target for AD cases around the world. According to the Global Trade Protection Report, 2,007 firms in China were the main target of AD cases between 1995 and 2006, with 540 investigations. Interestingly, U.S. firms ranked fourth being targeted in 172 cases, behind the EU and member states at 502 cases and South Korean firms with 228 cases.

Table 2.4 WTO Dispute Settlement Consultations, since WTO Established with the United States as Complainant, through 2008

Rank	Respondents	Total number of cases	% of total cases
1	EEC	16	18.4
2	Mexico	6	6.9
3	Korea	6	6.9
4	Japan	6	6.9
5	Canada	6	6.9
6	China	5	5.7
7	India	4	4.6
8	Brazil	4	4.6
9	Argentina	4	4.6
10	Philippines	3	3.4
11	Ireland	3	3.4
12	Belgium	3	3.4
13	Australia	3	3.4
14	Turkey	2	2.3
15	Greece	2	2.3
16	France	2	2.3
17	Venezuela	1	1.1
18	United Kingdom	1	1.1
19	Sweden	1	1.1
20	Romania	1	1.1
21	Portugal	1	1.1
22	Pakistan	1	1.1
23	Netherlands	1	1.1
24	Indonesia	1	1.1
25	Egypt	1	1.1
26	Denmark	1	1.1
27	Chile	1	1.1
	Totals	86	98.9

SOURCE: WTO. Data generated by Ted Wilson, Office of Economics, USITC. Percentage does not equal 100 due to rounding.

Table 2.5 WTO Dispute Settlement Consultations, since China's Accession with the United States as a Complainant, through 2008

Rank		Number	Percent
1	EEC	6	30.0
2	China	5	25.0
3	Canada	2	10.0
4	Mexico	2	10.0
5	Egypt	1	5.0
6	India	1	5.0
7	Japan	1	5.0
8	Turkey	1	5.0
9	Venezuela	1	5.0
	Totals	20	100.0

SOURCE: WTO. Data generated by Ted Wilson, Office of Economics, USITC.

I do not discuss or estimate the economic effects of AD actions, as that is beyond the scope of this chapter, but for a discussion of the potential economic impacts of AD actions see Blonigen and Prusa (2003). Examining U.S. AD data, we can see whether China's rapid trade growth with the United States led to a disproportionate number of AD investigations on firms in China, and/or a disproportionate amount of China's trade affected by AD findings. Table 2.6 shows that between 2001 and 2006, firms in China were respondents in 20 percent of all U.S. AD cases (more than any other country, but roughly in line with China's share of total U.S. non-oil imports), and that firms in China accounted for 31 percent of the affirmative determinations. Thus, while firms in China were named in new AD filings in proportion to China's U.S. import share, they were more likely than firms from other countries to be found causing injury to U.S. firms. For the longer 1980–2006 period, firms in China were a party in only 10.5 percent of the cases, so the share of cases involving China had definitely risen (see U.S. International Trade Commission [2008]).

The above discussion focuses on the injury determination of the AD process. The long-run average since 1980 is 37 percent of all AD/countervailing duty (CVD) cases (42 percent for AD alone) being found in the affirmative, affecting 0.3 percent of total imports. Thus, China's recent experience is not out of line with the long-term findings for all countries. Also note that the dumping determination is handled by the

Table 2.6 Number of U.S. Antidumping Cases and Affirmative Findings, China and Total, 2001–2006

	Antidumping cases		Affirmative findings	
Year	China	Total	China	Total
2001	9	92	5	40
2002	8	35	6	12
2003	9	35	6	14
2004	9	34	8	20
2005	3	10	2	6
2006	4	8	2	2
Totals for period	42	214	29	94
Percent China	20		31	

SOURCE: USITC data and author's calculations.

Department of Commerce, and its long-run average for affirmative findings of dumping is nearly 90 percent, while the ITC injury determination rate is much lower.

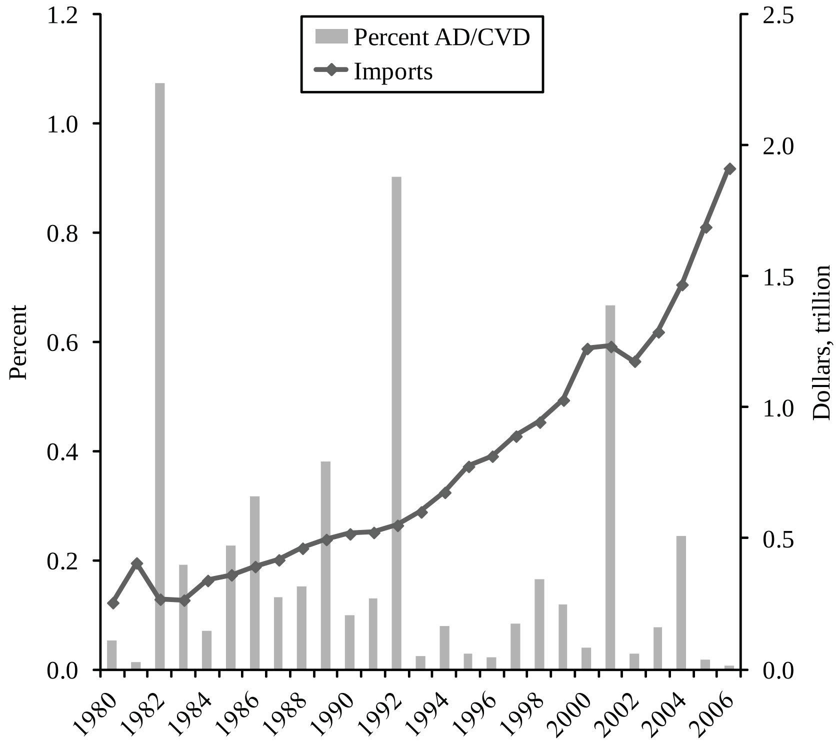
Another way to look at the treatment of firms from China in U.S. trade is the share of China's imports to the United States affected by AD cases. Irwin (2005) finds that rising U.S. AD activity on an aggregate level is related to the increase in import penetration, among other factors, and that the rise in import penetration is largely associated with falling U.S. import tariffs.

Figure 2.4 shows U.S. imports from the world plotted against those affected by new AD/CVD cases. Since 1980, there have been occasional spikes of around 1 percent of the value of imports affected by new AD/CVD duties; the long-run average, despite rapidly growing imports, is around 0.16 percent.

In Figure 2.5 we see that China's historical trade volume subjected to new U.S. AD duties tracked fairly closely with that of the world. Since 1980, there have been occasional spikes in activity of nearly 1 percent, thus similar to the world total, however the average over the period is 0.16 percent, which equals the world total for that period.

Figure 2.6 shows that, as with Irwin's findings, during the 1989–2007 period U.S. import tariffs for the world continued to decline, from 3.4 percent to 1.3 percent. Duties on imports from China fell from 8.5

Figure 2.4 U.S. Imports from the World, and Percentage Affected by Affirmative AD/CVD Findings

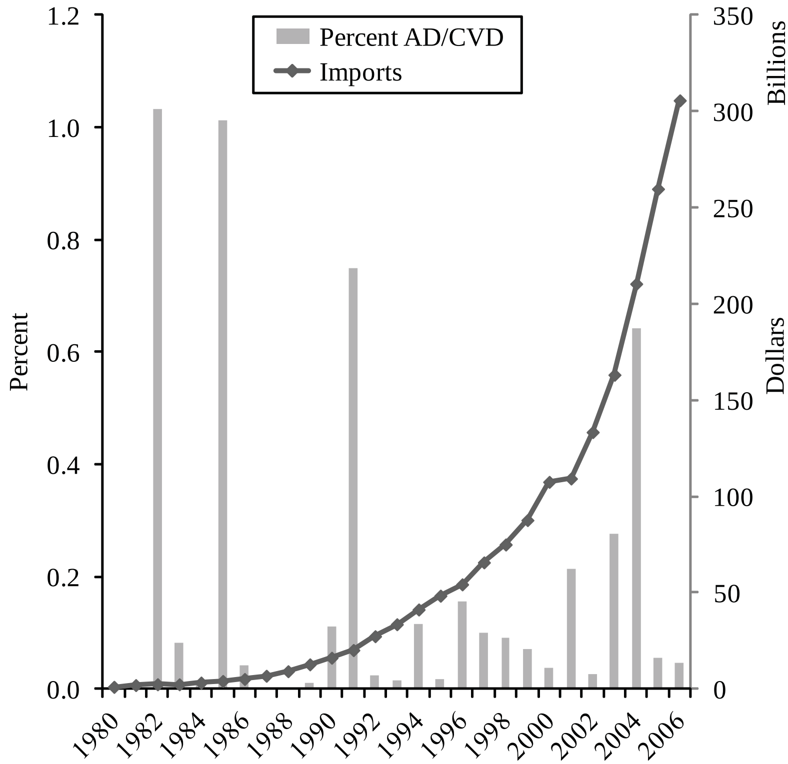


SOURCE: USITC data and author's calculations.

percent to 3.1 percent, representing the biggest decline among the countries and regions covered.[7] Such a decline in tariff rates and increased penetration is consistent with historical U.S. experience of rising AD activity.

U.S. imports from China have grown rapidly since its WTO accession, but in the aggregate firms in China appear to be treated in a quite similar respect to those in the rest of the world (see Figures 2.4 and 2.5). Between 2000 and 2006, less than 0.19 percent of total imports from China were subject to new affirmative determinations in the United States, while the world average was 0.14 percent. Both of these numbers represent a small fraction of U.S. imports. It is true that in

Figure 2.5 U.S. Imports from China, and Percentage Affected by Affirmative AD/CVD Findings

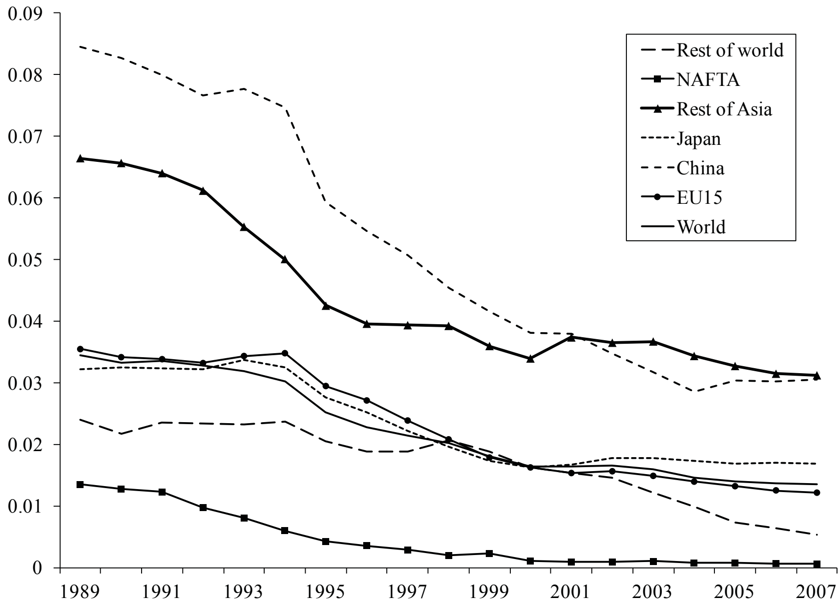


SOURCE: USITC and author's calculations.

the period 1980–1999, imports from China were much less affected by new AD cases in the United States than the world average. Imports from China during the pre-WTO accession era (1980–1990) averaged only 0.11 percent of import value subject to a new affirmative decision, while imports for the world over the same period averaged 0.18 percent. Thus, since WTO accession and 2006, China moved more in line with the average treatment in terms of U.S. imports subject to AD duties.

