Web Appendix A:

The Domestic Value Added of Chinese Exports

To accompany the Congressional Budget Office paper
How Changes in the Value of the Chinese Currency Affect U.S. Imports

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TABLES

APPENDIX A:
THE DOMESTIC VALUE ADDED OF CHINESE EXPORTS

This appendix reviews the economics literature that estimates the domestic value added of Chinese exports. Among the studies reviewed, those that best address data and methodological problems in the estimation procedure give estimates in the range of roughly 35 percent to 55 percent for various years from 1995 through 2002. The evidence is mixed regarding the trend in the value-added share over time.

BACKGROUND

When a firm produces a good, it generally purchases various inputs (such as raw materials and other intermediate inputs) from other firms and applies factors of production (labor, capital, and land) to those inputs to produce the good. For the firm to stay in business, the selling price of the good must cover the price of the purchased intermediate inputs plus the wages of the labor, the returns to capital (interest and profits), and the rent (or imputed rent) on land and buildings. Formally, the *value added* of a firm is defined as the value of its output minus the value of the intermediate inputs it purchases to produce the output, and it is generally equal to the returns to the factors of production—primarily wages, profits, and rent.[1]

The same concept can be applied to higher levels of economic organization. The value added by an industry is the value of the products of that industry minus the value of the inputs that the industry purchases from other industries. Similarly, the value added by a country to a product, usually called the *domestic value added* or *domestic content*, is the value of the product minus the value of the imported inputs used directly or indirectly to produce the product, often called the *foreign content*.

The foreign content includes not only the value of inputs imported from abroad but also the foreign content of inputs purchased domestically. Moreover, the foreign content of those inputs includes not only the imported inputs used to produce them but also the foreign content of the domestically purchased inputs used to produce them. Thus, to determine the domestic value added, a lengthy series of calculations must be made of the foreign content of the domestic inputs of the exports, the foreign content of the domestic inputs of those inputs, and so on.

The standard methodology used by most studies to estimate the domestic value added uses an input-output (IO) table for the Chinese economy. For an economy with *n* industries, an IO table is a table with *n* columns and *n* rows in which the entries in each column are the amounts of input that one of the industries purchases from each of the *n* industries of the economy. Correspondingly, the entries in each row are the amounts of input that one of the industries sells to each of the *n* industries of the economy. Just as simple algebra can be used to find the net present value of a series of interest payments extending infinitely into the future, simple matrix

[1] This discussion neglects taxes.

algebra can be applied to IO tables to find the result of the series of calculations that arises in domestic value-added calculations.

When using an IO table to calculate the domestic value added of Chinese exports, it is necessary that the IO table include separate elements for inputs purchased inside the country and inputs that are imported. Published IO tables generally do not have such separate elements. Different studies use different methods for estimating which and how much of the goods that China imports are used as inputs to production.

Another issue is that the domestic value added of a good produced for export might be different from the domestic value added of the same good produced for domestic consumption in China. Not the least of the reasons concerns what is called *processing trade*. The Chinese government exempts two categories of imports—those associated with processing and assembly and those associated with processing with imported materials—from tariffs, provided those imports are used in the production of goods that are exported.[2] The trade associated with those two programs is referred to as processing trade. It is likely that processing exports have lower domestic value added than would the same kinds of goods produced for domestic sale in China. Therefore, to produce the most accurate calculation of the domestic value added of exports, it would be desirable for the IO table to have separate elements for processing exports. Published IO tables generally do not have such separate elements. Some of the studies accept that limitation of the data and use the tables as they are. Their estimates can thus be expected to be biased upward to some degree. Other studies have developed methods for estimating separate elements for exports. The use of such estimated elements should reduce or eliminate the bias in the value-added estimates at the cost of introducing some degree of error as a result of whatever inaccuracy there may be in the estimated elements.

STUDIES THAT USE PUBLISHED IO TABLES WITHOUT MODIFICATION

Two of the studies that the Congressional Budget Office (CBO) reviewed use published IO tables as they are without modifying them to account for separate production for domestic consumption and export. Those studies give estimates for domestic value added in the range of roughly 60 percent to 95 percent (see Table A-1).

Analysis by the Staff of the U.S. International Trade Commission

An analysis by the staff of the U.S. International Trade Commission (ITC) in 2005, using a more inclusive definition of domestic content than that used in this appendix, estimates that the

[2] In the processing-and-assembly category, ownership of the inputs and the output they are used to produce is retained by the foreign firm that exports the inputs and imports the final products. In the processing-with-imported-materials category, ownership of the inputs is transferred to the Chinese firm using them for production.

