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Abstract

This paper extends the quantitative measures of vertical specialization proposed by Hummels, Ishii, and Yi (2001) into a framework that includes many countries based on an international input-output model. It not only distributes foreign value added in a country's exports to its original sources, but also further decomposes domestic value added in a country's exports into direct exports and indirect intermediate exports via third countries, thus completely slicing up the value-chain. This extended measure of vertical specialization allows us to estimate each country's net contribution of value-added in East Asian production networks at the industry level, providing systematic quantitative evidence for the nature of East Asian value chains and their growth from 1990 to 2000. Our data include nine major economies in East Asia (Japan, China, Korea, Taiwan, Singapore, Thailand, Malaysia, Indonesia, and the Philippines) plus the United States. Our results show that East Asian developing economies became more deeply integrated into the East Asia production network in the 1990s. This integration is indicated by both a dramatic increase in the developing-country share of value added in final goods supplied by East Asia to the United States, and by an increase in their indirect value added embodied in exports via other Asian countries. We also report interesting heterogeneity in the value chain across sectors. The electronics industry has the most integrated global production network, with value shares becoming more evenly distributed among East Asian economies in the period. In contrast, wearing apparel became more concentrated in Asian developing countries, with a shift in value-added away from industrialized Asian countries and the rest of the world between 1990 and 2000. The automobile industry experienced less change in the period; production still mainly involved Japan and Korea in 2000, with developing Asia just starting to show up in the chain.

JEL Classification Numbers: F1, C67, C82

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I. Introduction

World production has become increasingly fragmented. Global supply chains for many products stretch across many countries, with each country specializing in a particular stage of a good's vertically integrated production sequence. While such production networks exist in Europe and North America (such as between Germany and Hungary/Czechoslovakia and within NAFTA), the ones in East Asia have been more dynamic and have become a more substantial component of the economies in the region. Fragmented trade along vertical integrated production networks has been at the heart of the growth in trade among East Asian countries in recent decades. One can not really explain manufacturing activities and international trade patterns in East Asia without understanding these production networks.

There is a sizable literature demonstrating the growing importance of fragmentation-based specialization for economic growth and structural transformation in East Asian economies. For example, by decomposing East Asian countries' machinery trade statistics at six-digit HS level for 1990, 1996 and 2000 into one-way trade, horizontal and vertical intra-industry trade, Ando (2006) found that the explosive increase in trade of machinery parts and components is largely due to the expansion of back-and-forth transactions in vertically fragmented cross-border production processes, and he showed that international production sharing became an essential part of each East Asian economy in the 1990s. Using parts and components trade as a proxy for fragmentation, Athukorala and Yamashita (2006) found that the dependence on this new form of international specialization is proportionally larger in East Asia than in North America or Europe.

There are three major shortcomings in existing analyses of production networks in East Asia based solely on trade data. First, in the presence of production fragmentation, goods will be counted multiple times in trade data if they cross multiple national borders before being embodied in the final products, so trade statistics can report a multiple of the value of final goods. Therefore, using gross trade statistics to calculate the structure of exports can lead to inaccurate conclusions about the relative importance of specific trading regions and the technological sophistication of a country's exports (Athukorala, 2003). Second, as noted by Hummels, Ishii, and Yi (2001), analyses based on intermediate goods or parts and components trade have to rely on rather arbitrary classifications of goods into final and intermediates. Finally and most importantly, none of these existing trade-statistics-based

analyses is able to capture the source of value-added or quantify the contribution of each country to the total product value created in the production network. These methods thus fail to provide systematic evidence quantifying the nature and growth of value chains in East Asian production networks.

This paper extends quantitative measures of vertical specialization proposed by Hummels, Ishii, and Yi (2001), referred to as HIY in the subsequent discussion, into a framework that includes many countries based on an international input-output model. This extended measure allows us to estimate each country's net contribution to *value-added* in East Asian production networks at the industry level, thus providing systematic quantitative evidence for the nature and growth of value chains in the region. Our estimates show that East Asian developing economies (including China and the ASEAN-4 countries of Indonesia, Malaysia, and the Philippines, and Thailand) became more deeply integrated into regional production networks, as indicated by the dramatic increase of their share of value-added in final goods that East Asia shipped to the United States, although Japan and the newly industrialized NIE-3 (Singapore, Taiwan, and Korea) continued to dominate some networks. At the sector level, the sectors of East Asia exports with the highest foreign content (lowest domestic value-added) in 1990 were dominated by natural resource and labor intensive products such as petroleum, apparel, and leather products. By 2000, although the domestic content for the natural resource based sectors still remained low because of the scarcity of natural resources in these economies, capital- and skill-intensive industries (electronics and shipbuilding) replaced the most labor-intensive industries at the top of the list.

There is a large literature that uses international input-output (IO) tables to estimate the effect of final demand changes on value-added in production. However, it is relatively rare to use an international IO table to evaluate the growth of vertical specialization and to slice up value-added along an international supply chain.

The only related paper that we are aware of is Pula and Peltonen (2009).[2] They estimate the dependence of each country's value-added (GDP) on domestic, intra-East Asia and extra-regional demand based on their updated aggregate Asian input-output table, and

[2] In addition, Koopman, Wang, and Wei (2009) is a companion paper to this current paper focusing on Chinese value chains. Further discussion of Koopman, Wang, and Wei appears in section 3.

conclude there is no support for view that Asian supply chains have decoupled from global networks, although they find that emerging Asia is less "coupled" with the rest of the world than is suggested by gross trade statistics. These authors do not connect their results to HIY's measure of vertical specialization, however, and they do not conduct any analysis at the industry level.

Another related line of work focus on measuring value-added embedded in international trade, which removes double-counting in gross trade and tracks the value-added produced in each country to the final destination where that value-added is consumed (Johnson and Noguera, 2009; Daudin, Rifflart, and Schweisguth, 2008). Using input-output tables and bilateral trade data from the Global Trade Analysis Project (GTAP) database, these authors refine the HIY measure of the domestic content of exports, and examine the difference between gross and value-added trade flows to study patterns of production sharing across countries. They find that gross trade statistics can give misleading impressions of both the location of final demand and patterns of international supply. Unlike the current paper, however, most of their analyses are devoted to aggregate trade patterns and they do not address the issue of how vertical specialization in global production networks should be quantified.

The rest of the paper is organized as follows. In section 2, we start with HIY's measure of vertical specialization, discuss its implicit assumptions and shortcomings when used to estimate value added in a production network with many countries, and then specify our new value-chain measures for global production networks in two-, three-, and many-country cases. In section 3 we describe our major data sources and present our estimates of the total value chain in East Asian production networks in 1990 and 2000, including characteristics and growth trends in value chains by major markets and major industries. Section 4 concludes the paper with a brief discussion of its limitations and directions for future improvements.

II. Value Chain in Global Production Network: Concepts and Measurement

2.1 Concepts

In their seminal paper, HIY (2001) discussed two ways in which a country can participate in vertical specialization: a country can use imported intermediate inputs to produce exports, or it can export intermediate goods that are used as inputs in goods exported by another country. Based on a single country non-competitive type input-output model (implicit in their paper), HIY derived VS as measure of the value of imports embodied in a country's exports, and VS1 as measure of the value of exported goods that are used as imported inputs to produce other countries' exports. A complete picture of vertical specialization or a county's position in a vertical integrated production network involves both measures. However, VS1 is more difficult to measure than VS, because it requires matching bilateral trade flow data to the input-output tables of all destinations to which the country under consideration exports. Further, although HIY developed a precise definition for their VS measure in mathematical terms, they did not do the same for their VS1 measure, because correctly calculating VS1 requires the existence of a third country in the model.[3]

Two key assumptions are needed for the HIY's measure to work. First, the intensity in the use of imported inputs must be the same whether goods are produced for export or for domestic final demand. This assumption is violated when processing exports are pervasive due to policy incentives, as in China and Mexico, and exported goods use much greater share of imported intermediate inputs. When data on processing trade are utilized, one can relax the first assumption. Koopman, Wang, and Wei (2008) provide a methodology to re-compute domestic and foreign value added in such cases.[4]

The second key assumption is that all imported intermediate inputs must contain 100% foreign value added.[5] That is, there can be no indirect domestic content in a country's imports. The second assumption generally does not hold because, by the nature of production fragmentation, any given country's exports could contain imported inputs from many other

[3] Yi (1999) noted that on the import side, vertical specialization is just a subset of intermediate goods—it is those intermediates that are used to make goods for export—while on the export side, vertical specialization can include both final goods and intermediate goods. Hence, HIY's VS1 concept is closely related to, but distinct from, trade in intermediate goods.

[4] This paper has not incorporated information on processing trade, which is the subject of ongoing work. Limitations are addressed in the empirical results in section 3.

[5] This is equivalent to the assumption that the first exporting country's exports have to be 100% domestically sourced when computing VS1 in the HIY framework.

countries, including from itself. For example, computer parts imported by China could very well contain Chinese domestic value if other countries imported Chinese parts, processed them, and subsequently exported them back to China. In fact, a key phenomenon behind fragmentation is that countries increasingly link sequentially to produce final goods. Such a multiple-border-crossing, back-and-forth aspect of trade is what HIY intended to use VS and VS1 to measure. Obviously, a measure which combines VS and VS1 and also captures any domestically sourced content embodied in a country's imported intermediate inputs (such as our VAS matrix described in the next section) will be more consistent with the back-and-forth nature of trade that much of the anecdotal and case study evidence suggests has risen dramatically in recent decades.

Data from a world input-output table permit the relaxation of the second assumption. In our view, an international supply chain can be seen as distribution of value-added share among countries (regions) in a particular global industry. Within the supply chain, each producer purchases inputs and then adds value, which is included in the cost of the next stage of production. The sum of the value added by every stage in the chain equals the value of final goods produced by the network. To precisely define such chains across many countries one needs to quantify the contribution of each country (region) to the total value-added generated in the process of supplying final products. In this regard, a world input-output table provides the best available information, allowing us to completely slice up the value chain across all related countries at the industry average level.[6]

In detail, a world input-output table would contain a number of sub-matrices that have information on (a) transaction flows of intermediate products and final goods within and between each country in the world at the industry level, (b) the direct value-added of each industry in all countries, and (c) the gross output of each industry in all countries. In other words, the world IO table not only provides the origin and destination of all transaction flows by industry, but also specifies every intermediate and/or final use for all such flows. For example, the Asian IO table describes not only the number of electronics produced in China that were shipped to the United States, but also the number that were used as intermediate

[6] There are also product-level approaches to estimating the financial value embedded in a product and quantifying how the value is distributed among participants in the supply chain, moving from design and branding to component manufacturing to assembly to distribution and sales **(**Dedrick, Kraemer, and Linden, 2008).

inputs in each U.S. sector and the number that were used for U.S. private household consumption and capital formation. Similarly, the tables provide the information on the amount of steel used as intermediate inputs in Japan's motor vehicle industry, and also have information on which part of the world this steel comes from. Since this type of IO table matches bilateral trade-flow data to input-output relations and includes more detailed source/destination, supply/use information than a single country IO table, it is more suitable for measuring production fragmentation and vertical specialization.

In the next four sub-sections, we will use an international input-output model to illustrate how value added along a multi-country production chain can be decomposed into the sum of each participating country's net contributions. We will combine the VS and VS1 concepts proposed by HIY(2001) and extend them, in both plain English and mathematical terms, to a framework that includes many countries, thus providing a better and more precise measure of the nature and growth of value chains (vertical specialization) in global production networks. To present the major concepts and show the difference between the HIY measures and the new measures developed in this paper clearly, we start from two- and three-country cases and then extend to a world with many countries.[7]

2.2 Two-country case

Assume a two-country (home and foreign) world, in which each country produces N differentiated tradable products that can be consumed directly or used as intermediate inputs. Let X^r denote the N by 1 gross output vector of country r, Y^r the N by 1 final demand vector including domestic final demand in r and exports of final goods from r, and A_{sr} the N by N input-output coefficient matrix, giving intermediate use in country r of goods produced in s. Then the two-country production and trade system can be written in block matrix notation as follows:

$$\begin{bmatrix} X^1 \\ X^2 \end{bmatrix} = \begin{bmatrix} I - A_{11} & -A_{12} \\ -A_{21} & I - A_{22} \end{bmatrix}^{-1} \begin{bmatrix} Y^1 \\ Y^2 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y^1 \\ Y^2 \end{bmatrix} \quad , \qquad (1)$$

[7] The authors are very grateful for the constructive discussion with Dr. Kei-Mu Yi at the Federal Reserve Bank of Philadelphia in developing the two- and three-country cases and the relationship between our new measures of vertical specialization and the original HIY measures.

where B_{sr} denotes the N by N block Leontief inverse, which is the total requirement matrix that gives the amount of total output in producing country *s* required for a one-unit increase in final demand in country *r*. As final and intermediate goods are distinguished by country of use, we can write

$$\begin{bmatrix} X^1 \\ X^2 \end{bmatrix} = \begin{bmatrix} A_{11}X^1 + Y^{11} + E^{12} \\ A_{22}X^2 + Y^{22} + E^{21} \end{bmatrix}, \tag{2}$$

where $\begin{bmatrix} E^{12} \\ E^{21} \end{bmatrix} = \begin{bmatrix} A_{12}X^2 + Y^{12} \\ A_{21}X^1 + Y^{21} \end{bmatrix} = \begin{bmatrix} A_{12}(x^{21} + x^{22}) + Y^{12} \\ A_{21}(x^{12} + x^{11}) + Y^{21} \end{bmatrix}$

and E^{sr} denotes the N by 1 vector of exports (both intermediate and final goods) from *s* to *r*.

Equation (2) decomposes each country's production and exports. It shows that there are three components in each country's gross exports. For country 1, these consist of the following: (i) final goods consumed in the foreign country (Y^{12}); (ii) intermediate goods used to produce final goods consumed in the foreign country ($A_{12}x^{22}$); and (iii) intermediate goods used by the foreign country to produce final goods shipped back and consumed in the home country ($A_{12}x^{21}$).

It can be shown that in the two-country case, the blocks of the total requirement matrix are equal to the following (see Appendix for the derivation):

$$B_{11} = ((I - A_{11}) - A_{12}(I - A_{22})^{-1}A_{21})^{-1} \tag{3}$$

$$B_{22} = ((I - A_{22}) - A_{21}(I - A_{11})^{-1}A_{12})^{-1} \tag{4}$$

$$B_{12} = (I_1 - A_{11})^{-1}A_{12}B_{22} = B_{11}A_{12}(I - A_{22})^{-1} \tag{5}$$

$$B_{21} = (I_2 - A_{22})^{-1}A_{21}B_{11} = B_{22}A_{21}(I - A_{11})^{-1} \tag{6}$$

Let V_s be the 1 by N direct value-added coefficient vector. Each element of V_s is equal to one minus the intermediate input share from all countries, which is the share of direct domestic value added in total output. Based on the input-output coefficient adding-up condition,

$$V_1 = (u - uA_{11} - uA_{21}) \text{ and } V_2 = (u - uA_{12} - uA_{22}) \tag{7}$$

These equations are sufficient to define our basic measure of vertical specialization in a production network as

$$\text{VAS\_WWP E} = \begin{bmatrix} V_1 B_{11} & V_1 B_{12} \\ V_2 B_{21} & V_2 B_{22} \end{bmatrix} \begin{bmatrix} E^{12} & 0 \\ 0 & E^{21} \end{bmatrix} = \begin{bmatrix} V_1 B_{11} E^{12} & V_1 B_{12} E^{21} \\ V_2 B_{21} E^{12} & V_2 B_{22} E^{21} \end{bmatrix}, \qquad (8)$$

where VAS is a 2 by 2N matrix. Although rather elementary with only two countries, the product of VAS and the export matrix expresses all major concepts of our vertical specialization measures.