Thus, in terms of two measures of trade tensions, the numbers of WTO dispute settlement panels and the share of imports affected by import injury findings, we see that the United States largely treated

Figure 2.6 U.S. Average Duty Rates, by Country or Region, 1989–2007



SOURCE: USITC and author's calculations.

China and its firms as it did any other major trading partner, including its main political and economic allies. In the United States, as in other countries, the number of AD cases brought against firms in China has been increasing, and the number of cases involving firms in China found affirmative in the injury phase has risen above the world average. These data suggest that China's concerns that U.S. actions in the WTO and in its national import injury cases indicate that the United States does not care about harmonious trade relations may be misplaced and simply reflect a difference in culture and expectations as to how each side defines harmonious and normal trade relations.

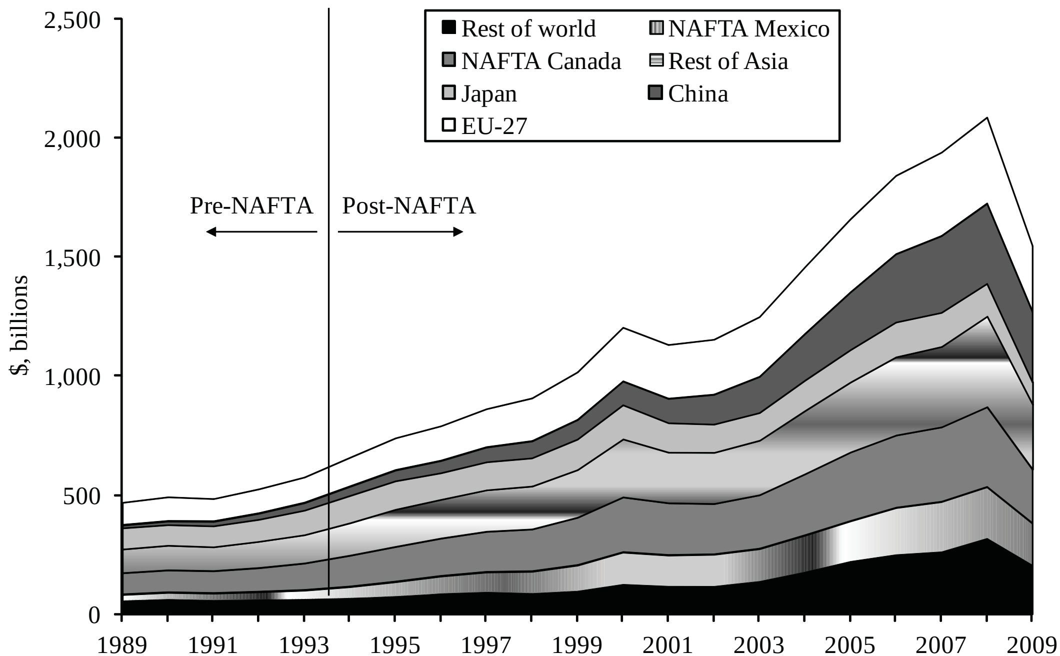
Apart from growing trade tensions, the rise of China as a supplier to the world is remarkable. The next part of this chapter focuses on a methodology to better understand how globalization—and the development of global value chains that appear to focus on China—may affect traditional gross trade values often used to describe bilateral trade relations. These insights, based on the domestic and foreign value embedded in gross trade data, suggest that the trade relationship between the United States and China is more complicated than traditional data suggest, and that Japan and other Asian countries export indirectly to the United States through China.

VALUE ADDED IN CHINESE EXPORTS

Recently, Pascal Lamy, director general of the WTO, suggested that ". . . by focusing on gross values of exports and imports, traditional trade statistics also give us a distorted picture of trade imbalances between countries." He argues that value-added trade statistics help reveal that the macroeconomic imbalances present in the current global economy are not likely to be corrected through focus on bilateral trade deficits (Lamy 2011).

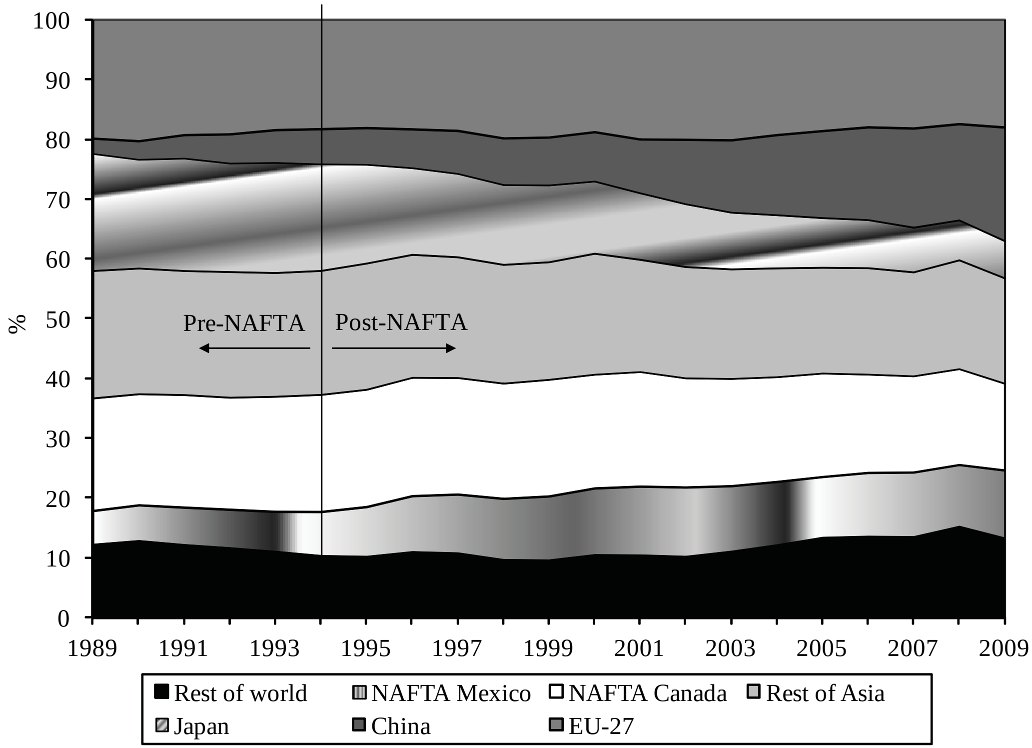
In the United States there has been great political and press attention paid to the long-term current account deficit, and particularly the bilateral trade deficit with China. At the U.S. International Trade Commission, beginning shortly after China's accession to the WTO in the early 2000s, we started receiving requests from our governmental customers regarding the growing trade imbalance with China. We first gathered data similar to that seen in Figure 2.7, traditional import values showing rising imports from China, and much of the rest of the world in value terms. Of course, when the questions first came in we had not yet experienced the recession of 2008 related to the financial crisis, so the path of import growth was fairly steadily upward, except for the 2001 recession. We next transformed the data into shares as seen in Figure 2.8, which plainly shows that something important was going on in Asia, and that much of it was related to Asian supply chain realignment and a focus on China as a point of final assembly in those chains. However, we had no way of clearly showing these links in the aggregate data at that time. Groups highly critical of trade referred to data such as that in Figure 2.7 and generally focused on China for keeping its currency artificially low in order to increase exports to the United States, among other countries. Critics argued that since other Asian countries continued to expand exports to the United States, China's increased exports were essentially completely offsetting domestic production, not substi-

Figure 2.7 U.S. Imports from Asia, NAFTA, and the World, 1989–2009



SOURCE: Author's calculations.

Figure 2.8 U.S. Imports Shares from Asia and NAFTA, 1989–2009



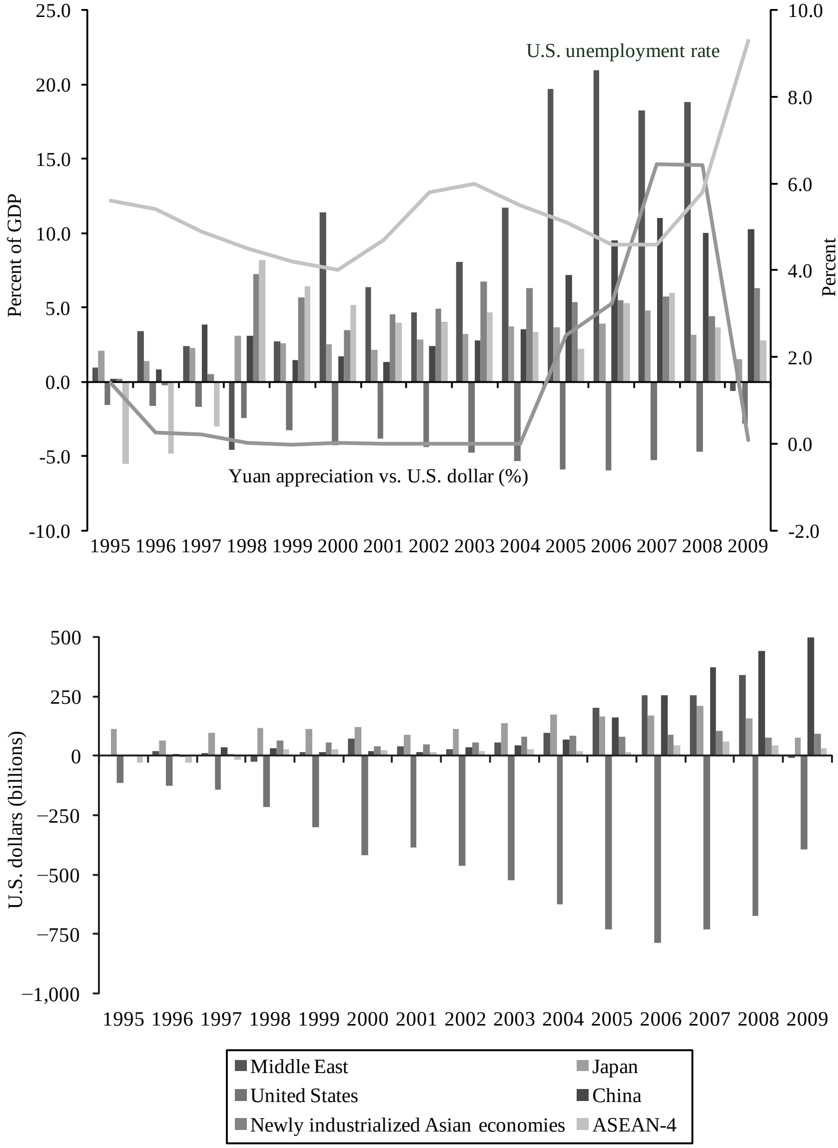
SOURCE: Author's calculations.

tuting for other Asian exports. Further, trade critics often pointed out that low prices from China, due to the currency undervaluation, stimulated demand in the United States for Chinese imports, and were then generating a growing current account deficit. To better address these kinds of comments we then developed data similar to that presented in Figure 2.9, which suggest that macro factors, particularly relatively strong economic growth—exhibited in this figure through a stable, low unemployment rate through most of the period, and relatively robust economic growth in the United States compared to other developed countries, combined with a low savings rate—were the main contributors to growing trade deficits. Despite the various forms of data presented, there was no clear "smoking gun" linking other Asian countries to Chinese exports. Similar arguments and concerns were expressed regarding NAFTA trade flows.