Table A-1

Estimates by the Various Studies of Domestic Value Added

Study	Date of IO Table	No. of Industries	Exports to	Percent Value Added	Comments
Studies That Use Published IO Tables Without Modification					
Analysis by ITC staff[a]	2001	57	World	83–94	Number includes foreign content of domestically sourced inputs
Dean, Fung, and Wang[b]	1997	124	World	70.7[g]	
	2002	122	World	64.1[g]	
Studies That Account for Separate Production for Domestic Consumption and Export					
Chen, Cheng, Fung, and Lau[c]	1995	33	World	54.5	
			U.S.	45.8–48.1	
Lau and Nine Others[d]	2002	42	U.S.	36.8	
Koopman, Wang, and Wei[e]	1997	124	World	52.3	
	2002	122	World	53.9	
	2002	122	U.S.	45.6	
A Study That Uses Another Methodology					
Fung, Lau, and Lee[f]	NA	NA	World	28.0 Processing trade	Based on processing imports and exports
	NA	NA	World	40 Nonprocessing trade	Based on anecdotal evidence

Source: Congressional Budget Office based on the studies included in the table.

Notes: IO = input-output; ITC = U.S. International Trade Commission; NA = not applicable.

a. Staff of the U.S. International Trade Commission, *Technical Assistance on Domestic Value Added to Exports in China*, produced for the staff of the House Committee on Ways and Means, April 20, 2005.

b. Judith M. Dean, K.C. Fung, and Zhi Wang, *Measuring the Vertical Specialization in Chinese Trade*, Office of Economics Working Paper No. 2007-01-A, U.S. International Trade Commission, January 2007.

c. Xikang Chen, Leonard Cheng, K.C. Fung, and Lawrence J. Lau, *The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States*, presentation to the Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, June 2001.

d. Lawrence J. Lau and others, *Estimates of U.S.-China Trade Balances in Terms of Domestic Value-Added*, Working Paper No. 295, Stanford University, October 2006, updated November 2006.

e. Robert Koopman, Zhi Wang, and Shang-Jin Wei, *How Much of Chinese Exports Is Really Made in China? Assessing Foreign and Domestic Value-Added in Gross Exports*, Office of Economics Working Paper No. 2008-03-B, U.S. International Trade Commission, March 2008, Appendix Tables D and E.

f. K.C. Fung, Lawrence J. Lau, and Joseph S. Lee, *U.S. Direct Investment in China*, The AEI Press, 2004, pp. 143–156.

g. The paper by Judith M. Dean, K.C. Fung, and Zhi Wang estimates the vertical-specialization percentage, which is 100 percent minus the value-added percentage. The numbers presented in this table are calculated from those results.

domestic content of Chinese exports in 2001 ranged from 83 percent to 94 percent of the value of those exports.[3] The analysis uses the Global Trade Analysis Project (GTAP) database. That database contains data for 57 industries/products and 87 countries/regions of the world for 2001, which the ITC staff aggregated into 10 industry/product sectors and 10 regions. Included in the data are bilateral trade flows and IO tables that include information on industry value added, imported intermediate inputs, and domestically produced intermediate inputs.

The analysis calculates two numbers for each of the sectors, but neither number is precisely the same as domestic value added. One of the numbers is the industry value added, which comprises primarily the wages and profits in the industry sector. The paper concludes that for China's main export sectors, the industry value added in 2001 ranged from 17 percent to 27 percent of output. The other number is domestic content, which because of data limitations the paper was forced to define as industry value added plus the total value (not just domestic value added) of domestically produced intermediate inputs. The paper concludes that for China's main export sectors, the domestic content so defined ranged from 83 percent to 94 percent in 2001.

The concept of domestic content used in the paper is closer than is industry value added to the concept of domestic value added used in this appendix. Nevertheless, the paper's domestic content estimates should be higher than the domestic value added as the term is used in this appendix because they include the foreign content of domestically produced intermediate inputs. Also, the GTAP database does not contain the information needed to distinguish production for domestic consumption from production for export, so the analysis assumes in its methodology that the domestic content of Chinese exports is the same as the domestic content of the same goods produced for domestic consumption, raising the estimates still higher.

Paper by Dean, Fung, and Wang

A January 2007 paper by ITC staff members Judith Dean, K.C. Fung, and Zhi Wang effectively estimates that the domestic value added of Chinese exports to the world in 2002 was roughly 65 percent.[4] The paper actually estimates the *vertical specialization* of China's exports, which is the share of foreign content in those exports. Such estimation is equivalent to estimating the domestic value added because the domestic value added is equal to 100 percent minus the vertical specialization. Using three alternative methods to determine the proportion of imports

[3] Staff of the U.S. International Trade Commission, *Technical Assistance on Domestic Value Added to Exports in China*, produced for the staff of the House Committee on Ways and Means, April 20, 2005.