Diagonal elements of VAS define the domestic value-added share in a unit of each country's exports. Off-diagonal elements give the shares of foreign value-added embodied in a unit of each country's exports, which correspond to the HIY VS and VS1 measures. It is easy to show that the sum along each of the 2N columns of VAS is unity:

$$V_1 B_{11} + V_2 B_{21} = V_1 B_{12} + V_2 B_{22} = u. \qquad (9)$$

$$\begin{aligned} &V_1 B_{11} + V_2 B_{21} = (I - A_{11} - A_{21}) B_{11} + (I - A_{12} - A_{22})(I - A_{22})^{-1} A_{21} B_{11} \\ &= (I - A_{11} - A_{21})(I - A_{11} - A_{12}(I - A_{22})^{-1} A_{21})^{-1} \\ &+ (A_{21} - A_{12}(I - A_{22})^{-1} A_{21})^{-1})((I - A_{11}) - A_{12}(I - A_{22})^{-1} A_{21})^{-1} \\ &= (A_{21} + I - A_{11} - A_{21} - A_{12}(I - A_{22})^{-1} A_{21})^{-1})((I - A_{11}) - A_{12}(I - A_{22})^{-1} A_{21})^{-1} = u \end{aligned}$$

Therefore, the home country's total gross exports can be decomposed into domestic value-added (DV) and foreign value-added (VS) as follows:

$$\text{DV}^1\text{\_WWP} = V_1 B_{11} E^{12} = V_1((I - A_{11}) - A_{12}(I - A_{22})^{-1} A_{21})^{-1} E^{12} \qquad (10)$$

and

$$\begin{aligned} &\text{VS}^1\text{\_WWP} = V_2 B_{21} E^{12} = (I - A_{12} - A_{22})(I - A_{22})^{-1} A_{21} B_{11} E^{12} \\ &= (I - A_{22})(I - A_{22})^{-1} A_{21} B_{11} E^{12} - A_{12}(I - A_{22})^{-1} A_{21} B_{11} E^{12} \\ &= (A_{21} - A_{12}(I - A_{22})^{-1} A_{21})((I - A_{11}) - A_{12}(I - A_{22})^{-1} A_{21})^{-1} E^{12} \end{aligned} \qquad (11)$$

Using the same notation, VS as defined by HIY (2001, page 80, equation 3) can be expressed as

$$\text{VS\_HIY} = \begin{bmatrix} uA_{21}(I - A_{11})^{-1} \\ uA_{12}(I - A_{22})^{-1} \end{bmatrix} \begin{bmatrix} E^{12} & 0 \\ 0 & E^{21} \end{bmatrix} = \begin{bmatrix} uA_{21}(I - A_{11})^{-1} E^{12} \\ uA_{12}(I - A_{22})^{-1} E^{21} \end{bmatrix} \qquad (12)$$

As shown by KWW (2008), domestic value-added (DV) in a country's exports is the mirror of VS in HIY's single country framework, and can be defined as:

$$\text{DV\_HIY} = \begin{bmatrix} V_1(I-A_{11})^{-1} \\ V_2(I-A_{22})^{-1} \end{bmatrix} \begin{bmatrix} E^{12} & 0 \\ 0 & E^{21} \end{bmatrix} = \begin{bmatrix} V_1(I-A_{11})^{-1}E^{12} \\ V_2(I-A_{22})^{-1}E^{21} \end{bmatrix} \quad (13)$$

Comparing equation (11) to (12) and equation (10) to (13), we can see that the HIY measures accurately capture value added in trade only when A_{12}=0 or A_{21}=0, which means that only one country can export intermediate products that are used in the other country's production process. As we will see throughout this section, whenever two or more countries export intermediate products, the HIY measures diverge from the true measures of value added in exports.

For example, when both countries export intermediate goods, the total domestic value-added in home's exports has to take into account the value-added embodied in intermediate goods that are exported to the foreign country, used to produce final goods abroad, and then shipped back and consumed at home. The term

$$A_{12}(I-A_{22})^{-1}A_{21} \quad (14)$$

in equation (10) is the quantitative measure of such an adjustment for each unit of gross exports from the home country. This term is equal to the HIY measure of VS for the foreign country, $A_{12}(I-A_{22})^{-1}$, which represents the imported content of the foreign country's exports, multiplied by A_{21}, the direct IO coefficient matrix of foreign inputs used in home production. This product equals the amount of home country intermediate input returned from abroad that was used to produce one unit of final goods in the foreign country.

The HIY measure of foreign vertical specialization (VS) is subject to further adjustment when both countries export intermediate goods. In equation (11), as above, an adjustment must be made to domestic intermediate input use to include the domestic content embedded in goods imported from abroad. A second adjustment must be made to imported intermediate use (i.e., matrix A_{21}) because home's imports of its own intermediate goods embodied in the foreign country's exported final goods should not counted as imported foreign content. The adjustment term is exactly the same as term (14).

The second HIY measure of value added in international supply chains is VS1, which measures the value of exports that are used as intermediate inputs to produce other countries' exports. Although HIY never define their VS1 measure mathematically, VS1 can be specified precisely based on our measures of vertical specialization in VAS. In a two-country world, the home country's VS1 measure can be defined as

$$\begin{aligned} &\mathrm{VS1}^1\_\mathrm{WWP} = V_1 B_{12} E^{21} = V_1 B_{11} A_{12} (I - A_{22})^{-1} E^{21} \\ &= V_1 ((I - A_{11}) - A_{12} (I - A_{22})^{-1} A_{21})^{-1} A_{12} (I - A_{22})^{-1} E^{21} \end{aligned} \tag{15}$$

The equation has two parts. First, $A_{12}(I - A_{22})^{-1} E^{21}$ is the home country's intermediate exports embodied in the foreign country's exports, or the foreign country's imported content. Second, $V_1((I - A_{11}) - A_{12}(I - A_{22})^{-1} A_{21})^{-1}$ is the domestic value-added share of the home country's exports (see equation 10), including both intermediate and final goods. Therefore, the product of these two terms equals domestic value-added embodied in the home country's intermediate goods exported to the foreign country and used by the foreign country as inputs to produce its exports. It measures the indirect domestic value-added embodied in the foreign country's exports, which must equal the domestic content of the home country's imports in a two-country world.

2.3 Three-country case:

While the two-country case illustrates the basic concept of our value-chain measures and their relationship to HIY's original measures, additional insights emerge when a third country is added to the framework. Using similar notation as in the previous sub-section, we can specify the production and trade system of the three-country world as follows:

$$\begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} = \begin{bmatrix} I - A_{11} & -A_{12} & -A_{13} \\ -A_{21} & I - A_{22} & -A_{23} \\ -A_{31} & -A_{32} & I - A_{33} \end{bmatrix}^{-1} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} = (I - A)^{-1} Y \tag{16}$$

$$\begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} = \begin{bmatrix} A_{11} X^1 + Y^{11} + E^1 \\ A_{22} X^2 + Y^{22} + E^2 \\ A_{33} X^3 + Y^{33} + E^3 \end{bmatrix} \tag{17}$$

where $\begin{bmatrix} E^1 \\ E^2 \\ E^3 \end{bmatrix} = \begin{bmatrix} E^{12}+E^{13} \\ E^{21}+E^{23} \\ E^{32}+E^{33} \end{bmatrix} = \begin{bmatrix} A_{12}X^2+Y^{12}+A_{13}X^3+Y^{13} \\ A_{21}X^1+Y^{21}+A_{23}X^3+Y^{23} \\ A_{31}X^1+Y^{31}+A_{32}X^2+Y^{32} \end{bmatrix}$

The main difference between equations (16) and (17) and equations (1) and (2) is the added dimension. Each country's exports now need to be divided among two different destinations instead just one destination.

The block inverse matrix becomes

$$\begin{bmatrix} I-A_{11} & -A_{12} & -A_{13} \\ -A_{21} & I-A_{22} & -A_{23} \\ -A_{31} & -A_{32} & I-A_{33} \end{bmatrix}^{-1} = (I-A)^{-1} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \quad (18)$$

Similar to the two-country case, our basic measure of vertical specialization (or value-chain in a production network) in this three-country N-industry world is defined as $\mathrm{VAS} = \begin{bmatrix} V_1B_{11} & V_1B_{12} & V_1B_{13} \\ V_2B_{21} & V_2B_{22} & V_2B_{23} \\ V_3B_{31} & V_3B_{32} & V_3B_{33} \end{bmatrix}$ where V_s is a 1 by N direct value-added coefficient vector of the producing country, B_{sr} is a N by N block inverse matrix, and the resulting V_sB_{sr} is a 1 by N row vector. Therefore VAS is a 3 by 3N matrix. Each of its elements has a similar economic meaning as in the two-country case. Diagonal elements define the domestic value-added share in a unit of each country's exports. Off-diagonal elements along the column provide information on the share of each country's net value-added contribution to the production chain. The sum of these off-diagonal elements along a column is the share of foreign value-added embodied in a unit of the country's exports, which is the share of VS. The sum of off-diagonal elements along a row provides information on the share of a country's value-added exports embodied as intermediate inputs in third countries' exports. This sum is the indirect value-added share in a unit of the country's total exports, or the share of VS1. Detailed specifications of the B_{sr} terms and their derivation are given in the appendix; here we only discuss each element in the first row and column to highlight the additional adjustments that have to be made due to the presence of a third country.

The first diagonal element of the VAS matrix is given by

$$V_1 B_{11} = V_1 \{(I - A_{11}) - A_{12}[(I - A_{22}) - A_{23}(I - A_{33})^{-1} A_{32}]^{-1}[A_{21} + A_{23}(I - A_{33})^{-1} A_{31}] - A_{13}[(I - A_{33}) - A_{32}(I - A_{22})^{-1} A_{23}]^{-1}[A_{31} + A_{32}(I - A_{22})^{-1} A_{21}]\}^{-1} \quad (19)$$

where $V_1 = (u - A_{11} - A_{21} - A_{31})$. Comparing equation (19) with equation (10), there are more adjustments in the three-country case than that in the two-country case, all involving intermediate exports via a third country. More specifically, to measure the domestic value-added share of country 1's total exports, the value-added embodied in its intermediate exports to countries 2 and 3 has to be accounted for. Country 1's (home's) intermediate goods could be used by an importing country (country 2 or country 3) to produce final goods that are exported back to the home country, or further exported instead to a third country (country 3 or country 2), and then used by the third country to produce exports to the home country. Adjustments have to be made to each of these intermediate flows. For example, compared to equation (10), in the three-country case $A_{23}(I - A_{33})^{-1} A_{32}$ represents is an adjustment made to (I-A_{22}), and $A_{23}(I - A_{33})^{-1} A_{31}$ is a similar adjustment made to A_{21}. The interpretation of these adjustments is similar to term (14). The term $A_{23}(I - A_{33})^{-1} A_{32}$ measures the adjustment for country 2's intermediate goods exported to country 3 that are subsequently shipped back to country 2, while $A_{23}(I - A_{33})^{-1} A_{31}$ measures the adjustment for country 2's intermediate goods exports to country 3 that are subsequently shipped to country 1.

The remaining elements in the first column and row of the VAS matrix are given by

$$V_1 B_{12} = V_1 B_{11}[A_{12} + A_{13}(I - A_{33})^{-1} A_{32}][(I - A_{22}) - A_{23}(I - A_{33})^{-1} A_{32}]^{-1} \quad (20)$$

$$V_1 B_{13} = V_1 B_{11}[A_{13} + A_{12}(I - A_{22})^{-1} A_{23}][(I - A_{33}) - A_{32}(I - A_{22})^{-1} A_{23}]^{-1} \quad (21)$$

$$V_2 B_{21} = V_2[(I - A_{22}) - A_{23}(I - A_{33})^{-1} A_{32}]^{-1}[A_{21} + A_{23}(I - A_{33})^{-1} A_{31}] B_{11} \quad (22)$$

$$V_3 B_{31} = V_3[(I - A_{33}) - A_{32}(I - A_{22})^{-1} A_{23}]^{-1}[A_{31} + A_{32}(I - A_{22})^{-1} A_{21}] B_{11} \quad (23)$$

Comparing equations (20) and (21) to equation (15), and equations (22) and (23) to equation (11), the third country adjustment terms such as $A_{13}(I - A_{33})^{-1} A_{32}$ and $A_{23}(I - A_{33})^{-1} A_{32}$ appearing in each of these equations have a similar structure and interpretation as term (14).

Similar to the two-country case, it also easy to show that

$$V_1 B_{11} + V_2 B_{21} + V_3 B_{31} = V_1 B_{12} + V_2 B_{22} + V_3 B_{32} = V_1 B_{13} + V_2 B_{23} + V_3 B_{33} = u \quad (24)$$

Therefore, in the three-country case we can define related measures of vertical specialization in a way similar to that in two-country case. Total domestic value-added embodied in country 1's exports is given by

$$\mathrm{DV}^1\_\mathrm{WWY} = V_1 B_{11} E^1 \tag{25}$$

This includes direct value-added exports to country 2 and 3 as well as indirect value-added exports via country 2 to country 3 and indirect value-added exports via country 3 to country 2. Domestic value-added embodied in the home country's imports from country 2 and country 3 are included as part of this indirect value-added export in our new measure. Foreign value added embodied in the home country's exports is given by

$$\mathrm{VS}^1\_\mathrm{WWY} = V_2 B_{21} E^1 + V_3 B_{31} E^1 \tag{26}$$

Indirect domestic value-added exports via third countries is given by

$$\mathrm{VS1}^1\_\mathrm{WWY} = V_1 B_{12} E^2 + V_1 B_{13} E^3 \tag{27}$$

This measures the value-added embodied in a country's intermediate exports used to produce a third country's exports that are returned to the home country or sent to other destinations.

Multiplying the VAS matrix by a country's exports at different aggregations, such as a country's total exports or its exports to a particular destination, as weights, we can obtain total and indirect domestic value added as well as each country's value added contribution to the production network at different levels. For example, at the most aggregate level

$$VAS\ E = \begin{bmatrix} V_1 B_{11} E^1 & V_1 B_{12} E^2 & V_1 B_{13} E^3 \\ V_2 B_{21} E^1 & V_2 B_{22} E^2 & V_2 B_{23} E^3 \\ V_3 B_{31} E^1 & V_3 B_{32} E^2 & V_3 B_{33} E^3 \end{bmatrix} \tag{28}$$

is a 3 by 3 matrix, which provides a complete picture of how value-added is generated geographically for each country's total exports, where

$$E = \begin{bmatrix} E^1 & 0 & 0 \\ 0 & E^2 & 0 \\ 0 & 0 & E^3 \end{bmatrix} = \begin{bmatrix} E^{12} + E^{13} & 0 & 0 \\ 0 & E^{21} + E^{23} & 0 \\ 0 & 0 & E^{31} + E^{32} \end{bmatrix} \text{ is a 3N by 3 matrix.}$$

We could obtain a similar measure for value added in goods exported from countries 2 and 3 to country 1 by focusing on only bilateral exports. This approach also works when exports are disaggregated by sector, an approach we will use in the empirical section below.