Methods for Understanding Domestic and Foreign Value Added in Trade

These efforts to inform our customers and the need to more fully understand what was happening in global trade flows led us to delve fairly deeply into value-added trade issues.[8] How would one assess foreign versus domestic content in a country's exports? In one of the literature's most influential papers, Hummels, Ishii, and Yi (2001; HIY in subsequent discussion) propose a method to decompose a country's exports into domestic and foreign value-added (FVA) share based on a country's input-output (IO) table. Hummels, Ishii, and Yi make a key assumption that the intensity in the use of imported inputs is the same between production for exports and production for domestic sales. However, this assumption is violated in the presence of processing exports, a prevalent part of China's export and import markets. Processing exports are characterized by imports for exports with favorable tariff treatment: firms import parts and other intermediate materials from abroad, with tariff exemptions on the imported inputs and other tax preferences from local or central governments, and, after processing or assembling, export the finished products. The policy preferences for processing exports usually lead to a significant difference in the intensity of imported intermediate inputs in the production of processing exports and that in other demand sources (for domestic final sales

Figure 2.9 Current Account Deficits, U.S. Unemployment, and the RMB-$ Exchange Rate



SOURCE: Author's calculations.

and normal exports). Since processing exports have accounted for more than 50 percent of China's exports every year at least since 1996, we felt that the HIY formula was likely to lead to a significant underestimation of the share of FVA in its exports. In fact, most economies offer tariff reductions or exemptions on imported intermediate inputs used in production for exports. By ignoring processing exports, one is likely to incorrectly estimate domestic and foreign content in trade, especially for economies that engage in a massive amount of tariff/tax-favored processing trade, such as China, Mexico, and Vietnam.

In Koopman, Wang, and Wei (2008; KWW in subsequent discussion), we aim to make two contributions to the literature. First, we present a formula for computing shares of foreign and domestic value added (DVA) in a country's exports when processing exports are pervasive. We develop this formula because we believe the production technology and input sourcing differs for goods produced for domestic consumption and normal exports compared to those produced under export processing regimes. We show that the HIY formula is a special case of this general formula. Second, we applied our methodology to China using data for 1997, 2002, and 2007. We estimate that the share of FVA in China's manufactured exports was about 50 percent in 1997–2002 before China's WTO membership—almost twice as high as that implied by the HIY formula—and has risen to over 60 percent in 2007 after five years of its WTO membership. Our method and data also allow us to examine sectoral level results, and we find interesting variations across sectors. Those sectors that are likely labeled as relatively sophisticated, such as computers, telecommunications equipment, and electronic devices, had particularly low domestic content (about 30 percent or less).

The approach in KWW is an accounting exercise and does not thoroughly examine the determinants, driving forces, and consequences of changes in domestic contents in China's gross exports. However, we believe we produced a solid methodology to estimate and account domestic and FVA in developing countries exports as a necessary first step toward a better understanding of these issues.

Besides HIY and related papers on vertical specialization, KWW is also related to the input-output (IO) literature. In particular, Chen et al. (2008) and Lau et al. (2007) are the first to develop a "noncompetitive" type IO model for China (i.e., one in which imported and domestically produced inputs are accounted for separately) and to incorporate processing exports explicitly. However, we believe that these papers do not describe a systematic way to infer separate IO coefficients for production of processing exports versus those for other final demands. As a result it is difficult for others to replicate their estimates or apply their methodologies to other countries. In addition, KWW use an aggregated version of China's 1995 and 2002 IO tables, respectively, to perform their analysis, with 20 some goods-producing industries. We provide a more up-to-date and more disaggregated assessment of FVA and DVA in Chinese exports with 83 goods-producing industries. Finally, they imposed an assumption in estimating the import use matrix from the competitive type IO table published by China's National Statistical Bureau: within each industry, the mix of the imported and domestic inputs is the same in capital formation, intermediate inputs, and final consumption. We relaxed this assumption by refining a method proposed in Dean, Fung, and Wang (2011) that combines China's processing imports statistics with the United Nations Broad Economic Categories classification.

The KWW Methodology

In this section we summarize the methodology developed in KWW. As the reader will see, the method is particularly innovative and generates very useful insights regarding domestic and foreign content of Chinese trade. This method has also been applied to Mexico's exports in De La Cruz et al. (2010), and more recently extended in a substantial way to examine global trade in value added in Koopman et al. (2010). In KWW we use very detailed information on China's trade regimes, bilateral and at the tariff line, to modify China's economy-wide IO data to reflect the substantial technology differences between its processing sectors and nonprocessing sectors. Our goal was to build on existing literature to split China's IO table into two parts, processing and nonprocessing, which would more accurately reflect the fact that the processing sector intensively used imported components that did not enter the domestic economy for other uses in final demand. Table 2.7 provides a sense of what we are trying to accomplish. We are essentially trying to estimate the values in the columns of the IO matrix for production for domestic use and normal exports and production of processing exports. A mathematical description of the approach follows.

Table 2.7 Input-Output Table with Separate Production Account for Processing Trade

			Intermediate use			
			Production for domestic use and normal exports	Production of processing exports	Final use (C+I+G+E)	Gross output or imports
		DIM	1,2,…, N	1,2,…, N	1	1
Domestic intermediate inputs	Production for domestic use and normal exports (D)	1 . . . N	Z^{DD}	Z^{DP}	$Y^{D} - E^{P}$	$X - E^{P}$
	Processing exports (P)	1 . . . N	0	0	E^{P}	E^{P}
Intermediate inputs from imports		1 . . . N	Z^{MD}	Z^{MP}	Y^{M}	M
Value-added		1	V^{D}	V^{P}		
Gross output		1	$X - E^{P}$	E^{P}		

SOURCE: Koopman, Wang, and Wei (2008).

We use superscript P and D, respectively, to represent processing exports and domestic sales and normal exports. This expanded IO model can be formally described by the following system of equations:

$$(2.1)\quad \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix} \begin{bmatrix} X - E^{P} \\ E^{P} \end{bmatrix} = \begin{bmatrix} Y^{D} - E^{P} \\ E^{P} \end{bmatrix}$$

$$(2.2)\quad A^{MD}(X - E^{P}) + A^{MP}E^{P} + Y^{M} = M$$

$$(2.3)\quad uA^{DD} + uA^{MD} + A_{v}^{D} = u$$

$$(2.4)\quad uA^{DP} + uA^{MP} + A_{v}^{P} = u$$

The analytical solution of the system is

$$(2.5)\quad \begin{bmatrix} X - E^{P} \\ E^{P} \end{bmatrix} = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} \begin{bmatrix} Y^{D} - E^{P} \\ E^{P} \end{bmatrix}$$

The generalized Leontief inverse for this expanded model can be computed as follows:

$$(2.6)\quad B = \begin{bmatrix} I - A^{DD} & -A^{DP} \\ 0 & I \end{bmatrix}^{-1} = \begin{bmatrix} B^{DD} & B^{DP} \\ B^{PD} & B^{PP} \end{bmatrix}$$

$$= \begin{bmatrix} (I - A^{DD})^{-1} & (I - A^{DD})^{-1}A^{DP} \\ 0 & I \end{bmatrix}$$

Substituting Equation (2.6) into Equation (2.5), we have

$$(2.7)\quad X - E^{P} = (I - A^{DD})^{-1}(Y^{D} - E^{P}) + (1 - A^{DD})^{-1}A^{DP}E^{p}$$

Substituting Equation (2.7) into Equation (2.2), the total demand for imported intermediate inputs is

$$(2.8)\quad M - Y^{M} = A^{MD}(I - A^{DD})^{-1}(Y^{D} - E^{P}) + A^{MD}(1 - A^{DD})^{-1}A^{DP}E^{P} + A^{MP}E^{p}$$

It has three components: the first term is total imported content in final domestic sale and normal exports, and the second and third terms are indirect and direct imported content in processing exports, respectively.

We can compute vertical specialization (VS) or foreign content share in processing and normal exports in each industry separately:

$$(2.9)\quad \begin{vmatrix} VSS^D \\ VSS^P \end{vmatrix}^T = \begin{vmatrix} uA^{MD}(I-A^{DD})^{-1} \\ uA^{MD}(1-A^{DD})^{-1}A^{DP} + uA^{MP} \end{vmatrix}^T$$

The total foreign content share in a particular industry is the sum of the two weighted by the share of processing and nonprocessing exports s^p and $u-s^p$, where both s and u are a 1 by n vector:

$$(2.10)\quad \overline{VSS} = (u-s^P, s^P)\begin{vmatrix} VSS^D \\ VSS^P \end{vmatrix}$$

The foreign content (or FVA) share in a country's total exports is

$$(2.11)\quad TVSS = uA^{MD}(I-A^{DD})^{-1}\frac{E-E^P}{te} + u(A^{MD}(1-A^{DD})^{-1}A^{DP} + A^{MP})\frac{E^P}{te}$$

where te is a scalar, the country's total exports. Equation (2.11) is a generalization of Equation (2.1), the formula to compute industry-level share of vertical specialization. Equation (2.11) is a generalization of the formula for country-level share of vertical specialization proposed by Hummels et al. (2001, p. 80). In particular, either when $A^{DD} = A^{DP}$ and $A^{MD} = A^{MP}$, or when $E^P/te = 0$, Equation (2.11) reduces to the HIY formula for VS.

Similarly, the domestic content share for processing and normal exports at the industry level can be computed separately:

$$(2.12)\quad \begin{vmatrix} DVS^D \\ DVS^P \end{vmatrix}^T = \bar{A}_v B = (A_v^D \quad A_v^P)\begin{bmatrix} (I-A^{DD})^{-1} & (I-A^{DD})^{-1}A^{DP} \\ 0 & I \end{bmatrix} = \begin{vmatrix} A_v^D(I-A^{DD})^{-1} \\ A_v^D(I-A^{DD})^{-1}A^{DP} + A_v^P \end{vmatrix}^T$$

The total domestic content share in a particular industry is a weighted sum of the two:

$$(2.13) \quad \overline{DVS} = (u - s^P, s^P) \begin{vmatrix} DVS^D \\ DVS^P \end{vmatrix}$$

The domestic content share in a country's total exports is

$$(2.14) \quad TDVS = A_V^D (I - A^{DD})^{-1} \frac{E - E^P}{te} + (A_V^D (1 - A^{DD})^{-1} A^{DP} + A_V^P) \frac{E^P}{te}$$

Either when $A^{DD} = A^{DP}$ and $A_v^D = A_v^P$ or when $E^P/te = 0$, Equation (2.14) reduces to the HIY formula. We can easily verify that for both processing and normal exports, the sum of domestic and foreign content shares is unity.