[4] Judith M. Dean, K.C. Fung, and Zhi Wang, *Measuring the Vertical Specialization in Chinese Trade*, Office of Economics Working Paper No. 2007-01-A, U.S. International Trade Commission, January 2007.

used as intermediate inputs to production, the paper provides estimates of the vertical specialization of Chinese exports to the world that are tightly clustered around 35 percent.[5]

The paper uses the Chinese official 2002 benchmark input-output table, which has 122 sectors, and a trade database purchased from China Customs that contains official Chinese import data at the 8-digit Harmonized System level and distinguishes processing trade from nonprocessing trade.[6] The IO table does not have separate elements for production for export and production for domestic consumption, so the paper does not treat the two separately.[7]

The fact that China has been the location for final assembly of products from all over Asia over the past decade and that, consequently, part of the U.S. trade deficit with China is actually a trade deficit with all of Asia funneled through China is evident from estimates from the study of the percentage of the foreign intermediate inputs in Chinese exports that come from various countries (see Table A-2). Japan, the Four Dragons (Hong Kong, Taiwan, South Korea, and Singapore), and the rest of Southeast Asia supplied 58 percent of the foreign intermediate inputs used in China's exports in both 1996 and 2005. Adding in the additional Pacific Rim countries of Australia and New Zealand raises the total to 63 percent for 1996 and 62 percent for 2005.

STUDIES THAT ACCOUNT FOR SEPARATE PRODUCTION FOR DOMESTIC CONSUMPTION AND FOR EXPORT

Three studies that CBO reviewed modify the IO tables that they use in order to take account of separate production for export and for domestic consumption. Their estimates of the domestic value added of Chinese exports are lower than those of the studies in the previous section—in the range of 35 percent to 55 percent.

Study by Chen, Cheng, Fung, and Lau

A 2001 study by Xikang Chen, Leonard K. Cheng, K. C. Fung, and Lawrence J. Lau finds that the weighted-average domestic value added of total Chinese exports to the world is 54.5 percent

5 The first of the three alternative methods for determining the portion of imports that is used as intermediate inputs to production is a new method that the authors set forth as an improvement over methods used to date. It assumes that all processing imports are used as intermediate inputs to production. To determine the portion of nonprocessing imports that is so used, it applies the United Nations Broad Economic Categories (BEC) classification scheme to those imports. (The BEC classification scheme classifies products as capital goods, intermediate goods, or consumer goods.)

The second and third methods are used as a check on the first. The second method applies the BEC classification scheme to all imports—processing and nonprocessing. The third method assumes that intermediate goods make up the same fraction of imports that they do of domestic production—specifically, that the ratio of imported intermediate goods to total imports is equal to the ratio of total intermediate goods in the Chinese economy to total absorption, where total absorption refers to the sum of capital goods, intermediate goods (including raw materials), and consumer goods.

6 The paper also uses a 1997 benchmark IO table along with the 2002 table to estimate trends in the domestic value added over time. Those trends will be discussed below in a section of this appendix devoted to trends.

7 As will be discussed later, the authors have since developed a method of estimating separate elements for processing exports and are working on new value-added estimates based on those elements.

Table A-2

Shares of Foreign-Sourced Intermediate Inputs in Chinese Exports, by Source Country, as Reported by Dean, Fung, and Wang (Percent)

	1996	2005
Japan	20	16
Four Dragons	32	33
Rest of Southeast Asia	6	9
Australia and New Zealand	5	4
United States	9	7
European Union (15)	8	9
All Other Countries	20	22

Source: Judith M. Dean, K.C. Fung, and Zhi Wang, *Measuring the Vertical Specialization in Chinese Trade*, Office of Economics Working Paper No. 2007-01-A, U.S. International Trade Commission, January 2007, Figure 3.

Notes: Four Dragons = Hong Kong, Taiwan, South Korea, and Singapore; European Union (15) = the 15 member countries of the European Union before 2004, when it expanded to 25 members.

(see Table A-3).[8] The domestic value added varies with the product sector, and the mix of products exported to the United States is slightly different from the mix exported to the world as a whole. Consequently, the domestic value added of total exports to the United States is somewhat lower at 45.8 percent or 48.1 percent, depending on whether the calculation is made using Chinese or U.S. trade data.[9] The value added of processing exports to the world, at 17.6 percent, is much lower than that of nonprocessing exports to the world, at 92.5 percent.

The study uses a 1995 input-output table for the Chinese economy. The table distinguishes 33 production sectors. The calculation treats processing exports separately from nonprocessing exports. The fraction of total imports that is used by Chinese industry as intermediate inputs is

8 Xikang Chen, Leonard Cheng, K.C. Fung, and Lawrence J. Lau, *The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States*, presentation to the Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, June 2001.

9 Chinese exports to the United States as published by the Chinese government are not the same as U.S. imports from China as published by the U.S. government, in part because of differences in how the two countries categorize Chinese exports to Hong Kong that are reexported from Hong Kong to the United States without any processing or other change. The authors adjusted both the Chinese and U.S. data to correct for such problems. However, the two sets of data remained slightly different after adjustment, and therefore the calculated domestic values added were slightly different.