2.4 Many countries

After working through the two- and three-country cases and gaining an understanding of all the relevant concepts and measures of vertical specialization, let us now move from theory to the real world with many countries. Without loss generality**,** assume there are G countries, with N industries in each country. The production in each sector in any country can potentially use intermediate inputs from any sector (including its own) from any country. Assuming a predetermined location of production that defines the structure of the global economy, the deliveries of goods and services between countries are determined by imbalances between supply and demand inside the different countries. A world IO table is a comprehensive account of annual product and payment flows within and between countries. We use the following notation to describe the elements of the world IO table (expressed in annual values): x_i^r = Gross output of industry i in country r; v_i^r = Direct value added by production of industry i in country r; z_{ij}^{sr} = Delivery of good i produced by country s and used as an intermediate by sector j in country r; and y_{ik}^{sr} = Delivery of good i produced in country s for final use in final demand type 'k' in country r. The total number of final demand types, such as private consumption or gross capital formation, is H. Then the following two accounting identities describe the relationship among elements of each row (i, r) and column (j, s) of the international IO table:

$$\sum_{s=1}^{G}\sum_{j=1}^{N} z_{ij}^{sr} + \sum_{s=1}^{G}\sum_{k=1}^{H} y_{ik}^{sr} = x_i^r \tag{29}$$

$$\sum_{r=1}^{G}\sum_{i=1}^{N} z_{ij}^{rs} + v_j^s = x_j^s \tag{30}$$

The two equations have straightforward economic meanings. A typical row in Equation (29) states that total gross output of commodity i in country r is equal to the sum of all deliveries to intermediate and final users in all countries (including itself) in the world. Equation (30) defines the value of gross output for commodity j in production country s as the sum of the values from all of its (domestic plus imported) intermediate and primary factor inputs. Equations (29) and (30) must hold for all $i, j \in$ N, $k \in$ H and $s, r \in$ G in each year.

Define $a_{ij}^{rr} = {}^{z_{ij}^{rr}}\!/_{x_j^{rr}}$ as the direct input coefficients of domestic products of country *r*, $a_{ij}^{sr} = {}^{z_{ij}^{sr}}\!/_{x_j^{rr}}$ $s \neq r$ as intermediate input/output coefficients of good *i* produced in source country *s* for use in sector *j* by destination country *r*; and $av_j^s = {}^{v_j^s}\!/_{x_j^s}$ as each sector *j*'s ratio of direct value added to gross output for each producing country *s*. Using matrix notation, equations (29) and (30) could be re-written as:

$$\begin{bmatrix} X^1 \\ : \\ X^G \end{bmatrix} = \begin{bmatrix} I - A_{11} & \cdots & -A_{1G} \\ : & I - A_{ss} & : \\ -A_{G1} & \cdots & I - A_{GG} \end{bmatrix}^{-1} \begin{bmatrix} Y^1 \\ : \\ Y^G \end{bmatrix} = (I - A)^{-1} Y \tag{31}$$

where A is a NG by NG square matrix with G^2 number of N by N block submatrices. It shows inter-industry input/output coefficients not only within each country, but also across all of the countries. There is no qualitative difference between equation (31) and equation (16). The only difference is their dimensions. Therefore, all the concepts and measures constructed in the previous sub-section could be straightly extended to current section. Although the analytical solution for the block matrix inverse is too complicated when the number of countries exceed three, we can define each element in the block inverse matrix B as $B_{sr} = [b_{ji}^{sr}]$ where the superscripts *s* and *r* denote source and destination country respectively, and subscripts *i* and *j* denote the use and supply industry respectively. Let us further define $V_s = \begin{bmatrix} av_1^s & \cdots & av_j^s & \cdots & av_n^s \end{bmatrix}$ as a 1 by GN vector of direct value-added. Then we can define our basic measure of value added in a global production network as a G by GN matrix

$$\text{VAS} = \begin{bmatrix} V_1 B_{11} & .... & V_1 B_{1G} \\ : & V_s B_{ss} & : \\ V_G B_{G1} & .... & V_G B_{GG} \end{bmatrix} = [vas_i^{sr}] = \left[\sum_{j=1}^{N} av_j^s b_{ji}^{sr} \right] \tag{32}$$

Each of its elements is the column sum of the product between a value-added coefficient and a total requirement coefficient, where industry *i* in destination country *r* represents the using industry, and industry *j* in source country *s* represent the supply industry. The direct value-added coefficient is from the producing industry *j* used in source country *s*. Intuitively, this is the same as pre-multiplying the Leontief inverse by the direct value-added ratio and summing over the columns (industries) for each bilateral transaction in every country and

industry, so we obtain the value-added generated directly and indirectly in one unit of final product for each industry in each country. The value-share contributed from all countries for a particular industry equals unity.

Similar to the three-country case, we can define the domestic value-added share in the corresponding source country's total exports as:

$$\text{Share of } DV^s = \frac{V_s B_{ss} E^s}{uE^s} = \frac{vas_i^{ss} e_i^s}{\sum_{i=1}^{N} e_i^s} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} av_j^s b_{ji}^{ss} e_i^s}{\sum_{i=1}^{N} e_i^s} \tag{33}$$

which are the diagonal elements of the VAS matrix weighted by the structure of the source country's exports. Please note $e_i^s = \sum_{s\neq r}^{G} e_i^{sr}$.

The diagonal elements of the VAS matrix capture domestically produced intermediate inputs in gross output of country *r* at the second, third, fourth, and subsequent stages before they become embodied in final goods delivered to other countries. Diagonal elements also capture the domestic value added embodied in intermediate exports to a third country used to produce subsequent exports of final goods. As before, the domestic value-added share based on HIY (i.e., one minus HIY's VS share) will underestimate domestic value added by neglecting both domestic value-added embodied in home's imports and indirect exports via indirect intermediate exports to third countries.

The foreign value-added share in the source country's total exports becomes

$$\text{Share of } VS^s = \frac{\sum_{s\neq r}^{G} V_s B_{sr} E^s}{uE^s} = \frac{\sum_{s\neq r}^{G} vas^{sr} e_i^{sr}}{\sum_{s\neq r}^{G}\sum_{i=1}^{N} e_i^{sr}} = \frac{\sum_{s\neq r}^{G}\sum_{i=1}^{N}\sum_{j=1}^{N} av_j^s b_{ji}^{sr} e_i^{sr}}{\sum_{s\neq r}^{G}\sum_{i=1}^{N} e_i^{sr}} \tag{34}$$

which is the sum of the off-diagonal elements of the source country column in the VAS matrix weighted by the source country's export structure. The off-diagonal elements in a column (for all r≠s, holding the destination country r constant) in the VAS matrix capture imported intermediate input from source country *s* in output of destination country *r* at the second and subsequent stages before it becomes embodied in final goods imported by destination country *r*. Therefore, the sum over source country s is similar to the VS measure proposed by HIY without the assumption that imported intermediates are 100% foreign

sourced. This revised VS measure also decomposes the foreign value-added embodied in direct exports of country *s* to destination country *r* into each of its original source countries.

The indirect value-added share of total exports from source country *s* due to intermediate exports that are exported as final goods by third countries (VS1) becomes

$$\text{Share of } VS1^s = \frac{\sum_{r\neq s}^{G} V_s B_{sr} E^r}{uE^s} = \frac{\sum_{r\neq s}^{G} vas^{sr} e_i^{sr}}{\sum_{r\neq s}^{G}\sum_{i=1}^{N} e_i^{sr}} = \frac{\sum_{r\neq s}^{G}\sum_{i=1}^{N}\sum_{j=1}^{N} av_j^s b_{ji}^{sr} e_i^{sr}}{\sum_{s\neq r}^{G}\sum_{j=1}^{N} e_i^{sr}} \quad , \tag{35}$$

which is the sum of the off-diagonal elements of the source country row in the VAS matrix weighted by the export structure of each country (excluding the source). Just as our modified VS measure provides a way to further decompose VS into all source countries, our modified VS1 measure provides a way to further decompose each country's value-added trade into direct and indirect value-added exports to the final destination.

These measures could also be defined at disaggregate level, for each source or destination country and for each industry. For example, for a particular industry

$$\text{Share of } DV_i^s = \frac{vas_i^{ss}}{e_i^s} = \frac{\sum_{j=1}^{N} av_j^s b_{ji}^{ss} e_i^s}{e_i^s} \tag{36}$$

$$\text{Share of } VS_i^s = \frac{\sum_{s\neq r}^{G} vas_i^{sr}}{\sum_{s\neq r}^{G} e_i^{sr}} = \frac{\sum_{s\neq r}^{G}\sum_{j=1}^{N} av_j^s b_{ji}^{sr} e_i^{sr}}{\sum_{s\neq r}^{G} e_i^{sr}} \tag{37}$$

At a disaggregate level, however, VS1 may not be expressible as a share of a country's exports at that detailed level, since the country may not have direct exports of the particular sector or direct exports to a particular partner country. If a sector had zero direct exports but positive indirect value-added exports via third countries, the share of VS1 in exports would be infinite.

Obviously, our basic value chain measure, VAS, is an extension of HIY's vertical specialization measures (VS and VS1) to G countries. It includes both domestic value-added shares (along the diagonal) and foreign value-added share from and to all other countries, thus combining VS and VS1 in a consistent framework. The detailed distribution of foreign value added in a country's direct and indirect exports to a destination country revealed by

this systematic measure will enable us to quantify each country's position in the production chain. In addition, it relaxes the unrealistic assumptions that imported intermediate inputs have 100% foreign content and that only a single country exports intermediate products, which are necessary for the HIY measures to empirically measure value-added trade.

2.5 Many countries, but only a subset of countries have an input-output table

World IO tables that include all countries are rare because of the tremendous data requirements in their compilation and the differing statistical classifications among countries. Many developing countries do not even have national IO tables. Available tables such the Asian international IO table usually cover only a select set of economies and treat other countries in the rest of the world as exogenous regions. To estimate value chain measures based on such a table, the model specified in the previous section has to be modified.

Dividing the G countries into a set of M endogenous and another set of G-M exogenous countries, the model specified by equations (29) and (30) becomes:

$$\sum_{s=1}^{M}\sum_{j=1}^{N} z_{ij}^{sr} + \sum_{s=1}^{M}\sum_{k=1}^{H} y_{ik}^{sr} + \sum_{s=G-M}^{G} e_{i}^{sr} = x_{i}^{r} \qquad (38)$$

$$\sum_{s=1}^{M}\sum_{i=1}^{N} z_{ij}^{sr} + \sum_{s=G-M}^{G}\sum_{i=1}^{N} m_{ij}^{sr} + v_{j}^{r} = x_{j}^{r} \qquad (39)$$

where e_i^{sr} = exports of product *i* from endogenous country *s* to exogenous country *r* in the rest of the world.; m_{ij}^{sr} = imports of product *i* used in sector 'j' in an endogenous country *r* from an exogenous country *s* in the rest of the world.

This modified international IO model is sometimes referred to as an "Inter-Regional IO model" (IRIO) in the input-output literature. The computation of VAS in such model is similar to equations (31) and (32) with a different dimension of related matrixes. (For instance, the dimensions of matrix A and the Leontief inverse B reduce to NM by NM with M^2 number of N by N blocks).

To estimate the value-added contribution from exogenous countries in the rest of the world (which does not have an input-output table), we need to assume imported intermediate inputs from the G-M exogenous countries are 100% foreign sourced, similar to HIY. Then the contribution of value added share from the G-M exogenous countries in each of the N industry is computed as follows:

$$VSS = M_0(I - A)^{-1} \tag{40}$$

where *VSS* is a G-M by N(G-M) matrix, with each row giving the contribution of value-added share from a corresponding exogenous country to each of the N industries.

$$M_0 = \begin{bmatrix} M_0^{M+1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & M_0^{G} \end{bmatrix}$$

M_o is also a diagonal block matrix of G-M by N(G-M) whose diagonal blocks are 1 by N row vectors $M_o^r = [m_{oj}^r]$, where each element m_{oj}^r is the column sum of the direct import coefficients for the corresponding exogenous country. In other words, $M_0^r = uM^r$ where $M^r = [m^{sr}{}_{ij}]$ is an N by N import coefficient matrix and u is a 1 by N vector of ones. Intuitively, the amount of imports from the rest of the world required directly and indirectly by one unit of final demand (including exports to rest of the world) can be obtained by pre-multiplying the Leontief inverse by the imported intermediate IO coefficient matrix.

The column sums of VAS and VSS always equal one by the adding up condition of the revised IO model, which says that the column sum of domestic input/output coefficients, import input/output coefficients, and the direct value-added ratio for each industry in each endogenous country has to equal unity.

III Characters and Changing Patterns of Value-Chain in East Asia Production Network

3.1 Data Source

Our main data source is the Asian international Input-Output tables (AIO). The AIO is compiled by the Institute of Development Economies (IDE), a public research institute affiliated with the Ministry of Economics, Trade, and Industry of Japan in collaboration with national statistical institutions in eight other Asian economies (China, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand) plus the United States. It provides the origin and destination of all transaction flows within and across these ten economies at the industry level, and includes trade flows with Hong Kong and the rest of the world. It specifies intermediate and/or final use for all such flows. The table is available for 1990 and 2000. The 2000 table separates the EU15 from the rest of the world.

Sixty-four sectors, including 36 non-food-processing manufacturing sectors, are common to the 1990 and 2000 tables after concordance. Final demand in the AIO has four components (i.e., H=4), including private consumption, government consumption, gross domestic fixed capital formation, and change in inventories. Direct value-added in the AIO includes wages and salaries, operating surplus, gross fixed capital formation, and indirect taxes less subsidies.

3.2 East Asia Manufactured Products sold at U.S. Markets

3.2.1 Domestic and foreign contents

To illustrate how the measures developed in the previous section can be used to systematically quantify the nature and growth of a global production network, we computed these measures for manufactured goods exported to the United States from the nine East Asian countries included in the AIO. Table 1a reports results for 1990 and 2000 for aggregate manufacturing exports (not including food).[8] Columns (2) and (3) report the current dollar value of exports from each of the nine East Asian economies in 1990 and 2000, and the share of intermediate exports in the total. In 2000, the median intermediate export share was 52.9% (Malaysia). The four countries with the highest share of intermediate goods exports that year are Korea (63.55), Philippines (61%), Singapore (60%), and Taiwan (62%). It is noteworthy that China's share is the lowest in Asia. Indeed, comparing 2000 with 1990, China stands out as the only country that experienced a decline in the share of intermediate in exports. By this metric, it would appear that China's participation in the global production chain decreased, but it likely indicates that China moved downstream in the production chain and increased the portion of its exports to the U.S. market that are final products. Adding credence to this view, the shares of foreign and East Asian value added in Chinese exports rose in the period, as we examine next.

(**Insert Table 1a here**)

[8] A related paper, Koopman, Wang, and Wei (2009) also reports results from the AIO, focusing in particular on Chinese value-added flows. Table 5 in Koopman, Wang, and Wei reports some of the information contained in table 1a, but does not include the same breakdown of foreign value added, and more importantly, lacks the shares of value added exported through third countries to the United States.

The share of intermediate goods in total exports can be a misleading yardstick to judge international integration. As noted by Koopman, Wang, and Wei (2009), the shares of domestic and foreign content in a country's exports may be more informative statistics; these are reported in Columns (4) through (7) in Table 1a. The foreign content share in column (5) exceeds 40% for Malaysia, the Philippines, Singapore, Taiwan, and Thailand in 2000. This suggests that these economies are heavy users of imported intermediates in the production of their exports. On the other end of the spectrum is Japan, whose foreign content is less than 10% of its exports, indicating that Japan uses relatively few foreign-sourced inputs in its own final goods exports. After Japan, China had the second lowest estimate (23.5%) of foreign content in its exports in 2000. This share underestimates foreign content in Chinese exports, however, because the data do not distinguish between processing and normal exports. As shown by Koopman, Wang, and Wei (2008), the estimated foreign content share rises to about 50% after accounting for the high reliance on imported inputs used in processing exports. The other Asian countries will likely require lower adjustments because they have lower reliance on processing exports.[9]

The share of foreign value added from other East Asian countries in Column (6) is another important indicator of the integration of these countries in the region's value chains. By this measure, East Asia became more integrated between 1990 and 2000: this share increased in eight of the nine countries. Malaysia and Taiwan, which experienced the largest increases in the share of foreign value added in their exports, also had the largest increases in regional value-added shares. For China, the Philippines, and Taiwan, regional value chains seem to have displaced some foreign inputs over the period, as the increase in the regional value-added share exceeded the increased share of all foreign value added.