However, statistical agencies typically only report a traditional IO matrix, A^D, and sometimes A^M, but not A^{DP}, A^{DD}, A^{MP}, and A^{MD} separately. Therefore, a method to estimate these matrices, based on available information, had to be developed. In KWW we accomplish this through a quadratic programming model by combining information from trade statistics and conventional IO tables. The basic idea of this model is to use information from the standard IO table to determine sector-level total imports/exports, and information from trade statistics to determine the relative proportion of processing and normal exports within each sector, and thus use up all available data to split the national economy into processing and nonprocessing blocks, each with its own IO structure. Using the data from the IO table to determine sector-level total imports/exports helps to ensure that the balance conditions in the official IO account are always satisfied, and that the IO table with separate processing and nonprocessing accounts estimated from the model always sums to the published official table. Such a method is a formalization of the calibration methods widely used in macroeconomics and CGE modeling when the number of endogenous variables is larger than the number of equations (see KWW, pp. 9–14, for details of the method).

Estimation results

Table 2.8 presents the results from KWW for the decomposition of aggregate FVA and DVA shares in 1997, 2002, and 2007. For comparison, the results from the HIY method that ignores processing trade are also reported. The estimated aggregate DVA share in China's merchandise exports was 54 percent in 1997 and 60.6 percent in 2007. For manufacturing products, these estimated shares are slightly lower in levels but trending upward significantly at 50 percent in 1997 and 59.7 percent in 2007, respectively. In general, the estimated direct DVA shares are less than half of the total DVA shares. However, the estimated indirect FVA share was relatively small; most of the foreign content comes from directly imported foreign inputs, especially in 1997 and 2002. The indirect FVA increase over time and reach about a quarter of China's directly imported foreign inputs in 2007, indicating that the share of simple processing and assembling of foreign parts is declining, while more imported intermediates are being used in the production of other intermediate inputs that are then used in the production process.

Relative to the estimates from the HIY method, our procedure produces estimates of a much higher share of FVA in Chinese gross exports and with a different trend over time. To be more precise, estimates from the HIY method show that the foreign content share (total vs. share) increased steadily from 17.6 percent in 1997 to 28.7 percent in 2007 for all merchandise exports, and from 19.0 percent to 27.1 percent for manufacturing only during the same period. In contrast, our estimates

Table 2.8 Shares of Domestic and Foreign Value Added in Total Exports (%)

	The HIY method			The KWW method		
	1997	2002	2007	1997	2002	2007
All merchandise						
Total foreign value added	17.6	25.1	28.7	46.0	46.1	39.4
Direct foreign value added	8.9	14.7	13.7	44.4	42.5	31.6
Total domestic value added	82.4	74.9	71.3	54.0	53.9	60.6
Direct domestic value added	29.4	26.0	20.3	22.2	19.7	17.1
Manufacturing goods only						
Total foreign value added	19.0	26.4	27.1	50.0	48.7	40.3
Direct foreign value added	9.7	15.6	16.3	48.3	45.1	32.4
Total domestic value added	81.1	73.6	72.9	50.0	51.3	59.7
Direct domestic value added	27.5	24.6	24.6	19.6	18.1	16.5

SOURCE: Koopman, Wang, and Wei (2008).

suggest a trend in the opposite direction, with the share of FVA in all merchandise exports falling from 46 percent in 1997 to 39.4 percent in 2007, and a similar decline for the share in manufacturing exports, which fell from 50 percent in 1997 to 40.3 percent in 2007. The decline occurs mainly during the 2002–2007 period, which corresponds to the first five years of China's entry to the WTO. Our estimates indicate that the HIY method appears to incorrectly estimate both the level and the trend in domestic versus foreign content in the People's Republic of China exports.

What accounts for the difference between our and the HIY approaches? There are at least three factors that drive the change of foreign content of the country's gross exports: 1) the relative proportions of its total imports used as intermediate inputs in producing processing exports and domestic sales and normal exports; 2) the share of processing exports in its total exports; and 3) the sector composition of its exports. Because processing exports tend to use substantially more imported inputs, and processing exports account for a major share of China's total exports, the HIY indicator is likely to substantially underestimate the true foreign content in China's exports. This explains why the level of domestic content by our measure is much lower than that of the HIY indicator. On the other hand, as exporting firms (both those producing for normal exports and those for processing exports) gradually increase their intermediate inputs sourcing from firms within China, or multinationals move their upstream production to be near their downstream production, the extent of domestic content in exports rises over time. This is exactly what has happened since China joined the WTO. However, because exports from industries with relatively lower domestic content often grow faster due to dramatic inflow of foreign direct investment, the composition of a country's total exports may play as an offsetting factor to reduce the share of DVA in the country's gross exports and thus slow down the increase of DVA share in a country's total exports. As the Chinese government starts to reduce the policy incentives for both FIEs and processing exports at the end of 2006, we are observing a trend of increasing domestic contents in Chinese exports as China continues its industrial upgrading in the years to come.

Our interpretation is confirmed by DVA shares for processing and normal exports estimated separately (Table 2.9). There is a more than 10 percentage point increase in the total FVA share for domestic sales and normal exports between 1997 and 2007, which is consistent with the trend indicated by the HIY measure. However, in processing exports we see that more domestic-produced inputs were used, and DVA share increased from 20.7 percent in 1997 to 37.0 percent in 2007, up more than 16 percentage points. Because processing exports still constitute more than 50 percent of China's total exports in 2007 the weighted average total DVA share went up over the decade.

There are conflicting forces at work. On the one hand, as domestic input suppliers increase their quality over time, and multinationals move more and more of their upstream production into China, exporting firms may decide to increase local sourcing of their inputs. On the other hand, the reductions in the country's trade barriers also encourage exporting firms to use more imported inputs. These two opposing forces partially offset each other. However, on net, the domestic content share in China's exports appears to be on the rise. Looking ahead, the share of imported content in exports could fall or rise, depending on the relative speed with which domestic input suppliers and multinationals can step

Table 2.9 Domestic and Foreign Value Added: Processing vs. Normal Exports (% of total exports)

	Normal exports			Processing exports		
	1997	2002	2007	1997	2002	2007
All merchandise						
Total foreign value added	5.2	10.4	16.0	79.0	74.6	62.7
Direct foreign value added	2.0	4.2	5.0	78.6	73.0	58.0
Total domestic value added	94.8	89.6	84.0	21.0	25.4	37.3
Direct domestic value added	35.1	31.9	23.4	11.7	10.1	10.9
Manufacturing goods only						
Total foreign value added	5.5	11.0	16.4	79.4	75.2	63.0
Direct foreign value added	2.1	4.5	5.2	79.0	73.6	58.3
Total domestic value added	94.5	89.0	83.6	20.7	24.8	37.0
Direct domestic value added	31.5	29.5	22.4	11.7	10.0	10.9

SOURCE: Koopman, Wang, and Wei (2008) and author's estimates based on China's 1997, 2002, and 2007 benchmark input-output table published by the Bureau of National Statistics and Official China trade statistics from China Customs.

NOTE: The HIY method refers to estimates from using the approach in Hummels, Ishii, and Yi (2001). The KWW method refers to estimates from using the approach developed in this paper that takes into account special features of processing exports.

up their quality and variety versus the extent of additional reductions in the cost of using imported inputs.

Sectoral results

To see if there are interesting patterns at the sector level that help explain the decline trend of imported contents in China's total exports, and further assess whether the increasing DVA share reflects actual upgrade of Chinese industrial structure, Tables 2.10 and 2.11 report, in ascending order on domestic content share, the value-added decomposition in China manufacturing exports by industry in 2002 and 2007, respectively, together with shares of processing and foreign invested enterprises exports in each sector's exports as well as the sector's share in China's total merchandise exports. We choose to report the results from 2002 and 2007 not only because we would like to use the latest IO table released, but also because these two benchmark tables are consistently classified on most recent Chinese industry classifications, which simplifies issues involved in overtime comparison. Similar results for 1997 are omitted to save space.

Among the 57 manufacturing industries in Table 2.10, 15 have a share of DVA in their exports less than 50 percent in 2002, and collectively account for nearly 35 percent of China's merchandise exports that year. Many low-DVA industries are likely to be labeled as relatively sophisticated, such as telecommunications equipment, electronic computer, measuring instruments, and electronic devices. A common feature of these industries is that processing exports account for over two-thirds of their exports, and foreign-invested enterprises played an overwhelming role. In 2007, the number of industries with less than 50 percent domestic contents in their exports declined to 10, but their exports accounted for more than 32 percent of China's total merchandise exports, and these low-DVA industries are more concentrated in high-tech sectors. There are 11 industries in the top 15 low-DVA industries in 2002 that maintained that ranking in 2007.

The next 18 industries in Table 2.11 have their share of DVA in the range of 51–65 percent; they collectively accounted for 28 percent of China's total merchandise exports in 2002. Several labor-intensive sectors are in this group, such as furniture; toys and sports products; and leather, fur, and down products.

The remaining 24 industries have relatively high shares of DVA. However, as a group they produced less than 30 percent of China's total merchandise exports in 2002. Apparel, the country's largest labor-intensive exporting industry, which by itself was responsible for 7 percent of the country's total merchandise exports in 2002, is at the top of this group with a share of domestic content at 66 percent. The 12 industries at the bottom of Table 2.10 with DVA share more than 75 percent collectively produced only less than 10 percent of China's total merchandise exports in 2002.

The weights of high-DVA industries in China's exports increased significantly in 2007. The number of industries with a DVA share of more than 75 percent increased to 25 in 2007 (bottom of Table 2.11), and their exports constituted more than 30 percent of China's total merchandise exports in 2007. Among these high-DVA industries, we not only see the traditional labor industries such as furniture, textiles, and apparel still play a significant role (they account for more than half of these high-DVA-sector exports), but also the increasing role of heavy and capital-intensive industries such as automobile, industrial machinery, and rolling steel (they account for nearly one-third of these high-DVA sector's exports). The data clearly indicate China's industrial upgrade is real and FIEs have played a very important role in this process.

The groundbreaking work by HIY (2001) on vertical specialization needs to be interpreted with care, particularly in countries that make extensive use of processing trade. We find that for China the traditional HIY method substantially overestimated China's domestic content in its exports and underestimated foreign content in its exports as in Table 2.9. The HIY method estimates total DVA in Chinese exports ranging from 82 percent to 71 percent between 1997 and 2007, and that DVA was declining. The KWW method estimates that Chinese DVA ranged from 46 percent to 39 percent during this period, much lower than the HIY method, and that Chinese DVA was rising.