Table A-3

Weighted-Average Domestic Value Added of Chinese Exports in 1995, as Reported by Chen, Cheng, Fung, and Lau (Percent)

Exports	Domestic Value Total
To the world	
Processing	17.6
Nonprocessing	92.5
Total	54.5
To the United States	
Total (Based on adjusted U.S. data)	48.1
Total (Based on adjusted Chinese data)	45.8

Source: Xikang Chen, Leonard Cheng, K.C. Fung, and Lawrence J. Lau, *The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States*, presentation to the Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, June 2001, tables on pages 34–38.

estimated by assuming that the ratio of imported intermediate goods to total imports is equal to the ratio of total intermediate goods in the Chinese economy to total absorption in the Chinese economy.[10]

The study notes that the share of processing exports in total exports trended upward from 49.6 percent in 1995 to 58.6 percent in 1999. Those percentages are sizable and indicate the importance of treating production for export separately from production for sale domestically and the need to treat processing exports explicitly, as is done in the study. The shares also vary substantially across production sectors, with the share in electric machinery and instruments being 84.9 percent, the share in primary metals manufacturing being 58.9 percent, the share in textiles being 36.0 percent, and the share in agriculture being 8.0 percent.

Some production sectors with particularly high domestic value added, according to the study, are agriculture, the various kinds of mining, sectors relating to petroleum and coal, and food manufacturing (see Table A-4). Some production sectors with particularly low domestic value added are electronic and communications equipment, electric machinery and instruments, instruments and meters, transport equipment, and machinery.

[10] That fact is not stated in the draft of the study under discussion here, which consists of slides used by one or more of the authors (probably Lau, since the slides were obtained from his personal Web site) to give a presentation. Rather, it is stated in the January 2007 paper by Judith Dean, K.C. Fung, and Xhi Wang, which was discussed above, as being true of a 2004 version of the study. (Recall from a footnote above that it is the third of the three methods used in the January 2007 paper.) K.C. Fung, a coauthor of both the January 2007 study and the study discussed here, confirmed to CBO staff that neither the methodology nor the results of the study changed significantly between the June 2001 version under discussion here and the 2004 version.

Table A-4

Domestic Value Added of Chinese Exports in 1995, by Production Sector, as Reported by Chen, Cheng, Fung, and Lau (Percent)

Sector Number	Sector Description	Total Domestic Value Added
21	Manufacture of electronic and communication equipment	24.3
20	Manufacture of electric machinery and instruments	25.7
22	Manufacture of instruments and meters, etc.	27.8
19	Manufacture of transport equipment	32.7
18	Manufacture of machinery	33.9
10	Manufacture of paper, cultural and educational articles	41.7
08	Manufacture of wearing apparel, leather and products of leather and fur	44.1
16	Primary metal manufacturing	45.9
27	Commerce	58.0
17	Manufacture of metal products	58.3
24	Industries not elsewhere classified	59.2
09	Sawmills and manufacture of furniture	59.9
14	Chemical industries	61.6
07	Manufacture of textiles	65.7
28	Restaurants	66.7
26	Freight transport and communication	68.5
15	Manufacture of building materials and nonmetallic mineral products	68.5
30	Public utilities and service to households	70.0
32	Finance and insurance	73.8
29	Passenger transport	78.1
06	Food manufacturing	78.4
05	Other mining	82.9
13	Coking, manufacture of gas and coal products	84.2
12	Petroleum refineries	84.6
03	Crude petroleum and natural gas production	86.5
11	Electricity, steam, and hot water production and supply	86.8
02	Coal mining	87.1
04	Metal ore mining	87.4
23	Maintenance and repair of machinery and equipment	88.0
01	Agriculture	90.5
25	Construction	91.2
33	Public administration	92.8
31	Culture, education, health, and scientific research	93.9

Source: Xikang Chen, Leonard Cheng, K.C. Fung, and Lawrence J. Lau, *The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States*, presentation to the Institute of Systems Science, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, June 2001, tables on pages 34–38.

Paper by Lau and Nine Other Authors

A 2006 paper by Lawrence J. Lau and nine other authors concludes that the domestic value added of Chinese exports to the United States in 2002 was 36.8 percent, which is somewhat lower than the estimate for 1995 in the 2001 study by Chen, Cheng, Fung, and Lau discussed

above that it updates. The paper calculates the domestic value added of both Chinese exports to the United States and U.S. exports to China for the purpose of determining the domestic value-added balance, which the authors argue is a better measure of the relative benefits of trade to two countries than the trade balance.[11] To calculate the domestic value added of Chinese exports to the United States, the paper applies the methodology of the 2001 study to more recent data. (All four authors of the June 2001 study are authors of the 2006 paper as well.)