Column (7) in Table 1a reports the share of U.S. value-added that is re-exported from the region back into the United States. U.S. domestic content was quite significant in the period for imports from the NIE-3 and ASEAN-4 (except Indonesia). In aggregate, the role of the United States as an intermediate inputs supplier in East Asian manufactured goods was almost unchanged during the ten-year period. Among individual Asian countries, only

[9] Japan and Singapore, for example, have low tariff rates on manufactured inputs, so the estimation errors are likely to be small, and the estimated foreign content shares in Table 1a are likely to be accurate.

Malaysia had a large increase in this share; Singapore, the Philippines, and Thailand had moderate decreases.

The last measure of regional integration is reported in column (8). This column presents our extended VS1 measure, which gives the domestic value added exported to the United States indirectly through other East Asian countries. This measure quantifies each East Asian country's engagement in the Asian production network from its exports perspective, rather than its import perspective. The export perspective also shows increasing integration within the region in the 1990–2000 period; overall, the value of domestic value-added exported through other countries in the region rose from 7% of regional exports to 10%. Individual countries show an interesting convergence toward the 10% average value over the period, and China's value decreased to a very low 4.2% in 2000, indicating that it moved further downstream in Asian production chains supplying the U.S. market.

3.2.2 Slicing up the value chain across countries

A major advantage of international I/O tables is that they allow for further decomposition of the foreign content of regional or country-specific exports according to their net value-added contributions. This is done with the help of the formulas in equation (37) for the endogenous countries and equation (40) for the two exogenous regions of Hong Kong and the rest of the world. Koopman, Wang, and Wei (2009) present such an analysis for individual countries.[10] To prevent duplication, we present here only the decomposition of the net value-added contribution of each country in the region's overall exports to the U.S. market. (Figure 1).

In general, the figure shows that developing countries have made gains at the expense of the more advanced economies. Japan remained the most important source of value added in the region's exports to the United States in 2000, although Japan's share of value added declined by 15 percentage points between 1990 and 2000. Taiwan also lost a substantial portion of its share of regional value added in this trade. China dramatically increased its share by 11 percentage points in the period. For the remaining countries, small declines in the

[10] They focus their discussion on China, and note several interesting patterns in the data. For example, the most significant suppliers of intermediate inputs for China's exports to the United States include Hong Kong, Japan, and the United States. The contributions by Japan, Korea, Taiwan, and the United States increased between 1990 and 2000, while Hong Kong's contribution declined considerably.

shares of more advanced economies experienced were balanced by developing country increases. In some developing countries, such as Indonesia and Malaysia, the gains were quite large relative to their rather small initial shares of value added.

(**Insert Figure 1 here**)

3.2.3 Decomposing gross and value-added manufacturing trade flows

In addition to decomposing value added shares, our methodology also breaks out gross and value added flows from these economies to the United States. As noted in Johnson and Noguera (2009), gross trade flows can differ substantially from value added flows in the presence of international supply chains. Table 1b reports the decomposition of East Asian manufacturing trade with the United States in both gross and value-added terms. Columns (2) through (9) report dollar-value flows, and columns (10) through (13) give each country's trade as a share of the relevant regional total.

(Insert Table 1b here)

East Asian imports from the United States in value-added terms are close to the gross trade values (and actually exceed gross imports from Japan, Korea, and Taiwan), indicating that the United States has only moderate foreign value added in its exports to the region. The importance of indirect value-added imports (as a share of the total) from the United States nearly doubled in the period; almost 15% of U.S. value-added exports to East Asia went through third countries in 2000.

In contrast, value-added exports to the United States are substantially smaller than gross exports for most East Asian economies, again indicating that these economies (other than Japan and Indonesia) use substantial amounts of foreign intermediates in the products they send to the United States. The region's share of value added that is exported indirectly to the United States also rose in the decade (to 14% of the total in 2000), although this is almost entirely due to large increases in indirect exports originating in Japan and the NIE-3.

The regional shares in columns (10) through (13) show that most countries have quite similar shares of gross and value-added trade in imports from the United States. Because of its limited use of foreign intermediates, Japan's share of regional value-added exports is higher than its share of gross exports, while the opposite is true for most other countries.

Changes between 1990 and 2000 highlight the relative decline in Japanese exports in both gross and value added terms, the rapid increase in Chinese exports, and the continued importance of Korea and Taiwan.

3.3 East Asian manufacturing exports to the U.S. market by sector

Table 2a reports our value-chain measures for final products made in East Asia sold in the U.S. market, similar to Table 1a but broken down by major manufacturing sectors. Sectors are ranked by their share in regional manufacturing exports to the United States in 2000 as shown in column (10). Electronics, motor vehicles, and machinery were the top three export categories to the U.S. market in both 1990 and 2000, and constituted more than 60% of East Asia's total gross manufacturing exports. However, only the share of electronics increased dramatically (from 32.2% to 40.8% of total exports), while the shares of both motor vehicles and machinery declined. Trends in intermediate exports, foreign content, and other value-added measures for these sectors are discussed in detail in section 3.4.

(Insert Table 2a here)

Figure 2a shows that the five sectors with the highest foreign content shares in 1990 (refined petroleum, non-ferrous metal, thread and yarn, wearing apparel, and leather products) were dominated by natural resource and labor intensive products.[11] By 2000, although the foreign content for those natural resource based sectors remained high because of the scarcity of natural resources in these economies, electronics and ship building replaced the two most labor- intensive industries (apparel and leather products), indicating that either labor costs or domestic sourcing in these sectors increased in the period.

(Insert Figure 2a here)

We can rank industries by the intensity of East Asian integration with their neighbors, based on foreign value-added imports from the other eight Asian countries (revised VS) or by domestic value-added via these countries (revised VS1). (The two measures are equal when we aggregate East Asian economies together.) Using exports to the United States as weights, electronics, ship building and wearing apparel were the most integrated sectors in both 1990

[11] Timber is excluded from this list because it is not available in the 2000 AIO.

and 2000 (Figure 2b). If we rank the industries based the domestic content in exports to the United States, however, the results are quite different in the two time periods (Figure 2c). In 1990, the top five product categories (other made-up textile products, plastic products, pulp and paper, thread and yarn, and leather products) were all are resource-intensive sectors. By 2000, the top sectors (shipbuilding, other transport equipment, thread and yarn, precision machines, and electronics and electronic products) were skill-intensive products, indicating more domestic U.S. content embodied in its imports from East Asia (because high value-added content such as product design often originates in the United States).

(Insert Figures 2b and 2c here)

Table 2b decomposes value-added in East Asian manufacturing exports to the U.S. market into their original contributing sources for major industries. The results demonstrate the substantial expansion of the East Asian production network in many manufacturing industries. Emerging East Asia became more integrated into the value-added production processing as Japan and the NIE-3 sourced more manufacturing inputs from ASEAN-4 and China. As a result, the net value-added contribution from Japan and NIE-3 declined in most sectors and was replaced by China and ASEAN-4. The redistribution among Asian countries presents an interesting contrast to the relatively stable contributions from the United States and the rest of the world between 1990 and 2000, indicating that the vertical production integration of manufacturing products occurred mainly within East Asia.

(**Insert Table 2b here**)

The most dramatic East Asian decline occurred in Japan. In 1990, Japan's value-added share in East Asian exports to the United States was more than 40% in 18 of the 35 industries reported in Table 2b, while it retained such a dominant position in only 9 sectors in 2000. The changing role of NIE-3 in the production chain was similar to the Japanese experience: the net value-added contribution from Korea, Taiwan, and Singapore in East Asian goods exported to the U.S. market exceeded 20% in 21 sectors at 1990, but the number of such sectors declined to 10 by 2000.

In contrast, developing countries (particularly China) experienced a very rapid increase. China's value-added contribution exceeded 40 percent in 1990 in only one sector (woven textiles), and was less than 10% in 23 of these industries. By 2000, China's net

value-added contribution was over 40% in 10 industries, and it had less than 10% net value-added contribution in only 7 industries. Changes in ASEAN-4 countries closely resemble to the Chinese experience. Indonesia, Malaysia, the Philippines, and Thailand together contributed more than 20% of net value added in only 4 industries in 1990, while the number of such industries expanded to 9 in 2000.

Table 2c decomposes bilateral trade flows in manufacturing sectors in both gross and value-added terms between East Asia and the United States. Except for several resource-based sectors such as refined petroleum and pulp and paper, the U.S. trade deficit with East Asia is smaller in value-added terms than that in gross terms. For some skill and capital intensive sectors, such as electronics and electronic products, the difference between the U.S. trade deficit measured in gross terms and in value-added terms increased between 1990 and 2000 (from 23% of the gross deficit to 40%), while for some labor intensive sectors, such as apparel, this gap diminished during the same period (from 25% of the gross deficit to 16%).

(**Insert table 2c here**)

3.4 East Asia manufacturing exports to the U.S. market in selected industries

To better understand the determinants of the aggregate trends and the characteristics of value chains at the industry level, this section will examine more disaggregated results in several selected industries. These industries include the top three sectors in Table 2b (electronics, motor vehicles, and machinery) in addition to the apparel sector. Characteristics of vertical specialization are presented in three tables for each sector. Table a for each sector mirrors the aggregate breakdown in Table 1a, presenting intermediate trade as well as our extended VS and VS1 measures for each industry. Table b for each sector further distributes the foreign content of East Asian exports to the United States into the contributions from each contributing economy. Table c for each sector compares each country's trade with the United States in gross and value-added terms.

The results show interesting heterogeneity across sectors. Although indirect value added exports through third countries rose for all sectors, other indicators of supply chain integration varied. The share of intermediate inputs in exports held steady in some industries and rose in others. The share of foreign content in exports rose in some industries and fell in

others. One consistent factor was that the Chinese contribution increased in all selected sectors, in some cases dramatically. Also, Japan consistently had a higher domestic value-added share in its exports than other countries in these sectors, as it did in aggregate exports, though the extent to which Japan dominated the supply chain varied by sector.

3.4.1 Electronics industry

Supply chains for electronics in the period were characterized by increasing exports of intermediate products, a rise in the share of products indirectly exported through other East Asian countries, and an increase in the value-added contribution from non-Asian economies. Table 3a shows the increased integration of electronics production between East Asia and the United States, as indicated by the dramatic increase of intermediate goods exported from East Asia to the United States in column (4). Most East Asian economies, except China and Indonesia, exported more intermediates than final goods to the U.S. market in 2000. Thus the supply chain overall became more tightly integrated the United States, while the two largest developing economies have moved further downstream in the supply chain. Table 3a also shows that the average direct domestic value-added for each East Asian country fell from 71.9% in 1990 to 59.4% in 2000 (column (4) minus column (8) in the "total" row). This decline was greater than the 5.6 percentage point rise in indirect value-added exports in the period (from 12.0% to 17.6% in column 8). In consequence, foreign value added rose to 23.0% of the total by 2000.

Table 3b further distributes the foreign content of East Asian electronic exports to the United States into each of its contributing economies.[12] Two features are notable from the table. One is China's emergence as a major player in the production network and the relative decline of Japan. China's value-added contribution to regional final electronics products exported to the United States increased from 3.2% in 1990 to 13.5% in 2000, while Japan's share declined from 56.7% to 34.2%. At the same time, all other East Asian countries except Singapore also increased their value-added shares in the production chain, indicating China's rise in the East Asian electronics production chain was not crowding out its East Asian developing neighbors, but may have actually enhanced the competitiveness and efficiency of

[12] Each row represents a breakdown of the supply chain, for a given county's exports to the United States, of all foreign countries that contribute value added to its production. For example, the first row shows that Indonesia contributed only 0.5% of the foreign content in Chinese exports to the United States in 1990.

the production chain as a whole. The other feature is that there is no sign of the "decoupling" of East Asia from the rest of the world in the electronic industry. The role of United States itself and the rest of the world in the production process actually increased in the period. By 2000, they contributed over 20% of the total value-added exports from East Asia to the U.S. market (column (11) plus (13)), and nearly 7% of the final electronics products that the United States imported from East Asia actually originated from U.S. domestic firms (Column (9), table 3a).[13] The high foreign content share reveals that East Asia remains deeply integrated with the United States and the rest of the world in the production process.

Table 3c shows that Japan remained the center of value-added creation in the production chain even as China began its rapid emergence. As with overall exports in Table 1b, Japan was the only country to have a substantially higher share of the region's exports in value-added terms than in gross terms (e.g., 45% via 29.3% in 2000, columns (13) and (14)). Japan supplied higher value-added intermediate inputs to other East Asian economies, thus indirectly exporting more domestic value-added to the U.S. electronics market through its neighboring East Asia economies. As Japan's share slipped in the period, though, China's expanded rapidly. In 1990, China's share of the region's exports to the United States was only 3% in both gross and value-added terms; these shares rose in 10 years to over 11%, catching up with the three newly industrialized economies.

(**Insert tables 3a to 3c here**)

3.4.2 Machinery industry

The value chain for machinery made in East Asia and supplied to the U.S. market is an important part of the Asian production network, but its nature and development pattern are different from the electronics industry. Tables 4a to 4c show three special features of this value chain: slower growth in overall integration, continued Japanese dominance in value-added terms, and the displacement of other East Asian economies by China.

First, Table 4a shows that vertical specialization within East Asia increased very moderately compared to the electronics industry. This slow change is indicated by the very slight rise in the share of intermediate products trade and the very small increase in indirect

[13] The overall foreign content share was 23% in 2000, as noted in Table 3a. Of this 23%, table 3b shows that Hong Kong had a minor role, contributing only 2.6% of value added.

value-added trade through other East Asian countries. The average domestic content of each East Asian economy also slightly increased from 84.9% to 85.7% (Column (5) minus (6)) while the value-added contribution from economies outside Asia also slightly declined.

Second, the role of Japan in the production chain is similar to that in the electronics industry, but Japan's dominant position did not change over the ten-year period. Table 4b shows a slight increase in Japan's share of value added in total regional exports to the United States. Also, similar to electronic industry, Japan was the only country with a share in value-added exports to the United States substantially higher than its share in gross exports; but its share of both gross and value-added exports basically stayed the same in 1990 and 2000 (column (12) and (13) in table 4c).

Finally, as in electronics, China dramatically increased its presence in the regional value chain for machinery. China's net value-added contribution increased from 1.9% to 8.2% (column (2) in table 4b), but in contrast to the electronics industry, China displaced Taiwan's position in the value chain instead of Japan's. As noted above, Japan's net value-added contribution was little changed, while Taiwan's share declined from 17.9% to 6.2% (table 4c).