Further, with our method and data we could provide fairly detailed sectoral estimates of DVA in exports, as in Table 2.10. From this perspective you can observe that in 2002 China's DVA in telecommunications, shipbuilding, and electronic computers was less than 20 percent of exported value. Many high-tech or sophisticated exports contained

Table 2.10 Domestic Value-Added Share in Manufacturing Exports by Sector, 2002

	Value-added decomposition (%)								
	Nonprocessing		Processing		Weighted sum				
IO industry description	Foreign value added	Domestic value added	Foreign value added	Domestic value added	Foreign value added	Domestic value added	% of processing exports	% of FIE exports	% of merchandise exports
Telecommunications equipment	12.6	87.5	94.7	5.3	87.5	12.5	91.2	88.4	3.2
Shipbuilding	17.7	82.3	85.3	14.7	82.5	17.5	95.8	21.0	0.6
Electronic computer	16.4	83.6	81.3	18.7	80.7	19.3	99.1	89.7	7.0
Cultural and office equipment	20.3	79.7	80.7	19.3	76.7	23.3	93.4	71.6	4.3
Household electric appliances	11.8	88.2	93.2	6.8	76.2	23.9	79.1	56.9	1.9
Household audiovisual apparatus	17.5	82.5	78.7	21.3	73.0	27.0	90.6	62.3	5.2
Printing, reproduction of recording media	8.9	91.1	80.3	19.7	68.1	31.9	83.0	62.7	0.3
Plastic	15.6	84.4	89.7	10.3	63.4	36.6	64.5	51.2	2.4
Electronic components	15.4	84.6	67.2	32.8	61.9	38.1	89.7	87.5	3.4
Steelmaking	11.0	89.0	87.2	12.8	55.8	44.3	58.8	86.1	0.0
Generators	14.8	85.2	68.1	32.0	55.7	44.3	76.8	55.8	0.9
Other electronic and communication equipment	2.2	97.8	64.0	36.0	54.7	45.3	84.9	84.9	1.8
Rubber	9.4	90.6	87.8	12.2	51.1	48.9	53.1	44.4	1.6
Nonferrous metal pressing	13.8	86.2	92.5	7.5	50.7	49.3	46.9	48.7	0.4
Measuring instruments	14.2	85.8	67.1	32.9	50.5	49.5	68.6	51.8	1.8
Paper and paper products	9.2	90.8	87.6	12.4	48.9	51.1	50.7	57.0	0.5
Furniture	11.7	88.3	87.5	12.5	47.5	52.5	47.2	56.8	1.7
Articles for culture, education, and sports activities	12.5	87.5	61.8	38.2	47.3	52.7	70.6	56.3	3.3

Nonferrous metal smelting	11.1	88.9	89.4	10.6	46.4	53.6	45.0	17.4	0.8
Smelting of ferroalloy	16.5	83.6	87.1	13.0	45.2	54.8	40.8	13.1	0.2
Synthetic materials	19.5	80.5	62.9	37.1	44.8	55.2	58.3	65.4	0.3
Petroleum refining and nuclear fuel	20.6	79.4	94.5	5.5	44.3	55.7	32.1	24.9	0.8
Metal products	9.7	90.3	89.8	10.2	44.3	55.7	43.2	45.6	4.4
Other transport equipment	14.0	86.0	87.3	12.7	44.2	55.8	41.2	50.5	1.2
Other electric machinery and equipment	11.6	88.4	59.9	40.1	43.9	56.2	66.8	60.1	5.6
Special chemical products	17.1	82.9	68.6	31.4	41.3	58.7	46.9	48.4	0.8
Other manufacturing products	10.8	89.2	68.7	31.3	41.0	59.0	52.2	37.6	1.7
Woolen textiles	8.9	91.1	91.2	8.8	40.0	60.1	37.8	42.6	0.3
Paints, printing inks, pigments, and similar products	16.5	83.5	91.7	8.3	38.4	61.6	29.1	44.4	0.4
Motor vehicles	10.5	89.6	90.0	10.0	38.4	61.6	35.2	48.2	0.8
Glass and its products	13.2	86.8	83.5	16.5	36.4	63.6	33.0	48.8	0.5
Leather, fur, down, and related products	8.1	91.9	59.7	40.4	36.1	63.9	54.3	50.3	4.5
Chemical products for daily use	14.7	85.3	73.2	26.8	36.0	64.1	36.3	43.6	0.4
Wearing apparel	8.7	91.3	65.7	34.3	34.4	65.6	45.1	39.2	7.0
Chemical fiber	19.8	80.2	90.8	9.2	34.3	65.7	20.5	29.2	0.0
Other special industrial equipment	10.8	89.3	68.0	32.0	33.6	66.4	39.9	44.0	1.3
Boilers, engines, and turbines	14.1	85.9	86.9	13.1	33.5	66.5	26.7	28.4	0.4
Other industrial machinery	9.9	90.1	61.4	38.6	32.4	67.6	43.7	43.7	3.5
Iron-smelting	13.2	86.8	89.0	11.0	31.2	68.8	23.7	3.0	0.1
Railroad transport equipment	16.2	83.9	85.4	14.6	29.9	70.1	19.9	5.9	0.1
Wood, bamboo, rattan, palm, and straw products	12.2	87.8	88.7	11.3	27.2	72.8	19.6	45.6	1.0

Table 2.10 (continued)

IO industry description	Value-added decomposition (%)						% of processing exports	% of FIE exports	% of merchandise exports
	Nonprocessing		Processing		Weighted sum				
	Foreign value added	Domestic value added	Foreign value added	Domestic value added	Foreign value added	Domestic value added			
Knitted and crocheted fabrics and articles	9.4	90.6	65.3	34.7	27.1	72.9	31.6	34.2	5.8
Agriculture, forestry, animal husbandry, and fishing machinery	14.3	85.7	86.1	13.9	27.1	72.9	17.8	20.8	0.1
Pesticides	23.0	77.0	88.5	11.5	27.1	72.9	6.3	14.4	0.2
Hemp textiles	10.5	89.5	88.3	11.7	25.7	74.3	19.5	19.5	0.3
Textiles productions	9.9	90.1	71.1	28.9	24.6	75.5	24.0	31.8	1.4
Cotton textiles	8.2	91.8	64.5	35.6	24.3	75.7	28.7	28.8	3.3
Fire-resistant materials	9.5	90.5	84.6	15.4	23.8	76.2	19.1	49.8	0.1
Metalworking machinery	12.8	87.2	81.2	18.8	21.9	78.1	13.3	27.0	0.2
Medicines	9.8	90.2	75.7	24.3	20.9	79.1	16.9	28.7	0.7
Pottery and porcelain	11.8	88.2	85.3	14.8	20.2	79.8	11.4	33.1	0.7
Other non-metallic mineral products	9.6	90.4	83.3	16.7	19.9	80.1	14.0	35.7	0.4
Fertilizers	15.6	84.4	90.3	9.7	18.9	81.1	4.5	21.7	0.1
Basic chemical raw materials	12.9	87.1	56.3	43.7	18.0	82.0	11.7	18.8	2.0
Rolling of steel	9.8	90.2	59.5	40.5	17.7	82.3	16.0	16.8	0.3
Cement, lime, and plaster	9.0	91.0	79.8	20.3	14.0	86.0	7.0	77.7	0.1
Coking	8.6	91.4	86.8	13.2	10.6	89.4	2.6	5.3	0.3
Total merchandise	10.4	89.6	74.6	25.4	46.1	53.9	55.7	51.8	92.5

SOURCE: Koopman, Wang, and Wei (2008). China 2002 and 2007 benchmark IO tables have 84 and 90 goods-producing sectors respectively; they both concord to China's 4 digit classification of economic activities (GB/T 4754-2002). This concordance enabled us to aggregate both year's estimates to 77 consistent goods-producing industries reported in this table.

less than 40 percent of Chinese domestic content. On the other hand, many of China's historical export sectors, such as apparel, textiles and fabrics, and many steel or metal-related items, had domestic content in excess of 60 percent. These estimates suggest that studies that examine extraordinary sophistication of China's exports, such as that by Rodrik (2006) and Schott (2008), might need to be interpreted with some care, as this sophistication may reflect the embodiment of sophisticated imported components. Further, if the domestic content in exports from China is low, especially in sectors that would have been considered sophisticated or high-skilled in the United States, then imports from the PRC may still generate a large downward pressure on the wage of the low-skilled Americans after all (as pointed out by Krugman [2008]). These are important policy questions and have implications for both developing and developed countries. A good understanding of the nature and extent of global supply chains could provide important insights for economists and policymakers.

The work we did on China, similar work for Mexico (De La Cruz et al. 2010), and a growing literature on value added in trade led us to develop a method to look at global value added trade, while incorporating the insights we developed for large single country traders making heavy use of processing. Thus, in Koopman et al. (2010) we develop an estimation technique designed to tie, at a global level, value-added estimates to gross trade flows, which is the most commonly available trade data and is heavily used to support various policy positions. Thus we use IO techniques to examine global value chain links using gross exports as a weighting mechanism. In this chapter we fully characterized value-added contributions from direct and indirect sources in a country's gross exports, formally generalizing the concept of vertical specialization to account for all sources of value added in gross exports in a multicountry, multisector framework. It also connects the vertical trade literature with value-added trade literature, generalizing concepts such as DVA that returns home in goods and services after being processed or finished abroad, denoted VS1* by Daudin, Rifflart, and Schweisguth (2009). This measure can be sizable for some large advanced economies.

To do this, we first divide gross exports into final demand and intermediates. Within intermediates, we further divide those goods that are consumed by the direct importer from those goods that are processed

Table 2.11 Domestic Value-Added Share in Manufacturing Exports by Sector, 2007

IO industry description	Value-added decomposition (%)						% of processing exports	% of FIE exports	% of merchandise exports
	Nonprocessing		Processing		Weighted sum				
	Foreign value added	Domestic value added	Foreign value added	Domestic value added	Foreign value added	Domestic value added			
Electronic component	22.5	77.5	76.9	23.1	67.7	32.3	83.1	89.8	4.9
Household audiovisual apparatus	24.1	75.9	70.4	29.6	67.4	32.6	93.4	79.1	2.5
Electronic computer	24.3	75.7	67.1	33.0	66.2	33.9	97.9	93.3	11.3
Cultural and office equipment	25.9	74.1	66.9	33.1	63.5	36.5	91.7	86.4	1.6
Other electronic and communication equip.	32.0	68.0	65.3	34.7	60.3	39.7	84.8	81.6	1.4
Telecommunications equipment	24.8	75.2	64.7	35.3	56.4	43.6	79.3	83.6	5.9
Shipbuilding	16.1	83.9	60.9	39.1	56.2	43.8	89.4	16.5	1.1
Petroleum refining and nuclear fuel	31.3	68.7	79.9	20.1	55.6	44.4	50.1	27.3	0.7
Measuring instruments	20.0	80.0	62.2	37.8	54.2	45.8	81.2	73.3	2.5
Synthetic materials	23.6	76.4	66.1	34.0	52.4	47.7	67.7	66.1	0.6
Household electric appliances	18.0	82.0	64.4	35.6	48.2	51.8	65.1	61.7	2.7
Other electric machinery and equipment	19.7	80.3	66.3	33.7	47.9	52.1	60.5	65.9	4.9
Rubber	18.3	81.8	73.0	27.0	46.7	53.4	51.8	41.9	1.7
Plastic	19.2	80.8	68.9	31.1	44.9	55.1	51.7	54.7	1.7
Articles for culture, education, and sports activities	17.0	83.0	54.4	45.6	41.7	58.4	66.0	64.9	2.1
Special chemical products	23.3	76.7	66.0	34.0	38.4	61.6	35.3	51.2	0.8
Chemical fiber	23.6	76.4	48.1	51.9	37.4	62.6	56.2	48.7	0.3
Other special industrial equipment	17.5	82.5	57.0	43.0	34.8	65.2	43.8	54.7	2.7