For the Chinese economy, the paper uses a 2002 input-output matrix with 42 production sectors. The 2006 paper modifies the input-output table to distinguish between imported and domestically produced intermediate inputs and to distinguish among production of processing exports, production of nonprocessing exports, and production of goods for domestic use in China. (The authors did so with the assistance of three Chinese governmental entities using raw unpublished data.)

Paper by Koopman, Wang, and Wei

After the publication of the 2007 Dean, Fung, and Wang paper discussed above, its authors and two other analysts developed a method (different from that used in the January 2001 paper by Chen, Cheng, Fung, and Lau) of estimating separate input-output matrices for production of processing exports and production of all other goods. They used that method to revise the analysis in the 2007 paper and produce two companion papers. One of those is a forthcoming revision of the 2007 paper that adds a discussion of how treating production for processing exports separately from other production changes the results. The other is a paper by Robert Koopman, Zhi Wang, and Shang-Jin Wei that was published in working paper form in March 2008. The paper focuses on the methodology and includes a number of estimates of domestic value added (not vertical specialization, as was the case with the 2007 paper).[12]

Treating production of processing exports separately from other production lowers the estimated domestic value added of aggregate exports (see Table A-5). Whereas the 2007 paper by Dean, Fung, and Wang estimated the domestic value added of Chinese exports to the world in 2002 to be roughly 65 percent, the corresponding estimate in the 2008 paper by Koopman, Wang, and Wei is 53.9 percent. The estimate for processing exports is much lower at 25.7 percent, and that for nonprocessing exports is much higher at 89.2 percent. The estimates for exports to the United States are slightly lower at 45.6 percent for total exports, 24.6 percent for processing exports, and 88.8 percent for nonprocessing exports.

[11] Lawrence J. Lau and others, *Estimates of U.S.-China Trade Balances in Terms of Domestic Value-Added*, Working Paper No. 295, Stanford University, October 2006, updated November 2006.

[12] Robert Koopman, Zhi Wang, and Shang-Jin Wei, *How Much of Chinese Exports Is Really Made in China? Assessing Foreign and Domestic Value-Added in Gross Exports*, Office of Economics Working Paper No. 2008-03-B, U.S. International Trade Commission, March 2008.

Table A-5

Weighted-Average Domestic Value Added of Chinese Merchandise Exports in 2002, as Reported by Koopman, Wang, and Wei (Percent)

Exports to	Nonprocessing Exports	Processing Exports	Total Exports
World	89.2	25.7	53.9
United States	88.8	24.6	45.6

Source: Robert Koopman, Zhi Wang, and Shang-Jin Wei, *How Much of Chinese Exports Is Really Made in China? Assessing Foreign and Domestic Value-Added in Gross Exports*, Office of Economics Working Paper No. 2008-03-B, U.S. International Trade Commission, March 2008, Table 7.

A STUDY THAT USES ANOTHER METHODOLOGY

A 2004 analysis by K.C. Fung, Lawrence J. Lau, and Joseph S. Lee estimates the value-added percentage of Chinese exports in two ways.[13] First, the analysts use data from the Chinese government on exports and imports for processing and assembly to calculate the percentage on the basis of the assumption that the value of those exports minus the value of those imports is equal to the value added for processing-and-assembly exports. Their estimates of domestic value added range from 18.8 percent to 35.2 percent depending on the year, with the most recent value being 28.0 percent in 2002 (see Table A-6).

Table A-6

Processing-and-Assembly Exports, Imports, and Domestic Value Added, as Reported by Fung, Lau, and Lee

Year	P&A Exports to World (U.S.$billions)	P&A Imports from World (U.S.$billions)	Implied Value Added as % of Exports
1993	16.0	13.0	18.8
1994	18.2	15.1	17.0
1995	20.7	16.2	21.7
1996	24.2	17.8	26.4
1997	29.4	20.9	28.9
1998	30.7	19.9	35.2
1999	35.8	23.6	34.1
2000	41.1	28.0	31.9
2001	42.2	28.9	31.5
2002	47.5	34.2	28.0

Source: K.C. Fung, Lawrence J. Lau, and Joseph S. Lee, *U.S. Direct Investment in China*, The AEI Press, 2004, pp. 148–149.

Note: P&A = processing and assembly.

[13] K.C. Fung, Lawrence J. Lau, and Joseph S. Lee, *U.S. Direct Investment in China*, The AEI Press, 2004, pp. 143–156.