(Insert tables 4a to 4c here)

3.4.3 Wearing apparel industry

It is well known that the production network for apparel is well developed in East Asia. However, the total value chain measures developed in this paper reveal that the characteristics and development patterns of the apparel value chain are very different than those of the electronic industry in East Asia. The first difference is that a very high share of goods exported to the United States from the region are final goods (column (3) of Table 5a).[14] The second major difference is that the value added for wearing apparel made in East Asia and sold in the U.S. market is increasingly sourced within East Asian economies. The average direct domestic value-added share increased from 64.4% to 72.2% (Column (4) minus (6) in Table 5a), while the contribution from economies outside East Asia declined from 19.9% in 1990 to 13.6% in 2000 (Table 5b). One similarity with electronics is the

[14] The source data for 2000 incorrectly reports the intermediate share as 7,6% for all countries; this will be addressed in a future update.

relatively high share of indirect value-added. The indirect value-added contribution to the value chain remained steady at about 12% (column (8) of table 5a). Variation in this share has increased over time, as direct exports of these goods from most developed Asian economies to the United States had shrunk considerably by 2000.

The other major trend in the apparel industry is the emergence developing economies. The Chinese net value-added contribution increased from 7.2% in 1990 to 26.8% in 2000 (table 5b). Most of this value-added is contributed by direct exports, and China exports a lower than average share indirectly through third countries. The ASEAN-4 contribution increased from 23% to 30.7% in the period. China and ASEAN-4 mainly replaced contributions from Taiwan and Singapore (their value-added shares declined by about two-thirds) and to a lesser extent Japan. Among developed suppliers, only Korea's contribution stayed relatively unchanged at about 15% during the period.

(Insert tables 5a to 5c here)

3.4.4 Motor vehicle industry

Tables 6a to 6c show that the automobile production network is much less developed in East Asia compared to the other selected industries. The network is largely concentrated in Japan and Korea, with more limited involvement by China and Taiwan. The high and steady average domestic content share (about 93% in table 6a) is driven by the high share in Japan, which dominated regional automobile production in the period. Most other countries had much lower domestic content in the period. Table 6b shows that Japan was an important source of foreign value added for production in the other eight East Asian countries. The integration with economies outside East Asia was relatively low compared to other industries, with low value-added contributions from the United States and the rest of the world (1.5% and 5.8% respectively, Table 6b).

There was some development during the 10 year period, however. First, Japan's contribution shrank in nearly all countries (though, as noted above, Japan's domestic value added in its own production remained nearly unchanged). Second, Korea sharply increased its weight in the value chain: its share of value-added had increased from 3.7% in 1990 to 9.5% by 2000. Third, China, and other developing countries started to show up in the value

chain in 2000, with their contribution mainly indirectly through exports of intermediates incorporated into Japanese and Korean automobiles sold in the U.S. market.

(**Insert tables 6a to 6c here**)

V. Conclusion and Direction for Future Work

In this paper, we extended quantitative measures of vertical specialization (VS and VS1) proposed by Hummels, Ishii, and Yi into a consistent framework with many countries based on an international input-output model. The extended measures relaxed the unrealistic assumptions that (a) all imported intermediate inputs contain 100% foreign value added, and (b) only one country exports intermediate inputs. Our new measures can account for back- and forth trade in intermediates across multiple borders, which the HIY measures cannot capture because of the single-country IO model they are based on. Our new measures not only distribute foreign value-added in a country's exports to its original sources, but also further decompose domestic value-added in a country's exports into direct value-added exports and indirect value-added exports via third countries, thus completely slicing up the value-chain. This decomposition further allows us to compare each country's bilateral trade in value-added terms to its gross trade.

Using an Asian international input-output table compiled by Japan's Institute of Development Economies, we applied the extended measures to estimate each East Asian country's net contribution of value-added in East Asian manufacturing production chains that supply the U.S. market. Our results provide systematic quantitative evidence for the nature and growth of East Asian value chains at the industry average level between 1990 and 2000. Our results show that East Asian developing economies (China and ASEAN-4) became more deeply integrated into East Asian production networks. Although Japan and the NIE-3 continued to be the largest contributors to the value chain, developing countries dramatically increased their share of value-added contained in final goods shipped to the U.S. market, and they also increased indirect value-added exports via neighboring countries. We also report interesting heterogeneity of the value chain across sectors. The electronics industry is the most dynamic and well integrated global production network; with the dramatic emergence of China and ASEAN-4, value-added shares become much more evenly distributed among East Asian economies in 2000 than in 1990. In contrast, automobile production still mainly

involved Japan and Korea in 2000, with developing Asia just starting to show up in the value chain. The value chain for wearing apparel became more concentrated in Asian developing countries, with value-added production shifting away from Japan, NIE-3, and the rest of the world during the period.

The total value chain measures developed in this paper and the decomposition of trade flows based on such measures provide useful insights for understanding the nature and growth of value chains in global production networks. The analysis demonstrates that international IO tables can be a valuable tool for completely slicing up the value chain and quantifying the degree of vertical specialization along a global production network. However, there are several limitations that should be mentioned. First, processing trade has not been included in the total value chain measures because of limitations of the AIO. Because processing and ordinary imports may have substantially different intensity of use of imported intermediate inputs, ignoring this difference may result in systematic aggregation bias that underestimates the foreign content share in gross exports. This bias can generate inaccurate estimates of the distribution of value-added along the global production network, particularly for the Chinese contribution. Second, the most recent AIO table available is 2000, and given the rapid changes in East Asian production and trade, especially the dramatic impact of China joining the WTO in 2001, the data in the 2000 AIO table may be too old to describe the current state of Asian production networks. Therefore, results reported in this paper should be seen only as "snapshots" of the East Asian manufacturing production value chain in 1990 and 2000. Finally, the AIO tables include only ten endogenous countries, leaving out the EU and other important markets for final goods, forcing us to maintain the unrealistic HIY assumptions in computing the vertical specialization in trade with the rest of the world. To overcome all these limitations, a time series world IO table, including all major economies in the world and all available processing trade information, has to be developed and incorporated into our measures. This will be the next stage of our research efforts in this area.

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Appendix: Derivation of the block inverse

Two-country case:

By inverse matrix definition we have

$$\begin{bmatrix} I-A_{11} & -A_{12} \\ -A_{21} & I-A_{22} \end{bmatrix}\begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}=\begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}\begin{bmatrix} I-A_{11} & -A_{12} \\ -A_{21} & I-A_{22} \end{bmatrix}\begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix}$$

Then we obtain following four equations (by right multiply)[15]

$$(I-A_{11})B_{11}-A_{12}B_{21}=I \tag{2.1}$$

$$(I-A_{11})B_{12}-A_{12}B_{22}=0 \tag{2.2}$$

$$(I-A_{22})B_{21}-A_{21}B_{11}=0 \tag{2.3}$$

$$(I-A_{22})B_{22}-A_{21}B_{12}=I \tag{2.4}$$

From (2.2) and (2.3)

$$B_{12}=(I-A_{11})^{-1}A_{12}B_{22} \tag{2.5}$$

$$B_{21}=(I-A_{22})^{-1}A_{21}B_{11} \tag{2.6}$$

Substituting into (2.1) and (2.4)

$$B_{11}=(I-A_{11}-A_{12}(I_2-A_{22})^{-1}A_{21})^{-1} \tag{2.7}$$

$$B_{22}=(I-A_{22}-A_{21}(I_1-A_{11})^{-1}A_{12})^{-1} \tag{2.8}$$

Equations (2.7) and (2.8) are exactly equations (4) and (5) in session 2.

By inverse matrix definition, we also could have (by left multiply)

$$B_{11}(I-A_{11})-B_{12}A_{21}=I \tag{2.1a}$$

$$B_{21}(I-A_{11})-B_{22}A_{21}=0 \tag{2.2a}$$

$$B_{12}(I-A_{22})-B_{11}A_{12}=0 \tag{2.3a}$$

$$B_{22}(I-A_{22})-B_{21}A_{12}=I \tag{2.4a}$$

From (2.2a) and (2.3a)

[15] Please note for matrix multiplication AB ≠ BA in general, while the multiplication rule for block matrix is the same as the general matrix.

$$B_{12} = B_{11}A_{12}(I - A_{22})^{-1} \tag{2.5a}$$

$$B_{21} = B_{22}A_{21}(I - A_{11})^{-1} \tag{2.6a}$$

Substituting into (2.1a) and (2.4a) will also give us (2.7) and (2.8), but combine (2.5) and (2.5a), (2.6) and (2.6a) we get additional relationship:

$$B_{12} = (I_1 - A_{11})^{-1}A_{12}B_{22} = B_{11}A_{12}(I - A_{22})^{-1} \tag{2.9}$$

$$B_{21} = (I_2 - A_{22})^{-1}A_{21}B_{11} = B_{22}A_{21}(I - A_{11})^{-1} \tag{2.10}$$

Equations (2.9) and (2.10) are exactly equations (6) and (7) in session 2.

Three-country case:

From the definition of inverse matrix, we have

$$(I - A_{11})B_{11} - A_{12}B_{21} - A_{13}B_{31} = I \tag{3.1}$$

$$-A_{21}B_{11} + (I - A_{22})B_{21} - A_{23}B_{31} = 0 \tag{3.2}$$

$$-A_{31}B_{11} - A_{32}B_{21} + (I - A_{33})B_{31} = 0 \tag{3.3}$$

$$(I - A_{11})B_{12} - A_{12}B_{22} - A_{13}B_{32} = 0 \tag{3.4}$$

$$-A_{21}B_{12} + (I - A_{22})B_{22} - A_{23}B_{32} = I \tag{3.5}$$

$$-A_{31}B_{12} - A_{32}B_{22} + (I - A_{33})B_{32} = 0 \tag{3.6}$$

$$(I - A_{11})B_{13} - A_{12}B_{23} - A_{13}B_{33} = 0 \tag{3.7}$$

$$-A_{21}B_{13} + (I - A_{22})B_{23} - A_{23}B_{33} = 0 \tag{3.8}$$

$$-A_{31}B_{13} - A_{32}B_{23} + (I - A_{33})B_{33} = I \tag{3.9}$$

For all off diagonal block, from (3.2) and (3.3)

$$B_{21} = (I - A_{22})^{-1}(A_{21}B_{11} + A_{23}B_{31}) \tag{3.10}$$

$$B_{31} = (I - A_{33})^{-1}(A_{31}B_{11} + A_{32}B_{21}) \tag{3.11}$$

From (3.4) and (3.6)

$$B_{12} = (I - A_{11})^{-1}(A_{12}B_{22} + A_{13}B_{32}) \tag{3.12}$$

$$B_{32} = (I - A_{33})^{-1}(A_{32}B_{22} + A_{31}B_{12}) \tag{3.13}$$

From (3.7) and (3.8)

$$B_{13} = (I - A_{11})^{-1}(A_{13}B_{33} + A_{12}B_{23}) \tag{3.14}$$

$$B_{23} = (I - A_{22})^{-1}(A_{23}B_{33} + A_{21}B_{13}) \tag{3.15}$$

Compared to the off-diagonal block in the two-country case, an additional term associated with the third country appears, which makes the analytical solution for diagonal block of the inverse much complex.

$$B_{21} = [I - A_{22} - A_{23}(I - A_{33})^{-1}A_{32}]^{-1}[A_{21} + A_{23}(I - A_{33})^{-1}A_{31}]B_{11} \tag{3.16}$$

$$B_{31} = [I - A_{33} - A_{32}(I - A_{22})^{-1}A_{23}]^{-1}[A_{31} + A_{32}(I - A_{22})^{-1}A_{21}]B_{11} \tag{3.17}$$

$$B_{12} = [I - A_{11} - A_{13}(I - A_{33})^{-1}A_{31}]^{-1}[A_{12} + A_{13}(I - A_{33})^{-1}A_{31}]B_{22} \tag{3.18}$$

$$B_{32} = [I - A_{33}) - A_{31}(I - A_{11})^{-1}A_{13}]^{-1}[A_{32} + A_{31}(I - A_{11})^{-1}A_{12}]B_{22} \tag{3.19}$$

$$B_{13} = [I - A_{11} - A_{12}(I - A_{22})^{-1}A_{21}]^{-1}[A_{13} + A_{12}(I - A_{22})^{-1}A_{23}]B_{33} \tag{3.20}$$

$$B_{23} = [I - A_{22} - A_{21}(I - A_{11})^{-1}A_{12}]^{-1}[A_{23} + A_{21}(I - A_{11})^{-1}A_{13}]B_{33} \tag{3.21}$$

Substituting into (3.1), (3.5) and (3.9)

$$\begin{aligned} B_{11} = \{&I - A_{11} - A_{12}[I - A_{22} - A_{23}(I - A_{33})^{-1}A_{32}]^{-1}[A_{21} + A_{23}(I - A_{33})^{-1}A_{31}] \\ &- A_{13}[I - A_{33} - A_{32}(I - A_{22})^{-1}A_{23}]^{-1}[A_{31} + A_{32}(I - A_{22})^{-1}A_{21}]\}^{-1} \end{aligned} \tag{3.22}$$

$$\begin{aligned} B_{22} = \{&I - A_{22} - A_{21}[I - A_{11} - A_{13}(I - A_{33})^{-1}A_{31}]^{-1}[A_{12} + A_{13}(I - A_{33})^{-1}A_{31}] \\ &- A_{23}[I - A_{33}) - A_{31}(I - A_{11})^{-1}A_{13}]^{-1}[A_{32} + A_{31}(I - A_{11})^{-1}A_{12}]\}^{-1} \end{aligned} \tag{3.23}$$

$$\begin{aligned} B_{33} = \{&I - A_{33} - A_{31}[I - A_{11} - A_{12}(I - A_{22})^{-1}A_{21}]^{-1}[A_{13} + A_{12}(I - A_{22})^{-1}A_{23}] \\ &- A_{32}[I - A_{22} - A_{21}(I - A_{11})^{-1}A_{12}]^{-1}[A_{23} + A_{21}(I - A_{11})^{-1}A_{13}]\}^{-1} \end{aligned} \tag{3.24}$$

Similar to the two-country case, we also could have

$$B_{11}(I - A_{11}) - B_{12}A_{21} - B_{13}A_{31} = I \tag{3.1a}$$

$$B_{21}(I - A_{11}) - B_{22}A_{21} - B_{23}A_{31} = 0 \tag{3.2a}$$

$$B_{31}(I - A_{11}) - B_{32}A_{21} - B_{33}A_{31} = 0 \tag{3.3a}$$

$$-B_{11}A_{12} + B_{12}(I - A_{22}) - B_{13}A_{32} = 0 \tag{3.4a}$$

$$-B_{21}A_{12} + B_{22}(I - A_{22}) - B_{23}A_{32} = I \tag{3.5a}$$

$$-B_{31}A_{12} + B_{32}(I - A_{22}) - B_{33}A_{32} = 0 \tag{3.6a}$$

$$-B_{11}A_{13} - B_{12}A_{23} + B_{13}(I - A_{33}) = 0 \tag{3.7a}$$

$$-B_{21}A_{13} - B_{22}A_{23} + B_{23}(I - A_{33}) = 0 \tag{3.8a}$$

$$-B_{31}A_{13} - B_{32}A_{23} + B_{33}(I - A_{33}) = I \tag{3.9a}$$

For all off diagonal block, from (3.2a) and (3.3a)

$$B_{21} = (B_{22}A_{21} + B_{23}A_{31})(I - A_{11})^{-1} \tag{3.10a}$$

$$B_{31} = (B_{32}A_{21} + B_{33}A_{31})(I - A_{11})^{-1} \tag{3.11a}$$

From (3.4a) and (3.6a)

$$B_{12} = (B_{11}A_{12} + B_{13}A_{32})(I - A_{22})^{-1} \tag{3.12a}$$

$$B_{32} = (B_{31}A_{12} + B_{33}A_{32})(I - A_{22})^{-1} \tag{3.13a}$$

From (3.7a) and (3.8a)

$$B_{13} = (B_{11}A_{13} + B_{12}A_{23})(I - A_{33})^{-1} \tag{3.14a}$$

$$B_{23} = (B_{21}A_{13} + B_{22}A_{23})(I - A_{33})^{-1} \tag{3.15a}$$

$$B_{21} = B_{22}[A_{21} + A_{23}(I - A_{33})^{-1}A_{31}][I - A_{11} - A_{13}(I - A_{33})^{-1}A_{31}]^{-1} \tag{3.16a}$$

$$B_{31} = B_{33}[A_{31} + A_{32}(I - A_{22})^{-1}A_{21}][I - A_{11} - A_{12}(I - A_{22})^{-1}A_{21}]^{-1} \tag{3.17a}$$

$$B_{12} = B_{11}[A_{12} + A_{13}(I - A_{33})^{-1}A_{32}][I - A_{22} - A_{23}(I - A_{33})^{-1}A_{32}]^{-1} \tag{3.18a}$$

$$B_{32} = B_{33}[A_{32} + A_{31}(I - A_{11})^{-1}A_{12}][I - A_{22}) - A_{21}(I - A_{11})^{-1}A_{12}]^{-1} \tag{3.19a}$$

$$B_{13} = B_{11}[A_{13} + A_{12}(I - A_{22})^{-1}A_{23}][I - A_{33} - A_{32}(I - A_{22})^{-1}A_{23}]^{-1} \tag{3.20a}$$

$$B_{23} = B_{22}[A_{23} + A_{21}(I - A_{11})^{-1}A_{13}][I - A_{33} - A_{31}(I - A_{11})^{-1}A_{13}]^{-1} \tag{3.21a}$$