Generators	19.7	80.3	48.8	51.2	33.4	66.6	47.2	50.3	0.7
Railroad transport equipment	22.3	77.7	45.9	54.1	31.0	69.0	37.0	12.2	0.1
Leather, fur, down, and related products	9.6	90.4	59.6	40.4	30.8	69.2	42.5	46.0	2.4
Paper and paper products	14.5	85.5	42.4	57.6	30.8	69.2	58.4	62.8	0.4
Metal products	15.0	85.1	60.4	39.7	29.9	70.1	32.9	49.5	4.4
Boilers, engines, and turbines	18.4	81.6	61.3	38.7	29.4	70.6	25.6	37.8	0.5
Nonferrous metal pressing	21.4	78.6	43.9	56.1	28.8	71.2	32.7	41.4	1.0
Other manufacturing products	13.5	86.5	52.0	48.1	27.7	72.3	36.8	41.5	1.6
Paints, printing inks, pigments, and similar products	23.5	76.5	43.2	56.8	27.5	72.6	20.1	47.3	0.3
Pesticides	26.1	73.9	46.5	53.6	27.1	72.9	4.8	19.5	0.1
Chemical products for daily use	19.2	80.8	41.6	58.4	26.7	73.3	33.5	55.5	0.3
Nonferrous metal smelting	23.8	76.2	43.6	56.4	26.7	73.3	14.6	19.6	0.8
Other transport equipment	19.0	81.0	45.1	54.9	26.2	73.8	27.8	46.5	0.9
Basic chemical raw materials	19.2	80.8	57.5	42.5	25.1	74.9	15.6	26.4	1.9
Motor vehicles	16.0	84.0	52.6	47.4	24.7	75.3	23.7	42.0	2.0
Agriculture, forestry, animal husbandry, and fishing machinery	19.4	80.6	42.3	57.7	24.4	75.6	21.9	32.7	0.1
Other industrial machinery	16.5	83.6	43.8	56.2	24.4	75.6	29.0	49.9	3.4
Iron-smelting	24.1	75.9	49.4	50.6	24.4	75.6	1.1	24.3	0.1
Smelting of ferroalloy	24.3	75.7	46.7	53.3	24.4	75.6	0.4	8.8	0.4
Furniture	13.3	86.7	43.9	56.1	23.8	76.2	34.2	56.0	2.0
Printing, reproduction of recording media	13.6	86.4	39.0	61.0	23.5	76.5	39.0	44.4	0.2
Glass and its products	16.7	83.3	41.0	59.0	23.3	76.7	27.2	46.4	0.6
Woolen textiles	10.6	89.4	42.2	57.9	23.1	76.9	39.8	46.8	0.2

Table 2.11 (continued)

	Value-added decomposition (%)								
	Nonprocessing		Processing		Weighted sum				
IO industry description	Foreign value added	Domestic value added	Foreign value added	Domestic value added	Foreign value added	Domestic value added	% of processing exports	% of FIE exports	% of merchandise exports
Metalworking machinery	18.8	81.2	43.2	56.8	22.7	77.3	16.0	36.4	0.3
Rolling of steel	20.0	80.0	47.2	52.9	22.2	77.8	8.3	22.6	3.8
Fertilizers	19.0	81.0	42.7	57.3	22.1	77.9	13.2	9.5	0.3
Cotton textiles	12.0	88.0	54.3	45.8	21.1	78.9	21.5	26.1	2.1
Wearing apparel	10.5	89.5	46.1	53.9	21.0	79.0	29.7	36.9	4.6
Medicines	12.4	87.6	62.5	37.5	19.7	80.3	14.5	32.3	0.8
Wood, bamboo, rattan, palm, and straw products	15.4	84.6	41.7	58.4	19.6	80.4	16.1	33.1	1.0
Steelmaking	19.2	80.8	48.3	51.7	19.2	80.8	0.2	7.1	0.3
Pottery and porcelain	16.6	83.4	41.9	58.2	18.0	82.0	5.2	29.9	0.5
Textiles productions	11.6	88.4	45.1	54.9	17.6	82.4	18.1	35.1	1.8
Knitted and crocheted fabrics and articles	11.8	88.2	48.4	51.6	17.5	82.5	15.6	25.7	5.7
Other non-metallic mineral products	14.0	86.0	43.4	56.6	17.0	83.0	10.1	25.1	0.5
Hemp textiles	13.4	86.6	43.2	56.8	16.1	83.9	9.0	14.7	0.2
Fire-resistant materials	13.5	86.6	44.9	55.1	15.3	84.7	5.8	51.6	0.1
Cement, lime, and plaster	11.0	89.0	47.1	52.9	11.6	88.4	1.7	29.6	0.1
Coking	10.4	89.6			10.4	89.6	0.0	11.4	0.3
Total merchandise	16.0	84.0	62.7	37.3	39.4	60.6	50.1	55.7	96.0

SOURCE: Author's calculations. China 2002 and 2007 benchmark IO tables have 84 and 90 goods-producing sector, respectively; they both concord to China's 4 digit classification of economic activities (GB/T 4754-2002). This concordance enables us to aggregate both years' estimates to 77 consistent goods-producing industries reported in this table.

and exported by the direct importer for consumption or further processing in a third country:

$$(2.15)\quad E_{rs} = Y_{rs} + A_{rs}X_s =$$

$$\underbrace{Y_{rs}}_{\substack{\text{Final goods}\\ \text{exported to } s}} + \underbrace{A_{rs}X_{ss}}_{\substack{\text{Intermediates}\\ \text{absorbed in } s}} + \underbrace{\sum\nolimits_{t\neq r,s} A_{rs}X_{st}}_{\substack{\text{Processed and exported}\\ \text{to third countries}}} + \underbrace{A_{rs}X_{sr}}_{\substack{\text{Processed and}\\ \text{exported back to } r}}$$

where X_{st} is the output of country s used to produce goods absorbed in country t. Note that the last three terms sum to the bilateral gross trade in intermediate goods, and each may include both intermediates and final products produced in the importing country s.

In Koopman et al. (2010), we transform the above equation to arrive at our key decomposition equation that states that a country's gross exports to the world is the sum of the following five broad terms:

$$(2.16)\quad E_{r*} = \text{DV}_r + \text{FV}_r$$

$$= \underbrace{V_r B_{rr} \sum_{s\neq r} Y_{rs}}_{(1)} + \underbrace{V_r B_{rr} \sum_{s\neq r} A_{rs}X_{ss}}_{(2)} + \underbrace{V_r B_{rr} \sum_{s\neq r} \sum_{t\neq r,s} A_{rs}X_{st}}_{(3)}$$

$$+ \underbrace{V_r B_{rr} \sum_{s\neq r} A_{rs}X_{sr}}_{(4)} + \underbrace{\text{FV}_\text{r}}_{(5)}$$

where,

(1) DVA embodied in exports of final goods and services absorbed by the direct importer,

(2) DVA embodied in exports of intermediate inputs used by the direct importer to produce its domestically needed products,

(3) DVA embodied in intermediate exports used by the direct importer to produce goods for third countries (indirect value-added exports),

(4) DVA embodied in intermediate exports used by the direct importer to produce goods shipped back to source (reflected DVA), and

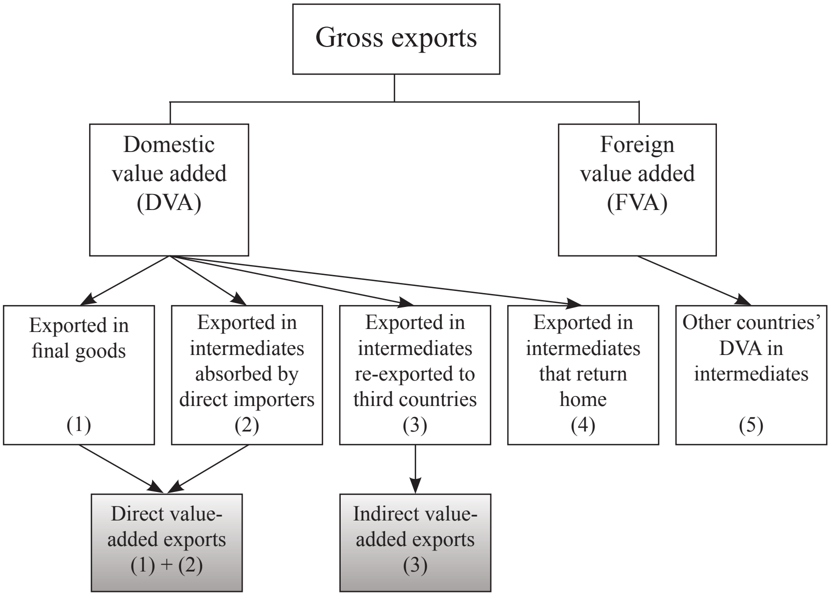
(5) value added from foreign countries embodied in gross exports (FVA used in exports).

This decomposition formula is also shown in Figure 2.10, which integrates the older literature on vertical specialization with the newer literature on value-added trade, while ensuring that measured value added from all sources accounts for total gross exports. The vertical specialization literature emphasized that gross exports contain two sources of value added, domestic and foreign. The second equation above shows that a country's DVA could be further broken down into additional components that reveal the destination of a country's exported value added, including its own value added that returns home in its imports.[9] The sum of (1), (2), and (3) equals each country's value-added exports to the world; the sum of (1), (2), (3), and (4) equals domestic content in a country's gross exports, thus nicely connecting the two major concepts in the vertical specialization and value-added trade literature on the one hand, and clearly distinguishing them on the other hand.

In addition, all other measures in the literature can be derived from a combination of the five basic measures. For instance, the sum of (3) and (4) equals HIY's VS1 in gross exports; the sum of (1), (2), and (3) divided by gross exports equals Johnson and Noguera's (2010) ratio of value-added exports to gross exports (VAX ratio); and the sum of (4) and (5) equals the portion of trade that is double counted in official trade statistics.[10]

In Table 2.12 we report the global decomposition by country or regional grouping in our database for 2004 and map it back to the existing measures in the literature. An interesting insight reported in the table is our estimate of the double or multiple counting (column 9) in global trade flows as a result of value added moving across multiple borders. We estimate that the global average is 25.6 percent. One can observe a number of interesting insights from this global approach. We can see that some countries, such as Japan, Indonesia, and the Philippines, are important intermediate suppliers, providing indirect value added through their exports to third countries. Some countries such as Brazil, Russia, Canada, Australia, and New Zealand export a lot of value-added intermediates that are consumed by the direct importer. Another interesting insight is that the EU and the United States have a much greater share of their DVA exports return home to them embedded in other countries' exports.

Figure 2.10 Decomposition of Gross Exports: Concepts



NOTE: (4) is also labeled as VS1* by Daudin et al. (2009). (5) is labeled as VS, and (3) + (4) is labeled as VS1 by HIY (2001). (4) and (5) involve value added that crosses national borders at least twice, and are the sources of multiple counting of value added in standard trade statistics. The share of domestic content in a country's exports equals (1) + (2) + (3) + (4). (1) + (2) is the VAX ratio for each country's exports to the world defined by Johnson and Noguera (2010).
SOURCE: Koopman et al. (2010).