Second, the authors write:

> Alternatively, we can use assumptions or educated guesses on the extent of value added as a share of the value of Chinese processing and assembly exports to the United States. The available figures are based on reports from some Hong Kong academics and from discussions with some Hong Kong traders. Chinese firms that engage in processing and assembly activities are often paid a processing fee. The processing fees received by the Chinese entities in these arrangements may average 10 percent of the value of the exports (see, for example, Ho 1993 [Yin-Ping Ho, "China's Foreign Trade and the Reform of the Foreign Trade System," in Joseph Cheng Yu-Shek and Maurice Brosseau, eds., *China Review 1993*, Hong Kong, Chinese University Press, 1993, pp. 17.1–17.41]). The fees represent a lower bound on the value added in China on account of processing and assembly activities because they do not include direct costs of Chinese labor as well as returns to the capital and equipment provided by the foreign firms. Some traders in Hong Kong indicated in 1996 that the value added in processed exports was about 20 percent. We use 20 percent as the basis for our alternative estimation.[14]

The authors note that the estimate by the second method is for the mid-1990s and agrees fairly well with the estimate for 1995 by the first method.

The estimates by both methods are for processing-and-assembly exports only, which the authors say were equal to almost 14.6 percent of total Chinese exports. (They do not mention exports related to processing with imported materials.) They say that little is known about the domestic value added of non-processing-and-assembly exports but that anecdotal evidence places it at 40 percent.

HOW DOMESTIC VALUE ADDED HAS CHANGED OVER TIME

Because the most recent input-output table for China's economy is for 2002, studies that use such tables cannot give reliable estimates for more recent years. Trends in the estimates are therefore of interest as indicators of likely values in more recent years. The results of the IO studies concerning trends are mixed. One pair of papers taken together indicates a decline in the domestic value added of Chinese exports from 1995 through 2002. Another indicates a decline from 1997 through 2002, but a paper that revises that analysis to account for separate production for processing exports finds a slight rise over that period. To get around the problem of dated IO tables, another paper does not directly estimate the domestic value added but instead provides indirect evidence that the value added increased over the past decade. The timing of the increase, however, cannot be pinpointed precisely.

[14] K.C. Fung, Lawrence J. Lau, and Joseph S. Lee, *U.S. Direct Investment in China*, pp. 145–146.

The 2006 paper by Lau and nine other authors updates the June 2001 paper by Chen, Cheng, Fung, and Lau and uses the same methodological framework as that study.[15] (All four authors of the June 2001 paper were authors of the 2006 paper as well.) Using Chinese trade data, the June 2001 paper found that the domestic value added of total exports to the United States in 1995 was 45.8 percent. The 2006 update found that the domestic value added in 2002 was 36.8 percent, suggesting a downward trend over time. The June 2001 paper also notes that the share of processing exports in total exports trended upward from 49.6 percent in 1995 to 58.6 percent in 1999. Since processing exports have lower domestic value added than other exports, that upward trend should have provided downward pressure on the domestic value added of total exports.

The 2007 Dean, Fung, and Wang paper discussed above, in addition to estimating the domestic value added in 2002, also estimates the domestic value added in 1997 and assesses a number of trends over time.[16,17] The paper estimates that the domestic value added of China's exports to the world declined from 70.7 percent in 1997 to 64.1 percent in 2002, and that the domestic value added of its exports to the United States declined from 74.6 percent in 1997 to 70.4 percent in 2002.

The input-output data upon which the 2007 paper is based allow changes in the domestic value added of China's exports to be traced at the product level. In 1997, the exports of 17 industries had domestic value added that was less than 75 percent and those of three industries had domestic value added that was less than 50 percent. In 2002, exports of 21 industries had domestic value added that was less than 75 percent, and those of six had domestic value added that was less than 50 percent.

The industries with the lowest domestic value added in 1997 were metal products, steel processing, other electric machinery and equipment, cotton textiles, wearing apparel, and plastic products (see Table A-7). In 2002, the industries whose domestic value added was as low as those included plastic products, steel processing, communications equipment, other general industrial machinery, metal products, electronic computers, petroleum refining, other electric machinery and equipment, electronic appliances, wearing apparel, sawmills and products of wood (and so forth), and electronic elements and devices.

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15 Although the paper says that it updates the earlier paper, it is not entirely clear from the description if the methodology of the newer paper is identical to that of the older paper but with newer data, or merely generally the same but perhaps with unspecified refinements. To whatever extent there were significant refinements in the newer study, comparison of the estimates to assess the trend becomes less valid.

16 As noted earlier, the 2007 Dean, Fung, and Wang paper actually estimates the vertical specialization, which is equivalent to estimating the domestic value added since domestic value added is equal to 100 percent minus the vertical specialization. To simplify the exposition in the present discussion, CBO has converted the vertical-specialization estimates to estimates of domestic value added and presents the latter as estimates of the paper.