Table 1a: Sources of Value-added in East Asia Manufacturing Exports to the United States

Source Country	*Total exports to the US*[a]	*Intermediate share of gross exports*	*Domestic value-added share*	*Foreign value added share*			*Indirect value-added exports via others in East Asia*[b]
				From all countries	*From others in East Asia*	*From U.S.*	
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
1990							
China	6,542	40.8	81.2	18.8	4.1	1.3	6.3
Indonesia	1,424	37.8	76.9	23.1	7.8	2.6	40.5
Japan	81,919	34.8	91.6	8.4	1.4	1.6	7.6
Korea	16,748	32.5	68.3	31.7	11.0	6.6	3.7
Malaysia	4,142	50.5	52.8	47.2	19.5	5.8	23.0
Philippines	1,957	30.5	55.0	45.0	16.7	8.1	7.6
Singapore	8,905	40.4	39.9	60.1	30.4	11.8	4.3
Thailand	3,830	31.0	56.9	43.1	16.2	7.6	7.1
Taiwan	21,691	38.8	63.6	36.4	12.7	6.4	3.9
Total	147,158	36.0	86.0	14.0	0.0	3.8	7.0
2000							
China	60,051	36.7	76.5	23.5	8.9	2.1	4.2
Indonesia	6,154	39.4	75.4	24.6	8.1	2.1	22.0
Japan	120,118	44.5	90.5	9.5	2.5	1.8	10.8
Korea	35,921	53.6	66.2	33.8	12.3	5.9	11.8
Malaysia	20,541	52.9	35.1	64.9	29.6	11.6	9.5
Philippines	9,459	61.2	55.4	44.6	20.7	6.0	10.2
Singapore	15,146	59.9	41.8	58.2	25.9	8.7	15.1
Thailand	11,821	50.0	54.9	45.1	20.8	5.9	11.1
Taiwan	32,061	61.6	54.5	45.5	19.9	6.3	14.8
Total	311,271	47.7	84.5	15.5	0.0	3.7	10.0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note:
a. In Millions of U.S. Dollars
b. As a share of total bilateral exports in column (2)

Table 1b Decomposition of Manufacture Trade Flow between East Asia and the United States by Countries

Source country	Imports from the U.S. (billion $)				Exports to the U.S. (billion $)				Share of regional totals (%)			
	Gross trade	Value-added trade			Gross trade	Value-added trade			Exports		Imports	
		Total	Direct	Indirect		Total	Direct	Indirect	Gross	VA	Gross	VA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1990												
China	4.5	4.43	4.06	0.37	7	6	5	0.41	4.4	4.6	6.8	7
Indonesia	1.33	1.45	1.2	0.24	1.42	1.73	1.13	0.6	1	1.4	2	2.3
Japan	29	27	26	1.39	82	81	74	7	55.7	64.6	43.5	42.4
Korea	10	10	9	0.49	17	12	11	0.66	11.4	9.5	15.7	15.2
Malaysia	3	4	3	0.58	4	3	2	0.76	2.8	2.4	5.1	5.6
Philippines	1.78	1.77	1.61	0.16	1.96	1.25	1.07	0.18	1.3	1	2.7	2.8
Singapore	6	6	5	0.62	9	4	4	0.4	6.1	3.1	8.6	8.9
Thailand	2.48	2.67	2.21	0.46	4	2.43	2.15	0.28	2.6	1.9	3.8	4.2
Taiwan	8	7	7	0.51	22	14	14	0.77	14.7	11.4	11.8	11.7
Total	66	64	59	5	147	126	115	11	100	100	100	100
2000												
China	15	16	13	4	60	50	46	3	19.3	19.3	12.1	13.4
Indonesia	2.22	2.21	1.88	0.33	6.15	6	4.6	1.7	2	2.4	1.8	1.8
Japan	41	38	34	5	120	124	108	17	38.6	48.3	32.7	31.5
Korea	20	18	17	2	36	26	22	4	11.5	10.3	16.2	15
Malaysia	10	10	8	2	21	10	7	2	6.6	3.7	8.1	8.6
Philippines	4	4	3	0.68	9	5	4	0.84	3	2	3	3.1
Singapore	8	9	7	2	15	8	6	2	4.9	3.2	6.8	7.3
Thailand	5	5	4	1.04	12	7	6	1.35	3.8	2.9	4.2	4.4
Taiwan	19	18	16	2	32	21	17	3	10.3	8	15.1	14.8
Total	124	122	103	18	311	257	222	36	100	100	100	100

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Table 2a Foreign vs. Domestic Value-added in East Asia Manufacturing Exports to the United States by Sector, 1990 and 2000

Sector	Year	Total exports to the U.S.	Int. share in gross exports	Domestic value-added share	Foreign value added share		Indirect value-added exports via others in East Asia	East Asia VS1/total DVA (8)/(5)	Share of gross manufac. Exports
					From all countries	From U.S.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Electronics and electronic products	1990	47,933	39.8	71.9	28.1	5.9	12	16.7	32.6
	2000	126,855	57.8	59.4	40.6	6.8	17.6	29.6	40.8
Motor vehicles	1990	30,250	14.6	91.6	8.4	1.3	1.5	1.7	20.6
	2000	47,904	26.4	89.7	10.3	1.5	2.9	3.2	15.4
Machinery	1990	10,686	36.3	84.9	15.1	2.1	4.3	5.1	7.3
	2000	20,958	37.3	85.7	14.3	1.9	4.7	5.5	6.7
Other manufacturing products	1990	7,781	13.7	76.9	23.1	3.1	5.8	7.6	5.3
	2000	13,524	15.4	79.4	20.6	1.8	7.1	8.9	4.3
Other electric machinery and appliance	1990	4,698	50.9	76.9	23.1	3.4	7.6	9.9	3.2
	2000	12,698	44.1	76.9	23.1	2.4	8	10.4	4.1
Wearing apparel	1990	5,923	16.3	64.3	35.7	3.9	11.9	18.6	4
	2000	10,555	7.6	72.2	27.8	2	12.3	17	3.4
Metal products	1990	5,109	75.2	76	24	2.4	7.4	9.7	3.5
	2000	8,949	61.4	77.4	22.6	1.4	7.9	10.2	2.9
Precision machines	1990	4,886	32	84	16	2.9	4.8	5.7	3.3
	2000	8,396	26.8	70.6	29.4	5.7	11.3	16.1	2.7
Leather and leather products	1990	2,246	4.1	65.5	34.5	8.7	7.2	11	1.5
	2000	5,792	5.5	77.4	22.6	2.5	8.1	10.5	1.9
Other transport equipment	1990	1,857	36.5	78.9	21.1	5.3	6.5	8.3	1.3
	2000	5,691	46.2	81.7	18.3	5	4.4	5.4	1.8
Plastic products	1990	2,870	64.3	69.8	30.2	6.8	7.8	11.1	2
	2000	4,509	91.6	75.5	24.5	2.7	9.3	12.3	1.4
Iron and steel	1990	2,900	99.5	78.4	21.6	2.1	3.8	4.8	2
	2000	4,457	96.6	75.3	24.7	1.2	8	10.6	1.4
Heavy Electrical equipment	1990	1,422	60.3	74.6	25.4	4.3	7.8	10.4	1
	2000	3,774	80.8	73.8	26.2	3	10.1	13.7	1.2
Wooden furniture	1990	187	29.4	74.3	25.7	2.6	8.6	11.6	0.1
	2000	3,657	4.2	78.3	21.7	1.7	8.1	10.4	1.2
Basic industrial chemicals	1990	1,631	93.8	70.9	29.1	3.8	5.6	7.9	1.1
	2000	3,438	96.4	73.3	26.7	2.1	6.2	8.5	1.1
Knit textiles	1990	2,248	4.7	71.5	28.5	5.2	8	11.2	1.5
	2000	2,595	72.4	70.1	29.9	3.1	11.4	16.3	0.8
Other made-up textile products	1990	1,525	23.4	69.3	30.7	6.7	7.2	10.4	1
	2000	2,582	33.5	77.1	22.9	2.4	8.5	11	0.8
Non-ferrous metal	1990	1,156	98.7	61.6	38.4	5.8	6.4	10.4	0.8
	2000	2,531	97.4	69.4	30.6	2.2	7.6	10.9	0.8
Other chemical products	1990	377	63.1	77.8	22.2	3.7	5.2	6.6	0.3
	2000	2,377	77.1	76.9	23.1	2.9	7.2	9.3	0.8

Table 2a, cont.

Sector	Year	Total exports to the U.S.	Int. share in gross exports	Domestic value-added share	Foreign value added share		Indirect value-added exports via others in East Asia	East Asia VS1/total DVA (8)/(5)	Share of gross manufac. Exports
					From all countries	From U.S.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1990	397	30	90.6	9.4	1.2	1.6	1.8	0.3
Drugs and medicine	2000	2,357	35	87.8	12.2	1.5	3	3.4	0.8
Other non-metallic mineral products	1990	1,271	45.4	84.3	15.7	1.9	3.6	4.3	0.9
	2000	2,054	47.7	85.5	14.5	1.1	4.4	5.2	0.7
	1990	3,250	14.9	74.2	25.8	5.5	7.8	10.5	2.2
Other rubber products	2000	1,776	88.3	75.3	24.7	2.5	10.4	13.8	0.6
Boilers, Engines and turbines	1990	681	67.4	91.3	8.7	1.6	1.3	1.4	0.5
	2000	1,770	65.2	84.1	15.9	3.6	3.9	4.7	0.6
	1990	1,072	55.5	78.1	21.9	2.6	8.3	10.7	0.7
Tires and tubes	2000	1,769	60.9	78.7	21.3	2.3	7.2	9.2	0.6
Synthetic resins and fiber	1990	591	99	72.3	27.7	5.5	5.5	7.6	0.4
	2000	1,556	98.3	70.6	29.4	3.6	7.9	11.1	0.5
	1990	1,465	85.6	86.8	13.2	2.6	2.6	3	1
Woven textiles	2000	1,498	77.1	73.3	26.7	2.6	9.8	13.4	0.5
	1990	837	74.4	74.9	25.1	3.9	9.5	12.7	0.6
Other wooden products	2000	1,378	88.1	79.6	20.4	1.7	6.3	8	0.4
	1990	557	88.9	74.2	25.8	6.9	4.8	6.4	0.4
Pulp and paper	2000	1,331	86.5	75.9	24.1	4	5.4	7.1	0.4
	1990	112	4.5	70.2	29.8	4.3	13.9	19.7	0.1
Shipbuilding	2000	1,025	15.4	67.8	32.2	4.6	12.4	18.3	0.3
	1990	343	85.2	81.4	18.6	2.9	5	6.1	0.2
Glass and glass products	2000	996	90.3	83.9	16.1	1.7	5.2	6.2	0.3
Refined petroleum and its products	1990	363	55.9	45.1	54.9	0.9	10.7	23.9	0.2
	2000	935	66.3	50.6	49.4	1.1	7	13.8	0.3
Cement and cement products	1990	56	99.6	91.8	8.2	0.6	1.4	1.5	0
	2000	670	98.3	85.2	14.8	1	4.9	5.8	0.2
	1990	316	49.3	84.3	15.7	2.7	3.9	4.6	0.2
Printing and publishing	2000	562	53	78.5	21.5	2.7	6.7	8.5	0.2
	1990	62	95.3	62.3	37.7	7.9	8.6	13.8	0
Thread and yarn	2000	204	82	65	35	5.3	10.2	15.6	0.1
Chemical fertilizers and pesticides	1990	76	89.4	79.8	20.2	3.7	3.1	3.9	0.1
	2000	104	86.9	79.9	20.1	3	4.9	6.2	0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars

Table 2b: Tracing Net Value Added Contribution in Manufacturing Products Made in East Asia Sold at the U.S. Market to their Sources by Sectors, 1009 and 2000, in percent