This global approach also allows us to provide interesting policy-relevant insights that otherwise might not have been evident. For example, in the USITC's recent study (2011) we provide insights on U.S. trade using value-added trade data.[11] Although U.S. imports from China and Mexico are considerable, these countries contribute less value added to U.S. imports than Europe, Canada, and Japan, the three largest contributors to value added (Table 2.13). Remarkably, U.S. value added that returns home after receiving further processing elsewhere ranks fourth, at 8.3 percent. Among all countries, the United States has the highest share of its own value-added exports returned home in its

Table 2.12 Decomposition of Gross Exports, 2004

	Basic decomposition					Connection with existing measures				
	DVA in direct exports of final goods	DVA in intermediates absorbed by direct importer	Indirect DVA exports to third countries	Retuned DVA	Foreign value added	VAX ratio[a]	VS1[b]	Domestic content[b]	Multiple counting	GVC participation (vertical trade, OECD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Advanced economies										
Australia, New Zealand	27.0	33.6	27.4	0.6	11.5	88.0	27.9	88.5	12.0	39.4
Canada	23.5	36.2	10.9	1.3	28.1	70.5	12.2	71.9	29.5	40.4
EFTA	23.0	36.3	14.7	0.8	25.2	74.0	15.5	74.8	26.0	40.8
EU	38.1	29.6	13.5	7.4	11.4	81.1	20.9	88.6	18.9	32.3
Japan	38.4	18.5	28.0	2.9	12.2	84.9	30.8	87.8	15.1	43.1
United States	32.5	27.6	14.6	12.4	12.9	74.6	27.0	87.1	25.4	39.9
Asian NICs										
Hong Kong	27.2	25.8	18.9	0.6	27.5	71.9	19.5	72.5	28.1	47.0
Korea	29.5	13.5	22.3	0.9	33.9	65.2	23.2	66.1	34.8	57.0
Taiwan	19.2	12.6	26.4	0.8	41.1	58.2	27.1	58.9	41.8	68.2
Singapore	11.0	13.1	12.2	0.6	63.2	36.3	12.8	36.8	63.7	76.0
Emerging Asia										
China normal	44.2	20.3	19.7	1.2	14.6	84.2	20.9	85.4	15.8	35.5
China processing	28.8	10.2	4.1	0.3	56.6	43.1	4.4	43.4	56.9	61.0
Indonesia	20.0	28.1	28.4	0.6	22.9	76.5	29.0	77.1	23.5	51.9
Malaysia	16.7	17.7	24.1	0.9	40.5	58.6	25.0	59.5	41.4	65.5

Philippines	17.6	11.1	29.0	0.4	41.9	57.8	29.4	58.1	42.2	71.2
Thailand	27.9	14.0	18.1	0.3	39.7	60.0	18.5	60.3	40.0	58.1
Vietnam	32.9	15.3	14.4	0.4	37.0	62.6	14.8	63.0	37.4	51.8
Rest of East Asia	35.3	26.9	16.1	0.1	21.7	78.2	16.2	78.3	21.8	37.9
India	30.2	30.8	18.6	0.4	20.1	79.6	18.9	79.9	20.4	39.0
Rest of South Asia	48.8	19.2	10.6	0.1	21.3	78.6	10.7	78.7	21.4	32.0
Other emerging										
Brazil	27.4	40.7	19.0	0.3	12.7	87.0	19.2	87.3	13.0	31.9
EU accession countries	28.7	29.2	10.4	1.0	30.8	68.3	11.4	69.2	31.7	42.1
Mexico normal	23.5	41.1	17.4	0.6	17.3	82.1	18.1	82.7	17.9	35.3
Mexico processing	20.6	10.1	5.6	0.3	63.4	36.3	5.9	36.7	63.7	69.3
Rest of Americas	23.8	40.6	20.4	0.7	14.4	84.9	21.2	85.6	15.2	35.6
Russian Federation	9.5	49.1	30.5	0.7	10.2	89.1	31.2	89.8	10.9	41.4
South Africa	23.1	34.5	24.0	0.2	18.2	81.6	24.2	81.8	18.4	42.4
Rest of the world	15.0	45.6	22.4	2.5	14.6	83.0	24.9	85.4	17.0	39.5
World average	29.2	27.7	17.5	4.0	21.5	74.4	21.5	78.5	25.6	43.0

[a] Data from Johnson and Noguera (2010).
[b] Data from Hummels, Ishii, and Yi (2001).
NOTE: All columns are expressed as a share of total gross exports. DVA = domestic value added. Country groupings follow IMF regions (http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/groups.htm#oem).
SOURCE: Author's calculations.

imports.[12] This high share reflects both the large size of the U.S. market and its tight integration with Canada and Mexico.

The value-added approach more accurately portrays the origin of the value in U.S. imports than can standard gross import data. For example, Japan has an 8.7 percent share of total U.S. imports, but accounts for 10.4 percent of the value added in U.S. imports. Japan's higher share of value-added imports indicates that a substantial share of its exports (26 percent) first journey to other countries and undergo additional processing before being exported to the United States. Specifically, Japan produces a large volume of high-value components that are shipped to other Asian countries, particularly China, where they are assembled into consumer goods and then exported (Dean, Lovely, and Mora 2009). In contrast, China's share of U.S. value-added imports (7.7 percent) is less than its share of total U.S. imports (11.1 percent). China is the final assembler in a number of supply chains in which Japan and other countries in East Asia supply parts. Similarly, exports from many smaller East Asian countries pass through third countries, such as China, before entering the United States. Canada and Mexico also have lower shares of U.S. value-added imports than their total U.S. imports. U.S. imports from Canada and Mexico contain many U.S.-produced components, which contribute to the large share of U.S. exported value that returns home. Obviously understanding the underlying geographic composition of value added in imports can ensure a deeper understanding of a large number of policy issues, such as FTA negotiations, supply chain disruptions, and the impact of currency revaluations.

Various countries and regions contribute value to U.S. imports in different sectors (Table 2.14). Europe is the largest source of value added for many sectors, particularly business services. U.S.-returned value added is most significant in motor vehicles and parts (19.1 percent); much of this represents value added returned home from other NAFTA countries, as the United States is heavily involved in auto supply chains in this region. Europe and Japan also contribute significant amounts of value added to U.S. imports of motor vehicles and parts. U.S.-returned value added is also fairly high for apparel (11.0 percent), since some rules of origin provide for duty-free imports of apparel made from U.S. yarns and fabrics. East Asia, which has abundant low-cost labor and is well integrated into supply chains with China, contributed the most value added to U.S. imports of apparel (27.8 percent).[13]

Table 2.13 U.S. Imports and Value-Added Shares in U.S. Imports, 2004, by Source

Region	Total imports ($, millions)	Share of general imports (%)	Share of value-added imports (%)	Share of value-added passing through a third country before entering the United States (%)
Europe	393,301	24.7	26.1	17.6
Canada	242,170	15.2	11.0	3.2
Japan	138,417	8.7	10.4	26.0
United States	—	0.0	8.3	100.0
China	176,879	11.1	7.7	14.8
Mexico	154,571	9.7	4.9	4.0
Rest of Americas[a]	76,183	4.8	4.7	13.2
Developing East Asia	79,250	5.0	4.5	32.4
Taiwan, Singapore, Hong Kong	73,066	4.6	4.3	36.7
Korea	51,707	3.3	3.3	31.8
Brazil	23,662	1.5	1.6	20.3
Australia and New Zealand	15,717	1.0	1.3	33.6
Russia	12,003	0.8	1.3	46.4
India	17,486	1.1	1.1	22.0
South Asia	9,557	0.6	0.5	10.2
Rest of world	120,320	7.6	8.5	23.5
Total	1,590,124	100.0	100.0	25.8[b]

[a]Including South American, Central American, and Caribbean countries other than Mexico and Brazil.
[b]U.S. average, weighted by U.S. imports from all sources.
SOURCE: Commission estimates. Table 3.2 in the USITC study.

Table 2.14 Country or Regional Sources of Value Added on U.S. Imports, Selected Sectors, 2004 (%)

Sector	U.S returned	China	Japan	East Asia	Canada	Mexico	Latin America	Europe	Others
Total	8.3	7.7	10.4	12.0	11.0	4.9	6.3	26.1	13.2
Selected sectors									
Apparel	11.0	11.2	2.4	27.8	2.4	2.0	10.4	11.4	21.4
Chemicals, rubber, and plastics	6.3	5.0	9.7	8.7	12.0	2.5	3.6	42.8	9.4
Motor vehicles and parts	19.1	2.5	23.0	7.2	16.0	3.8	1.9	23.1	3.4
Electronic equipment	8.6	14.4	19.0	29.6	2.4	9.3	1.3	11.4	3.9
Machinery and equipment	11.3	10.1	17.2	9.7	6.9	4.7	2.9	32.1	5.1
Business services	1.5	1.3	6.2	12.7	8.8	0.2	2.7	55.5	11.3

SOURCE: Commission estimates from USITC (2008, Table 3.3).

Sectoral insights on value-added imports can again inform FTA negotiations, provide insights on supply chain disruptions, and help identify potential indirect effects of protection measures.

The value-added shares of U.S. absorption (i.e., the use of intermediate inputs plus consumption of final products, or equivalently total domestic expenditures on goods and services) provide another view of the sectors and regions where global value chains are important to the U.S. economy. Absorption can distinguish the relative U.S. and FVA shares in products consumed in the United States. Overall, the United States itself generates a large share (89 percent) of the value of final and intermediate goods that it uses (Table 2.15). This share is on par with those of Japan (90 percent) and the EU-15 (88 percent), and is higher than those of most developing countries.[14] The many goods and services produced and consumed in the United States and the large portion of U.S. value returned in imports contribute to the high share.

Although overall U.S. value in absorption is high, the domestic value share is typically lower for sectors actively involved in global supply chains. There is substantial foreign content in electronic equipment, apparel, and motor vehicles. For apparel, consistent with value added in imports, China and East Asia contribute more value to U.S. absorption than Mexico and Latin America (largely from Central America). Japan, Canada, and Europe are major participants in supply chains for motor vehicles and parts, and together account for almost one-third of the value added in U.S. absorption in the sector. Japan, East Asia, Mexico, and Europe participate in the supply chain for electronic equipment, which is one of the largest in terms of the number of countries contributing significant value added. Electronics has the highest share of foreign content: fully two-thirds of the value of all electronics products used by U.S. industry and consumers originates abroad. Hence, foreign value in some U.S. industries may be substantially higher than estimates in previous studies based on gross input use or gross trade.

In business services, a category that includes consulting and computer support, the United States provides a large portion (88.5 percent) of its absorbed value added, while Europe contributes 5.9 percent. Despite the high profile of India's consulting and computer services and the prominence of some large suppliers, India supplied only 0.1 percent of the value added in U.S. absorption of business services in 2004, though this may have risen in recent years.