17 To produce estimates for 2001 and earlier, the paper uses a 1997 benchmark input-output matrix that has 124 sectors.

Table A-7

Chinese Industries with Lowest Domestic Value Added, as Reported by Dean, Fung, and Wang (Domestic Value Added in Percent)

1997		2002	
Sector	Value Added	Sector	Value Added
Metal products	35	Plastic products	24
Steel processing	41	Steel processing	31
Other electric machinery and equipment	47	Communications equipment	41
Cotton textiles	52	Other general industrial machinery	42
Wearing apparel	55	Metal products	45
Plastic products	61	Electronic computers	48
		Petroleum refining	51
		Other electric machinery and equipment	53
		Electronic appliances	54
		Wearing apparel	58
		Sawmills and products of wood, etc.	59
		Electronic elements and devices	59

Source: Congressional Budget Office based on Judith M. Dean, K.C. Fung, and Zhi Wang, *Measuring the Vertical Specialization in Chinese Trade*, Office of Economics Working Paper No. 2007-01-A, U.S. International Trade Commission, January 2007, Figures 4 and 5.

The product-level data used in the 2007 study also show that the mix of Chinese exports to the United States shifted toward products with lower domestic value added over the period considered (see Table A-8). Products such as games, toys, dolls, stuffed toys, and women's footwear, which might be expected to have relatively high domestic value added, dropped lower on the list of top U.S. imports from 2002 to 2006; and products such as computers and printed circuit assemblies, which might be expected to have relatively low domestic value added, moved up higher on the list. The 2007 paper by Dean, Fung, and Wang calculates the effects of the changing mix of products, and the results indicate that those effects contributed to the decline in the domestic value added of aggregate Chinese exports from 1997 to 2002. Moreover, the changing mix continued to provide downward pressure on the aggregate domestic value added through 2004, followed by a very slight rise in 2005. Without more recent information on the contribution of the production structure (as incorporated in the IO table), however, it is not possible to determine what has actually happened to domestic value added since 2002.

Table A-8

Top U.S. Imports from China in 2002 and 2006

2002	2006
Other computer equipment	Other computer equipment
Audio and video equipment	Audio and video equipment
Games, toys, and children's vehicles	Electronic computers
Institutional furniture	Radio and television broadcasting and wireless communications equipment
Miscellaneous manufactured commodities, NESOI	Games, toys, and children's vehicles
Women's footwear (Except athletic)	Institutional furniture
Other footwear	Printed circuit assemblies (Electronic assemblies)
Dolls and stuffed toys	Women's footwear (Except athletic)
Electric housewares and household fans	Office machinery
Printed circuit assemblies (Electronic assemblies)	Electric housewares and household fans

Source: Congressional Budget Office based on trade data from the U.S. Bureau of the Census.

Notes: Import categories are 6-digit classifications of the North American Industrial Classification System.

NESOI = Not elsewhere specified or included.

Similar to the 2007 Dean, Fung, and Wang paper, the 2008 Koopman, Wang, and Wei paper discussed above also estimates the domestic value added in 1997 in addition to estimating it for 2002 and uses the results to assess trends. The results from the two papers differ. Whereas the 2007 paper found that the domestic value added of China's exports to the world declined slightly from 1997 to 2002, the 2008 paper finds that it rose slightly from 52.3 percent in 1997 to 53.9 percent in 2002.

The paper presents estimates of the domestic value added of exports by industry. In 1997, the exports of 51 industries had domestic value added that was less than 75 percent and those of 27 industries had domestic value added that was less than 50 percent. In 2002, exports of 46 industries had domestic value added that was less than 75 percent, and those of 13 had domestic value added that was less than 50 percent. Those tallies are considerably larger than the corresponding ones in the 2007 Dean, Fung, and Wang paper. Whereas the tallies in that paper increased from 1997 to 2002, however, the numbers here decline, indicating that the domestic value added of a number of individual products increased over the period.

The industries with the lowest domestic value added in 1997 were electronic computers, electronic appliances, cultural and office equipment, other electronic and communication equipment, and sugar refining (see Table A-9). In 2002, those with the lowest domestic value added were similar: electronic computers, telecommunications equipment, cultural and office equipment, other computer peripheral equipment, and electronic elements and devices. Various kinds of electronic products are heavily represented in the tally for 1997—more heavily represented than was the case in the Dean, Fung, and Wang paper—and they became even more heavily represented in 2002.