Sectors	year	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	USA	Hong Kong	Rest of the World
Electronics and electronic products	1990	3.2	0.3	56.7	6.1	3.1	6.8	0.5	5.8	1.4	5.9	1.4	8.7
	2000	13.5	1.5	34.2	8.1	5.3	7.0	0.7	4.6	2.1	6.8	2.6	13.5
Motor vehicles	1990	0.2	0.3	88.2	3.7	0.1	0.3	0.1	0.0	0.1	1.3	0.0	5.5
	2000	1.7	0.4	79.8	9.5	0.2	0.5	0.1	0.1	0.4	1.5	0.1	5.8
Machinery	1990	1.9	0.3	65.5	2.0	0.4	17.9	0.2	0.8	0.2	2.1	0.3	8.4
	2000	8.2	0.7	68.5	4.2	1.2	6.2	0.2	0.7	0.4	1.9	0.3	7.3
Other manufacturing products	1990	5.8	0.9	39.5	10.0	1.2	18.2	0.4	0.7	5.9	3.1	1.4	12.7
	2000	48.2	1.6	21.2	4.7	1.4	6.0	0.1	0.2	3.0	1.8	1.0	10.8
Other electric machinery and appliance	1990	4.5	0.6	46.5	13.0	1.3	9.6	2.3	2.7	3.9	3.4	0.5	11.6
	2000	40.3	1.0	27.4	7.2	1.6	3.8	0.9	0.6	2.1	2.4	1.0	11.8
Wearing apparel	1990	7.2	8.1	7.2	15.3	3.9	18.0	6.7	5.6	4.3	3.9	3.8	16.0
	2000	26.8	10.3	3.9	15.4	2.0	6.0	9.2	1.8	9.2	2.0	1.9	11.6
Metal products	1990	16.1	3.0	32.0	9.2	1.7	14.4	1.6	1.8	3.6	2.4	0.6	13.6
	2000	48.3	2.9	10.9	4.8	0.6	13.9	1.1	0.2	2.5	1.4	0.5	12.8
Precision machines	1990	5.8	0.3	67.6	4.7	0.6	6.9	0.1	1.6	1.2	2.9	1.1	7.2
	2000	10.6	1.2	38.3	4.6	3.0	5.0	12.6	3.2	3.4	5.7	1.6	10.8
Leather and leather products	1990	12.6	4.5	4.7	13.9	0.4	24.5	1.8	0.2	10.1	8.7	2.5	16.1
	2000	60.3	8.6	2.3	5.2	0.2	1.8	0.3	0.2	6.7	2.5	1.3	10.7
Other transport equipment	1990	2.1	0.4	51.3	4.2	0.4	24.8	0.1	2.0	0.4	5.3	0.4	8.9
	2000	23.4	0.5	51.1	4.0	0.3	5.7	0.4	0.3	0.3	5.0	0.3	8.6
Plastic products	1990	1.7	0.5	9.4	1.2	0.3	63.7	0.1	0.4	0.2	6.8	0.5	15.1
	2000	46.9	1.4	16.6	5.7	1.5	10.4	0.7	0.6	1.1	2.7	0.7	11.7
Iron and steel	1990	4.1	1.2	58.8	14.0	0.3	2.6	0.7	0.3	0.0	2.1	0.1	15.6
	2000	20.8	1.8	27.7	17.0	1.0	12.2	0.4	0.2	2.3	1.2	0.2	15.2
Heavy Electrical equipment	1990	3.5	0.4	48.9	4.3	0.6	22.2	0.2	1.7	0.6	4.3	1.0	12.3
	2000	9.4	1.8	38.7	14.4	1.3	14.6	0.2	1.0	2.6	3.0	1.1	12.0
Wooden furniture	1990	0.6	16.2	3.7	0.5	3.9	1.5	9.2	12.3	35.0	2.6	0.5	14.1
	2000	46.9	8.9	3.1	1.8	8.5	9.6	2.2	0.4	5.1	1.7	0.7	11.1
Basic industrial chemicals	1990	12.4	1.2	46.2	2.7	1.4	2.6	0.5	9.2	0.2	3.8	0.3	19.4
	2000	18.0	2.0	48.3	4.4	3.9	1.9	0.2	0.4	0.4	2.1	0.2	18.2
Knit textiles	1990	0.3	0.5	4.9	23.5	3.2	39.0	4.8	0.3	3.0	5.2	1.0	14.4
	2000	14.9	13.6	4.3	5.2	7.7	23.9	0.2	0.5	11.3	3.1	0.9	14.6
Other made-up textile products	1990	3.2	0.6	9.5	48.1	0.6	10.4	2.4	0.1	1.6	6.7	1.1	15.7
	2000	42.7	2.0	6.2	15.6	0.4	14.2	0.9	0.3	3.3	2.4	0.8	11.3
Non-ferrous metal	1990	4.0	1.0	30.9	1.8	0.4	20.1	0.9	0.5	8.4	5.8	1.1	25.1
	2000	38.8	2.3	17.3	3.9	3.5	9.1	0.2	0.7	1.2	2.2	0.7	20.2
Other chemical products	1990	15.6	1.3	42.7	6.0	3.2	11.0	1.6	0.9	0.9	3.7	0.6	12.8
	2000	17.5	1.9	44.8	4.2	7.5	3.4	0.3	3.2	1.1	2.9	0.4	12.7
Drugs and medicine	1990	14.3	0.6	71.0	4.0	0.1	0.3	0.0	1.8	0.1	1.2	0.3	6.3
	2000	26.7	1.0	38.7	2.2	0.5	1.0	0.0	20.5	0.2	1.5	0.2	7.4
Other non-metallic mineral products	1990	19.7	1.3	31.4	6.0	2.5	21.9	1.2	0.1	3.7	1.9	0.5	9.7
	2000	53.4	4.4	18.9	1.3	1.8	2.1	1.6	0.2	6.2	1.1	0.4	8.5

Sectors	year	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	USA	Hong Kong	Rest of the World
Other rubber products	1990	7.2	3.0	3.9	60.0	3.2	2.6	0.2	0.1	1.8	5.5	0.2	12.3
	2000	11.4	10.2	13.6	6.1	24.1	4.3	0.4	0.6	14.9	2.5	0.4	11.4
Boilers, Engines and turbines	1990	0.8	0.3	89.6	1.0	0.1	0.5	0.1	0.1	0.1	1.6	0.1	5.7
	2000	5.0	1.2	66.5	11.8	2.0	0.4	0.4	0.1	0.6	3.6	0.2	8.2
Tires and tubes	1990	0.5	1.6	58.5	13.2	2.1	7.6	0.1	0.2	2.6	2.6	0.1	10.9
	2000	14.0	2.6	48.4	12.0	0.6	4.8	0.2	0.5	2.8	2.3	0.2	11.5
Synthetic resins and fiber	1990	2.1	0.8	56.7	7.6	0.4	6.1	0.1	3.8	0.1	5.5	0.1	16.6
	2000	3.0	3.5	46.8	11.9	1.3	6.0	0.1	0.7	5.0	3.6	0.1	17.8
Woven textiles	1990	75.2	0.7	6.2	3.3	0.5	2.8	0.0	0.1	0.6	2.6	1.9	6.1
	2000	21.8	5.3	14.2	20.9	2.3	10.2	0.9	0.3	7.3	2.6	0.7	13.6
Other wooden products	1990	17.5	9.6	2.9	1.9	5.5	28.1	9.0	0.2	9.8	3.9	0.6	11.0
	2000	50.8	10.4	2.6	1.0	5.1	5.3	4.5	0.2	6.1	1.7	0.5	11.8
Pulp and paper	1990	20.8	0.8	21.8	10.5	1.3	19.8	1.7	1.1	1.2	6.9	0.9	13.2
	2000	23.8	6.8	32.5	12.7	0.5	2.0	0.8	0.3	1.9	4.0	0.5	14.3
Shipbuilding	1990	1.2	0.5	40.4	1.4	0.5	30.7	0.2	9.0	0.3	4.3	0.3	11.4
	2000	2.1	0.4	12.4	53.2	1.0	8.7	0.1	2.1	0.2	4.6	0.7	14.6
Glass and glass products	1990	12.6	1.7	37.0	7.0	0.7	24.4	0.4	0.6	1.8	2.9	0.5	10.3
	2000	33.5	2.3	37.5	2.6	3.2	6.5	1.6	0.3	1.6	1.7	0.3	8.8
Refined petroleum and its products	1990	12.6	24.0	3.7	1.7	6.2	0.1	0.0	7.4	0.0	0.9	0.2	43.1
	2000	17.3	9.3	6.6	9.7	10.9	0.3	0.1	2.3	1.2	1.1	0.2	41.1
Cement and cement products	1990	0.4	0.4	91.8	0.3	0.1	0.1	0.0	0.0	0.1	0.6	0.0	6.1
	2000	56.7	1.5	2.4	6.5	0.3	1.3	0.7	0.1	20.7	1.0	0.5	8.4
Printing and publishing	1990	4.5	0.4	58.4	6.1	0.9	4.6	0.0	12.7	0.5	2.7	0.3	8.9
	2000	33.3	10.9	16.7	6.4	2.0	2.0	0.1	12.4	1.3	2.7	0.7	11.4
Thread and yarn	1990	13.7	2.4	6.8	13.2	2.0	13.6	2.1	3.7	13.3	7.9	0.8	20.5
	2000	7.9	7.8	7.6	19.8	0.8	2.8	6.7	0.3	21.4	5.3	0.5	19.0
Chemical fertilizers and pesticides	1990	4.4	0.6	67.9	1.3	5.4	2.9	0.0	0.2	0.1	3.7	0.2	13.3
	2000	17.8	0.8	54.5	6.6	1.5	0.6	0.3	0.2	2.6	3.0	0.2	11.9

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Table 2c Decomposition of Manufacture Trade Flow between East Asia and the United States, by Sector, 1990 and 2000, in Millions of U.S. Dollars

Sector	Year	Imports from the U.S.			Exports to the U.S.			Trade Balance		Regional share of value-added manufacturing exports
		Gross trade	Value-added		Gross trade	Value-added				
			Total	Indirect		Total	Indirect	Value-added	Gross	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Electronics and electronic products	1990	15,516	15,116	1,555	47,934	40,003	6,030	-24,887	-32,418	31.8
	2000	42,531	45,949	11,542	126,855	96,619	23,625	-50,670	-84,324	37.5
Motor vehicles	1990	1,897	1,658	87	30,249	28,135	495	-26,477	-28,352	22.4
	2000	3,056	2,645	172	47,904	44,271	1,567	-41,626	-44,848	17.2
Machinery	1990	7,139	6,960	312	10,685	9,538	472	-2,578	-3,546	7.6
	2000	14,356	13,523	929	20,958	18,893	1,043	-5,370	-6,602	7.3
Other manufacturing products	1990	1,718	1,670	120	7,781	6,431	462	-4,761	-6,063	5.1
	2000	2,198	2,071	132	13,523	11,675	963	-9,604	-11,325	4.5
Other electric machinery and appliance	1990	1,031	1,008	67	4,699	4,028	296	-3,020	-3,667	3.2
	2000	2,609	2,574	348	12,698	10,836	958	-8,263	-10,090	4.2
Wearing apparel	1990	128	178	64	5,923	4,514	696	-4,337	-5,795	3.6
	2000	219	272	88	10,555	8,917	1,299	-8,645	-10,336	3.5
Metal products	1990	1,225	1,213	88	5,109	4,295	288	-3,083	-3,884	3.4
	2000	1,734	1,749	201	8,949	7,648	672	-5,899	-7,215	3
Precision machines	1990	2,973	2,840	111	4,886	4,360	219	-1,521	-1,913	3.5
	2000	8,743	8,246	475	8,396	6,867	958	1,379	347	2.7
Leather and leather products	1990	332	482	182	2,246	1,640	162	-1,157	-1,914	1.3
	2000	524	689	247	5,792	4,948	471	-4,260	-5,268	1.9
Other transport equipment	1990	7,197	6,521	69	1,857	1,585	111	4,936	5,340	1.3
	2000	11,749	9,499	145	5,691	4,842	256	4,657	6,057	1.9
Plastic products	1990	640	696	107	2,870	2,318	192	-1,622	-2,230	1.8
	2000	1,698	1,773	291	4,508	3,823	417	-2,050	-2,811	1.5
Iron and steel	1990	1,205	1,300	214	2,900	2,385	108	-1,085	-1,695	1.9
	2000	858	918	192	4,457	3,734	343	-2,816	-3,599	1.5
Heavy Electrical equipment	1990	1,508	1,587	181	1,421	1,219	87	368	87	1
	2000	2,130	2,199	358	3,773	3,189	375	-990	-1,643	1.2
Wooden furniture	1990	168	176	20	187	156	16	20	-19	0.1
	2000	349	350	39	3,657	3,163	296	-2,813	-3,308	1.2
Basic industrial chemicals	1990	4,343	4,069	205	1,632	1,249	91	2,820	2,712	1
	2000	5,653	5,240	603	3,439	2,709	222	2,531	2,215	1.1
Knit textiles	1990	130	242	122	2,248	1,789	181	-1,546	-2,117	1.4
	2000	246	321	112	2,595	2,114	296	-1,792	-2,349	0.8
Other made-up textile products	1990	344	406	98	1,525	1,184	103	-778	-1,181	0.9
	2000	435	479	104	2,582	2,211	214	-1,732	-2,147	0.9

	1990	4,001	3,678	238	1,156	808	66	2,870	2,845	0.6
Non-ferrous metal	2000	3,358	2,845	252	2,531	1,913	189	933	826	0.7
	1990	2,300	2,225	105	377	321	16	1,904	1,923	0.3
Other chemical products	2000	4,165	3,991	331	2,377	2,047	124	1,944	1,788	0.8
	1990	744	708	9	397	366	6	342	347	0.3
Drugs and medicine	2000	2,246	1,879	21	2,357	2,142	71	-263	-112	0.8
Other non-metallic mineral products	1990	301	301	20	1,271	1,129	41	-828	-970	0.9
	2000	440	434	33	2,054	1,843	91	-1,409	-1,615	0.7
	1990	190	208	34	3,250	2,696	246	-2,488	-3,061	2.1
Other rubber products	2000	267	275	42	1,776	1,522	183	-1,246	-1,509	0.6
Boilers, Engines and turbines	1990	504	483	19	682	632	9	-149	-178	0.5
	2000	2,691	2,360	60	1,770	1,578	54	782	921	0.6
	1990	134	124	6	1,072	927	89	-803	-939	0.7
Tires and tubes	2000	133	143	30	1,769	1,520	128	-1,377	-1,636	0.6
	1990	1,663	1,705	228	591	457	34	1,247	1,072	0.4
Synthetic resins and fiber	2000	1,695	1,778	382	1,556	1,215	127	564	139	0.5
	1990	265	382	142	1,466	1,221	73	-839	-1,200	1
Woven textiles	2000	235	435	237	1,498	1,246	145	-811	-1,263	0.5
	1990	628	610	30	837	729	64	-119	-209	0.6
Other wooden products	2000	660	647	74	1,378	1,186	84	-539	-718	0.5
	1990	2,606	2,402	75	557	446	24	1,956	2,049	0.4
Pulp and paper	2000	3,573	3,330	250	1,331	1,078	73	2,252	2,242	0.4
	1990	793	776	33	112	94	16	682	681	0.1
Shipbuilding	2000	573	552	46	1,025	823	124	-270	-452	0.3
	1990	312	314	21	342	296	17	18	-31	0.2
Glass and glass products	2000	762	761	62	995	886	52	-125	-233	0.3
Refined petroleum and its products	1990	1,546	1,200	94	363	191	43	1,010	1,184	0.2
	2000	1,972	1,487	222	936	539	66	948	1,037	0.2
Cement and cement products	1990	10	13	4	56	52	1	-39	-46	0
	2000	22	24	4	670	605	33	-581	-648	0.2
	1990	328	316	7	316	280	11	36	12	0.2
Printing and publishing	2000	627	603	18	562	483	34	120	65	0.2
	1990	272	360	111	62	44	5	316	210	0
Thread and yarn	2000	160	225	88	203	153	21	72	-44	0.1
Chemical fertilizers and pesticides	1990	926	855	27	76	63	2	793	850	0
	2000	1,056	917	32	104	87	6	830	952	0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars

Table 3a Foreign vs. Domestic Value-added in East Asia Electronics Exports to the U.S. Market, 1990 and 2000

Source Country	*Total Exports to the U.S*[a].	*Int. share in gross exports*	*Domestic Value-added*	*Foreign value-added*			*Domestic value-added via others in East Asia*
				From all countries	*From others in East Asia*	*From the U.S.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1990							
China	1,424	20.7	75.7	24.3	6.3	1.4	6.3
Indonesia	20	48.6	62	38	15.4	3.4	-
Japan	24,262	36.9	91.4	8.6	1.6	2.2	15.7
Korea	4,776	46.3	60.3	39.7	20.4	8.2	8
Malaysia	2,892	54.3	50.9	49.1	19.4	7.3	16.9
Philippines	553	63.3	49.2	50.8	27.5	12.4	28.9
Singapore	6,603	37.9	37.6	62.4	32.4	13.5	3.6
Thailand	1,348	38.3	38.4	61.6	30	17	8.6
Taiwan	6,057	43.6	51	49	21.8	9.9	6.1
Total	47,933	39.8	83.9	16.1	0	5.9	12
2000							
China	14,606	29.8	63.4	36.6	14.1	3.9	6.9
Indonesia	997	33.1	73.3	26.7	8.3	2.1	44.6
Japan	36,038	56.3	87.7	12.3	4	2.5	28.8
Korea	18,421	67.6	54.9	45.1	18	10.3	17.5
Malaysia	15,829	52.8	30	70	32.1	13.3	7.8
Philippines	4,676	94	33.4	66.6	30.1	13.4	104
Singapore	12,864	63.6	37.3	62.7	29.5	9.7	15.2
Thailand	5,505	58	35.2	64.8	32.5	11.1	13.8
Taiwan	17,918	65.7	46	54	25.8	8	15.3
Total	126,855	57.8	77	23	0	6.8	17.6