Table 2.15 Country or Regional Sources of Value Added in U.S. Absorption, Selected Sectors, 2004 (%)

Sector	U.S.	China	Japan	East Asia	Canada	Mexico	Latin America	Europe	Others
Total	89.0	0.9	1.3	1.5	1.3	0.6	0.7	3.2	1.4
Selected sectors									
Apparel	54.3	4.1	0.6	18.3	2.1	1.8	5.7	2.9	8.6
Chemicals, rubber, and plastics	69.1	3.1	4.2	4.2	3.4	0.8	1.4	11.9	1.5
Motor vehicles and parts	57.3	1.5	11.3	3.4	10.1	4.6	0.6	10.6	0.5
Electronic equipment	33.3	9.3	12.7	23.3	1.8	10.9	0.8	7.0	0.8
Machinery and equipment	76.1	2.7	4.5	3.1	2.2	1.6	0.7	8.4	0.6
Business services	88.5	0.3	1.4	1.1	1.4	0.0	0.5	5.9	0.8

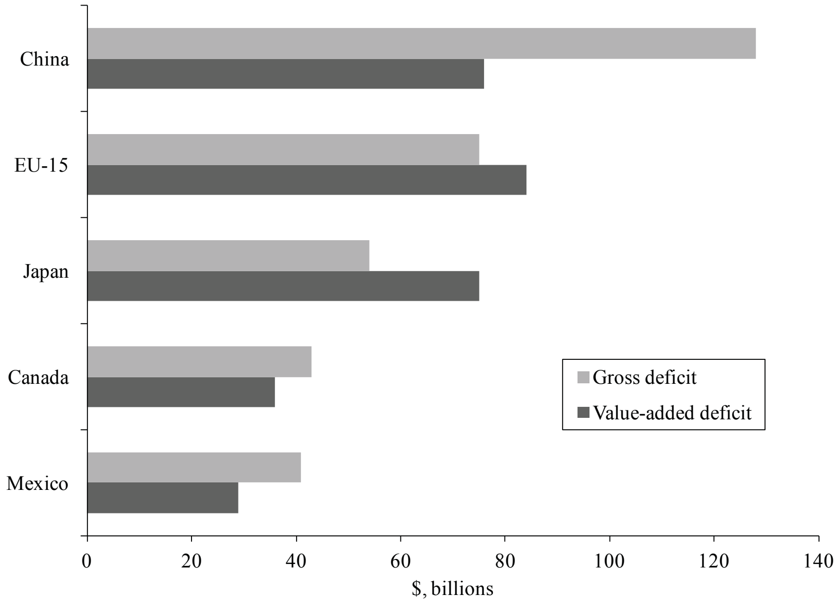
SOURCE: Commission estimates from USITC (2008, Table 3.4).

In addition, the U.S. trade balance is a frequently discussed trade issue. The United States has had large trade deficits in recent years (e.g., $500 billion in 2010), and it has also had substantial bilateral deficits with major trading partners. The value-added trade work discussed here, and in the literature more broadly, has demonstrated that many countries may add value to a particular good or service in a global supply chain, and that attributing the entire export value to the last exporting country can provide a misleading picture of the sources of value in trade. While the overall trade balance is not affected by value-added calculations, examinations of bilateral trade balances on a value-added basis yield different conclusions about the extent to which specific foreign countries contribute to a country's deficit, and here we will focus on the U.S. deficit.

The contribution of China to the U.S. trade deficit differs substantially depending on which of the two measures is used. China is often the final assembler in a large number of global supply chains, and it uses components from many other countries to produce its exports. In Figure 2.11 we see that the U.S.-China trade deficit on a value-added basis is considerably smaller (by about 40 percent in 2004) than on the commonly reported basis of official gross trade.[15] In contrast, Japan exports parts and components to countries throughout Asia, many of which are eventually assembled into final products and exported to the United States. Thus the U.S.-Japan trade balance on a value-added basis is larger than the comparable gross trade deficit. The U.S. value-added trade deficits with other major trading partners (Canada, Mexico, and the EU-15) differ by smaller amounts from their corresponding gross trade deficits.

There is significant political debate in the United States regarding efforts to encourage China to appreciate the Renminbi (RMB) faster. The logic behind this argument is that if the RMB were to unilaterally appreciate by 30 percent, then Chinese export prices will increase by 30 percent, raising prices in the United States of Chinese products and reducing U.S. demand for those imported products. Apparently expectations are that U.S. consumers would then buy other, U.S-made products, or production of those products would shift back to the United States, and/or U.S. consumers would decide to save the money they otherwise would have spent, resulting in an overall decline in U.S. imports. Furthermore, a number of commentators have suggested that such an

Figure 2.11 U.S. Bilateral Trade Deficits with Major Trading Partners, 2004



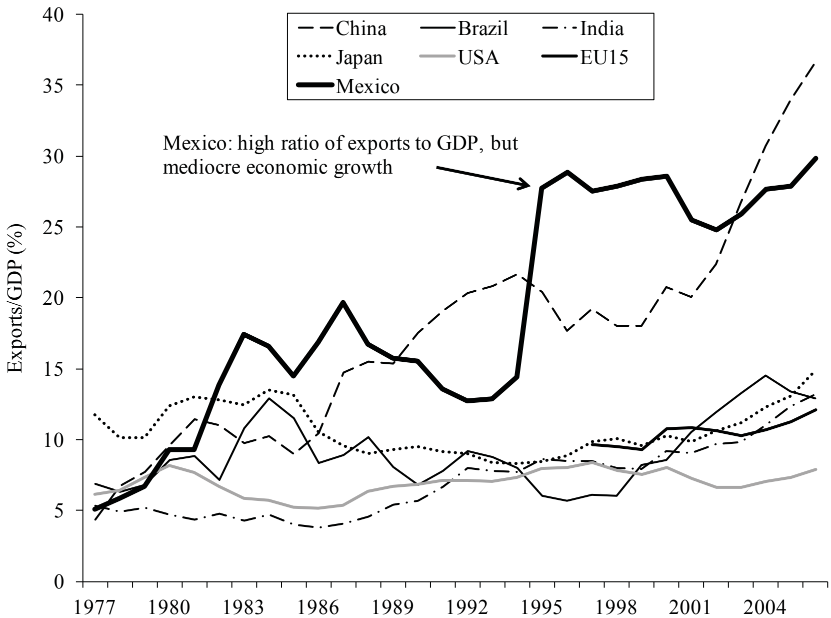
SOURCE: Commission estimates from USITC (2008, box 3.4)

appreciation could raise U.S. employment anywhere from 600,000 to 2.3 million additional jobs.[16]

However, unilateral RMB appreciation will likely raise the costs of Chinese content, or value added, in its exports. Thus, if Chinese value added for electronics products is 15 percent of its exports prices, then a 30 percent appreciation of the RMB could raise the price of Chinese electronics products by only 4.5 percent, not 30 percent. Of course, historically, exchange rate pass through has typically been much less than 1.0, perhaps because of value-added content related issues, but also because of competitive pricing decisions by exporters who may absorb some of the increase. Further, it appears more likely that U.S. consumers would continue to demand similar products, probably imported from some other international supplier, at a higher price, though perhaps priced in a different currency. An excellent overview of these issues can be found in Arnold (2008). Thus, with a more in-depth understanding of value-added trade, one can better understand the potential impact on country-specific export prices based on a currency appreciation.

Another insight gained from value-added trade is correcting a fairly standard, though potentially misleading, measure of export's contribution to GDP growth. In Figure 2.12 we see that export growth as a share of GDP is not necessarily a good indicator of GDP growth, as Mexico, a country with a relatively high ratio of export to GDP, has had mixed GDP growth over the period, while countries such as Brazil and India, with relatively low shares of export to GDP growth, are experiencing rather robust and extensive economic growth. McKinsey researchers illustrated that export growth's contribution to economic growth in China using traditional GDP growth decomposition methods was very misleading (Horn, Singer, and Woetzel 2010). Using traditional methods suggests that exports contributed 40–60 percent of China's economic growth from 1990 to 2008; however, they recalculate China's GDP growth for 2002–2007, 2008, and 2009, adopt the KWW (2008) method, and find that exports contributed 14–27 percent of overall GDP

Figure 2.12 Gross Exports as a Share of GDP, Selected Countries



growth and that the role of investment and private consumption are substantially more important. Economists generally view sustained economic growth as being driven by investment and consumption growth on the demand side.

In sum, the fact that we can now generate single country and global value-added trade databases now allows the insights generated from a vast array of product-specific value and supply chain case studies to be translated into more aggregated data tied to traditional measures of global trade. The ability to combine product level case studies with sector and country level data is a major step forward in our efforts to more accurately inform policymakers about the impacts and implications of trade and trade policy.

Notes

The contributions of Zhi Wang, Shang-Jin Wei, and Justino De La Cruz are greatly appreciated; however, any and all remaining errors in this paper are mine. The views expressed here are solely those of the author and do not reflect the views of the U.S. International Trade Commission or any of its commissioners.

1. For a more extensive discussion on these issues see, for example, Fosler and Bottelier (2007) and Branstetter and Lardy (2006).
2. Ahearne et al. (2007) presents a nice summary.
3. See Hammer (2006) for extensive discussions on driving factors in U.S-China trade and Yao (2008) for a similar discussion on trade between China and the world.
4. This section is drawn from U.S. Trade Shifts found at http://www.usitc.gov/tradeshifts/2007/default.htm (accessed June 27, 2012).
5. This is a very abbreviated summary of the U.S.-China trade relationship. For more detailed discussions of U.S.-China and China-world trade patterns, see Hammer (2006) and Yao (2008).
6. See, for example, testimony from C. Fred Bergsten, of the Peterson Institute of International Economics, before the Hearing on China's Exchange Rate Policy, Committee on Ways and Means, U.S. House of Representatives, September 15, 2012. http://waysandmeans.house.gov/media/transcript/9854.html#trumka (accessed June 27, 2012).
7. China's trade-weighted tariff rate reflects the relatively high tariffs remaining on imports of textiles and apparel. In fact, China's declining average tariff rate over the period in the table reflects more of the changing composition of China's exports increasingly toward products in lower tariff lines as found in HS 84.
8. De La Cruz et al. (2010); Koopman, Wang, and Wei (2010); and Powers et al. (2010) are among some of the papers generated from this effort. In the following

discussions on value-added trade in China and for global value added estimates, I draw heavily from sections of Koopman, Wang, and Wei (2008) and Koopman et al. (2010).

9. Since Equation (16) decomposes all bilateral exports from country *s* to country *r*, it also simultaneously decomposes bilateral imports.
10. Component (3) should not be included in double counting because when this value crosses a border the second time, it becomes foreign value in the direct importer's exports. For this reason, it is not included as double counting to avoid an overcorrection.
11. The discussion surrounding Tables 2.12, 2.13, and 2.14 draws heavily on USITC (2011).
12. The world average is 4.0 percent. Other economies with high shares include the EU (7.2 percent) and Japan (3.4 percent) (Koopman et al. 2010).
13. Major changes have occurred in global supply chains involving textiles and apparel since 2004, and China's prominence in U.S. imports has likely increased.
14. EU-15 refers to the first 15 countries to join the EU. DVA shares for Japan, the EU-15, and other countries come from Koopman et al. (2010).
15. Using a slightly different method, a recent study by the WTO and the Institute of Developing Economies–Japan External Trade Organization (2011) finds that this discrepancy was about 53 percent in 2005 and 42 percent in 2008. Johnson and Noguera (2010) have roughly similar results also, though in their estimates the bilateral U.S. deficit with Mexico reversed to a surplus.
16. Bergsten (2010) estimates between 600,000 and 1.2 million jobs from a substantial appreciation, Krugman (2010) estimates the effect at 1.4 million jobs, and Scott (2010) estimates 2.3 million jobs with a return of the bilateral deficit to 2001 levels. It has been difficult to reproduce employment impacts like this using standard USITC general equilibrium models, even when we restrict the model to force substitution of forgone imports to U.S. production.

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