Table A-9

Chinese Industries with Lowest Domestic Value Added, as Reported by Koopman, Wang, and Wei (Domestic value added in percent)

1997		2002	
Industry	Value Added	Industry	Value Added
Electronic computers	13.6	Electronic computers	4.6
Electronic appliances	15.0	Telecommunications equipment	14.9
Cultural and office equipment	17.3	Cultural and office equipment	19.1
Other electronic and communication equip.	19.6	Other computer peripheral equipment	19.7
Sugar refining	21.0	Electronic elements and devices	22.2
Generators	25.3	Radio, television, and communication equipment and apparatus	35.5
Electronic elements and devices	25.6	Household electric appliances	37.2
Steel processing	25.8	Plastic products	37.4
Household electric appliances	26.6	Generators	39.6
Bicycles	26.9	Instruments, meters, and other measuring equipment	42.2

Source: Congressional Budget Office based on Robert Koopman, Zhi Wang, and Shang-Jin Wei, *How Much of Chinese Exports Is Really Made in China? Assessing Foreign and Domestic Value-Added in Gross Exports*, Office of Economics Working Paper No. 2008-03-B, U.S. International Trade Commission, March 2008, Appendix Tables D and E.

A 2007 paper by Jahangir Aziz and Xiangming Li provides evidence that the domestic value added of Chinese exports might have increased since 2002, although by how much cannot be ascertained from the results in the paper.[18] The paper first presents various crude calculations and other evidence suggesting that the domestic value added might have increased.[19] It then proceeds to an extensive analysis of the elasticity, or sensitivity, of Chinese exports to changes in the real exchange rate of the renminbi relative to the dollar—that is, the exchange rate adjusted for price changes in both China and the United States.[20] Increasing responsiveness to the real exchange rate is consistent with an increase in the domestic value added of China's exports by the same logic that holds that appreciation of the renminbi will have a smaller effect on the prices of China's exports to the United States to the extent that Chinese exports include a high percentage of foreign value added.

Specifically, the study estimates the elasticity of China's exports to changes in the real exchange rate of the renminbi relative to the dollar for rolling eight-year samples beginning in the first

18 Jahangir Aziz and Xiangming Li, *China's Changing Trade Elasticities*, International Monetary Fund, IMF Working Paper WP/07/266, November 2007.

19 For example, the paper argues that in one of the two major programs relating to processing trade (the processing-and-assembly program) firms never pay import taxes or value-added taxes on imports, whereas in the other program (the processing-with-imported-inputs program) the taxes are paid but then repaid when and if the product is exported. It argues further that the domestic value added of exports under the first of those programs could vary arbitrarily over time. It then presents calculations similar to those in the 2004 analysis by Fung, Lau, and Lee discussed above that indicate a likely rise in the domestic value added of processing exports. Such a rise does not necessarily mean that the value added of total exports has risen because no evidence has been presented on the trend in value added in nonprocessing exports and because the share of processing exports in total exports rose over time (at least from 1995 through 1999, according to the analysis by Fung, Lau, and Lee).

20 The elasticity of an export with respect to the real exchange rate is defined as the percentage change in the quantity exported that results from a 1 percent increase in the real exchange rate. Thus, if the real exchange rate increases, one would expect the demand for Chinese exports of that good to decline and therefore for the amount of the good exported by China to decline. An elasticity of -2 means that the quantity of the good exported declines by 2 percent for each 1 percent increase in the real exchange rate.

quarter of 1995 (1995.Q1) and extending through the last quarter of 2006 (2006.Q4). Thus, it estimates the elasticity for the period 1995.Q1 to 2002.Q4, for the period 1995.Q2 to 2003.Q1, and so on through the period 1999.Q1 to 2006.Q4. The paper finds that the aggregate elasticity of all Chinese exports increased in magnitude from roughly -1.4 in the 1995.Q1–2002.Q4 period to roughly -2.2 in the 1999.Q1–2006.Q4 period. The change in the aggregate elasticity could have been caused by changes in the composition of Chinese exports so that individual products that have relatively high elasticities make up a greater share of Chinese exports and products with relatively low elasticities make up a smaller share. Alternatively, the change could have been caused by changes in the elasticities of the individual products exported.

To determine the contributions of the two possible causes, the paper decomposes the change in aggregate elasticity. To determine the contribution of the first cause, the paper breaks Chinese exports into seven product groups and estimates the elasticity of exports of each of those groups over the entire period from 1995.Q1 through 2006.Q4. It then applies those elasticities to the changing shares of the seven groups of Chinese exports over time. The paper finds that the average elasticity calculated in that manner increased in magnitude from slightly less than -1.4 in 1995 to slightly less than -1.8 in 2006.

To determine the contribution of the second cause, the paper calculates elasticities for each of the groups for rolling eight-year periods and applies the estimates to the products' shares in 2000. The paper finds that the average elasticity calculated in that manner increased in magnitude from -1.0 in the 1995.Q1–2002.Q4 period to roughly -2.3 in the 1999.Q1–2006.Q4 period. A likely cause of that increase is an increase in the domestic value added of Chinese exports.

Most of the increase attributable to the second cause occurred between the 1996.Q1–2003.Q4 period, when the elasticity was roughly -1.0, and the 1996.Q4–2004.Q3 period, when the elasticity was roughly -2.0. Because of the substantial overlap of those two periods, the precise timing of the increase cannot be determined.