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars

Table 3b: Tracing Foreign Value Added in Electronics Made in East Asian Sold at the U.S. Market

Source country	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	United States	Hong Kong	Rest of World	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1990, in percent												
China	-	0.5	19.3	2.2	0.8	2.3	0.1	0.4	0.2	5.9	53.2	15.2	100.0
Indonesia	1.1	-	26.3	3.1	1.0	5.1	0.2	3.0	0.6	8.9	4.6	46.0	100.0
Japan	2.3	3.0	-	4.3	1.7	4.3	0.9	1.1	0.9	25.1	1.3	55.0	100.0
Korea	0.2	0.8	45.1	-	1.4	2.0	0.4	1.0	0.3	20.7	3.3	24.6	100.0
Malaysia	1.1	1.0	23.0	1.9	-	3.2	0.6	7.9	0.8	14.8	2.1	43.6	100.0
Taiwan	0.2	0.6	37.2	2.2	1.7	-	0.6	1.6	0.4	20.2	4.6	30.6	100.0
Philippines	0.3	0.4	41.4	2.2	1.3	2.8	-	5.2	0.4	24.3	6.2	15.3	100.0
Singapore	0.9	0.8	35.7	3.0	5.6	3.3	1.0	-	1.6	21.6	4.3	22.2	100.0
Thailand	0.8	0.4	32.2	2.4	2.1	3.3	0.4	7.0	-	27.6	2.3	21.5	100.0
Total[a]	**3.2**	**0.3**	**56.7**	**6.1**	**3.1**	**6.8**	**0.5**	**5.8**	**1.4**	**5.9**	**1.4**	**8.7**	**100.0**
	2000, in percent												
China	-	0.9	16.2	7.4	2.2	7.8	1.0	2.0	1.2	10.6	16.5	34.3	100.0
Indonesia	3.9	-	14.9	3.9	1.8	2.1	0.2	2.4	1.7	7.9	1.2	59.9	100.0
Japan	5.4	2.7	-	7.4	3.5	8.3	2.1	2.1	1.4	20.7	4.2	42.2	100.0
Korea	4.0	0.9	24.7	-	2.3	4.0	1.2	2.1	0.8	22.9	5.2	32.0	100.0
Malaysia	3.2	1.5	21.4	4.0	-	4.4	1.6	7.2	2.5	19.0	5.2	29.9	100.0
Taiwan	3.2	1.2	28.3	6.5	2.7	-	1.9	2.6	1.3	14.9	4.0	33.3	100.0
Philippines	1.5	0.6	27.9	5.7	1.8	3.1	-	3.4	1.3	20.1	5.7	29.0	100.0
Singapore	4.3	1.4	25.4	3.5	7.3	3.0	0.5	-	1.7	15.4	2.7	35.0	100.0
Thailand	5.7	1.8	24.9	5.0	3.8	3.6	1.1	4.3	-	17.2	3.9	28.9	100.0
Total[a]	**13.5**	**1.5**	**34.2**	**8.1**	**5.3**	**7.0**	**0.7**	**4.6**	**2.1**	**6.8**	**2.6**	**13.5**	**100.0**

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note. a. The total also includes each country's domestic value-added, so it includes all the value-added contributions to final goods made in East Asia and exported to the United States.

Table 3c Decomposition of Electronic Trade Flow between East Asia and the United States by Countries

Source country	Imports from the U.S. (million $)				Exports to the U.S. (million $)				Share of regional totals (%)			
	Gross trade	Value-added trade			Gross trade	Value-added trade			Exports		Imports	
		Total	Direct	Indirect		Total	Direct	Indirect	Gross	VA	Gross	VA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1990												
China	369	366	322	43	1,424	1,196	1,077	119	3	3	2.4	2.4
Indonesia	52	59	45	13	20	159	12	147	0	0.4	0.3	0.4
Japan	6,881	6,358	6,015	343	24,262	26,377	22,170	4,207	50.6	65.9	44.3	42.1
Korea	1,881	1,815	1,644	171	4,776	3,222	2,880	342	10	8.1	12.1	12
Malaysia	1,577	1,637	1,378	259	2,892	1,839	1,471	368	6	4.6	10.2	10.8
Philippines	247	247	215	32	554	372	272	99	1.2	0.9	1.6	1.6
Singapore	1,974	2,080	1,726	355	6,602	2,760	2,483	277	13.8	6.9	12.7	13.8
Thailand	881	919	770	149	1,348	637	518	119	2.8	1.6	5.7	6.1
Taiwan	1,655	1,635	1,446	188	6,057	3,441	3,090	352	12.6	8.6	10.7	10.8
Total	15,516	15,116	13,562	1,555	47,934	40,003	33,973	6,030	100	100	100	100
2000												
China	4,400	5,398	3,559	1,839	14,606	11,104	9,262	1,841	11.5	11.5	10.3	11.7
Indonesia	83	101	67	34	997	1,449	731	718	0.8	1.5	0.2	0.2
Japan	12,451	13,167	10,073	3,094	36,038	43,476	31,607	11,869	28.4	45	29.3	28.7
Korea	8,021	7,517	6,489	1,029	18,421	12,557	10,111	2,446	14.5	13	18.9	16.4
Malaysia	6,243	6,658	5,050	1,608	15,829	6,260	4,750	1,511	12.5	6.5	14.7	14.5
Philippines	2,029	2,050	1,642	408	4,676	2,257	1,561	697	3.7	2.3	4.8	4.5
Singapore	2,899	3,697	2,345	1,351	12,864	6,491	4,794	1,697	10.1	6.7	6.8	8
Thailand	2,099	2,282	1,698	584	5,505	2,709	1,937	772	4.3	2.8	4.9	5
Taiwan	4,307	5,079	3,485	1,594	17,918	10,316	8,241	2,075	14.1	10.7	10.1	11.1
Total	42,531	45,949	34,407	11,542	126,855	96,619	72,994	23,625	100	100	100	100

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Table-4a Foreign vs. Domestic Value-added in East Asia Machinery Exports to the U.S. Market, 1990 and 2000

Source Country	*Total Exports to the U.S.* [a]	*Int. share in gross exports*	*Domestic Value-added*	*Foreign value-added*			*Domestic value-added via others in East Asia*
				From all countries	*From others in East Asia*	*From the U.S.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1990							
China	342	60.8	89.1	10.9	2.7	1.2	8.9
Indonesia	1	0	39.6	60.4	6.8	0.9	-
Japan	7187	36.1	92.7	7.3	1.2	1.1	4.3
Korea	272	43.1	73.5	26.5	9.8	4.7	13
Malaysia	83	68.9	67.8	32.2	13.1	2.9	47.1
Philippines	17	39.7	68	32	12.9	6.2	50.8
Singapore	285	68.1	49.5	50.5	23.9	10.7	7.1
Thailand	56	76.6	60.6	39.4	16.4	2.3	49.1
Taiwan	2441	26.8	67.6	32.4	10.8	4.1	0.5
Total	10686	36.3	89.2	11.8	0	2.1	4.3
2000							
China	2328	48.2	82.1	17.9	6.5	1.3	7.6
Indonesia	182	35.6	42.6	57.4	23.9	7.9	39.9
Japan	14330	34	92.2	7.8	1.8	1.2	3.1
Korea	1321	49.7	74	26	8.4	3.5	9.7
Malaysia	402	45.7	60.1	39.9	16.9	4.9	13.1
Philippines	51	29.9	55.2	44.8	19.4	2.4	26.7
Singapore	202	28.6	51.4	48.6	22.5	9	12.9
Thailand	130	62.4	57.3	42.7	20.5	3.2	44
Taiwan	2012	37.9	60.9	39.1	16.4	5.1	4
Total	20958	37.3	90.5	9.5	0	1.9	4.7

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars

Table 4b: Tracing Foreign Value Added in Machinery Made in East Asian Sold at the U.S. Market

Source country	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	United States	Hong Kong	Rest of World	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1990, in percent												
China	-	1.4	17.1	1.0	1.6	2.2	0.2	0.5	0.6	10.6	24.4	40.4	100.0
Indonesia	0.2	-	10.0	0.3	0.1	0.2	0.0	0.3	0.1	1.5	0.1	87.0	100.0
Japan	2.9	4.0	-	2.8	1.4	2.1	0.8	0.7	1.3	15.1	0.7	68.4	100.0
Korea	0.2	1.4	32.4	-	1.2	1.1	0.2	0.4	0.3	17.7	0.5	44.8	100.0
Malaysia	2.4	1.2	25.8	2.4	-	3.1	0.3	4.7	0.9	9.1	1.3	48.9	100.0
Taiwan	0.2	1.2	28.1	1.6	0.9	-	0.4	0.6	0.3	12.5	2.2	51.9	100.0
Philippines	0.4	0.5	24.5	4.9	1.4	5.7	-	2.5	0.3	19.3	2.5	38.0	100.0
Singapore	1.9	1.1	36.4	1.9	3.1	2.1	0.2	-	0.7	21.1	0.7	30.9	100.0
Thailand	2.7	0.5	30.7	1.7	1.3	3.2	0.2	1.4	-	5.9	1.0	51.3	100.0
Total[a]	1.9	0.3	65.5	2.0	0.4	17.9	0.2	0.8	0.2	2.1	0.3	8.4	100.0
	2000, in percent												
China	-	1.4	18.4	6.4	1.0	7.1	0.3	0.7	0.8	7.2	4.8	51.9	100.0
Indonesia	3.3	-	27.3	2.8	2.1	3.8	0.3	1.3	0.7	13.7	0.8	43.7	100.0
Japan	7.0	3.9	-	3.9	1.9	3.2	0.7	0.8	1.6	15.7	1.8	59.5	100.0
Korea	4.3	1.9	23.2	-	0.9	1.1	0.2	0.6	0.4	13.5	1.5	52.4	100.0
Malaysia	3.4	2.2	22.9	3.5	-	3.8	0.4	4.5	1.8	12.4	2.2	43.1	100.0
Taiwan	5.0	1.3	29.3	2.8	1.1	-	0.6	1.0	0.9	13.0	2.1	43.1	100.0
Philippines	3.1	4.6	19.3	5.3	3.7	4.6	-	1.6	1.1	5.3	1.6	49.8	100.0
Singapore	2.9	4.0	29.5	2.3	4.0	1.8	0.2	-	1.4	18.5	1.2	34.0	100.0
Thailand	3.4	1.1	34.3	2.1	1.9	3.3	0.4	1.4	-	7.6	0.8	43.7	100.0
Total[a]	8.2	0.7	68.5	4.2	1.2	6.2	0.2	0.7	0.4	1.9	0.3	7.3	100.0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note. a. The total also includes each country's domestic value-added, so it includes all the value-added contributions to final goods made in East Asia and exported to the United States.

Table 4c Decomposition of Machinery Trade Flow between East Asia and the United States by Countries

Source country	Imports from the U.S. (million $)				Exports to the U.S. (million $)				Share of regional totals (%)			
	Gross trade	Value-added trade			Gross trade	Value-added trade			Exports		Imports	
		Total	Direct	Indirect		Total	Direct	Indirect	Gross	VA	Gross	VA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1990												
China	761.5	748.5	709.2	39.3	343	326	306	20.6	3.2	3.4	10.7	10.8
Indonesia	44.8	64.3	41.7	22.5	0.5	33.9	0.2	33.7	0	0.4	0.6	0.9
Japan	1,808	1,726	1,684	42	7,187	6,985	6,666	319	67.3	73.2	25.3	24.8
Korea	1,565	1,505	1,458	46.9	273	232	200	31.8	2.6	2.4	21.9	21.6
Malaysia	329	353	306	46.4	83	77	56	20.6	0.8	0.8	4.6	5.1
Philippines	536.5	516.2	499.7	16.5	16.9	19.4	11.5	7.9	0.2	0.2	7.5	7.4
Singapore	1,085	1,035	1,010	25.1	285	152	141	10.3	2.7	1.6	15.2	14.9
Thailand	146.8	171.3	136.7	34.6	56	44.7	34.2	10.5	0.5	0.5	2.1	2.5
Taiwan	863	842	804	38.3	2,441	1,669	1,651	17.4	22.8	17.5	12.1	12.1
Total	7,139	6,961	6,649	312	10,685	9,538	9,066	472	100	100	100	100
2000												
China	1,895	1,907	1,662	244	2,328	2,060	1,912	147	11.1	10.9	13.2	14.1
Indonesia	347.2	346.2	304.6	41.6	182.3	153	77.7	75	0.9	0.8	2.4	2.6
Japan	3,603	3,272	3,161	112	14,330	13,712	13,208	504	68.4	72.6	25.1	24.2
Korea	2,608	2,376	2,288	88	1,320	1,083	977	106	6.3	5.7	18.2	17.6
Malaysia	826	830	724	105	402	287	242	46	1.9	1.5	5.8	6.1
Philippines	383	376	336	40.6	52	44	28	15.4	0.2	0.2	2.7	2.8
Singapore	1,552	1,478	1,361	117	202	135	104	31	1	0.7	10.8	10.9
Thailand	277	291	243	48.2	130	109	75	34.5	0.6	0.6	1.9	2.2
Taiwan	2,867	2,647	2,515	133	2,012	1,310	1,226	84	9.6	6.9	20	19.6
Total	14,356	13,523	12,594	929	20,958	18,893	17,849	1,043	100	100	100	100

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Table-5a Foreign vs. Domestic Value-added in East Asia Wearing Apparel exports to U.S. Market, 1990 and 2000

Source Country	*Total Exports to the U.S.* [a]	*Int. share in gross exports*	*Domestic Value-added*	*Foreign value-added*			*Domestic value-added via others in East Asia*
				From all countries	*From others in East Asia*	*From the U.S.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1990							
China	479	11.6	73.9	26.1	3.1	0.9	10.1
Indonesia	559	11.5	74.4	25.6	8	3.2	6.7
Japan	111	11.1	88.8	11.2	2.6	1.1	272.8
Korea	1,450	23.2	63.9	36.1	9.5	4.4	4.4
Malaysia	320	9.7	57.7	42.3	23.5	2.4	8.9
Philippines	761	11.5	49	51	16	8.2	0.3
Singapore	596	11.6	49.9	50.1	27.2	3.5	2.7
Thailand	316	11.4	70.7	29.3	11.4	3.2	5.1
Taiwan	1,329	20.3	71	29	7.6	3.5	13.2
Total	5,923	16.3	76.3	24.7	0	3.9	11.9
2000							
China	3,037	7.6	85.1	14.9	6.7	0.9	8.1
Indonesia	1,332	7.6	75.1	24.9	9.7	1.6	6.3
Japan	41	7.6	88.6	11.4	3.8	0.9	896.6
Korea	1,964	7.6	73	27	10.7	2.1	9.5
Malaysia	473	7.6	35.5	64.5	32.3	5.6	9.3
Philippines	1,639	7.6	58.9	41.1	21.3	3	0.3
Singapore	320	7.6	46.1	53.9	16.5	2.9	11.9
Thailand	1,201	7.6	75.9	24.1	11	1.8	4.8
Taiwan	547	7.6	68.1	31.9	12.1	3.3	48.3
Total	10,555	7.6	84.5	15.5	0	2	12.3

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars.

Table 5b: Tracing Foreign Value Added in Wearing Apparel Made in East Asian Sold at the U.S. Market

Source country	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	United States	Hong Kong	Rest of World	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1990, in percent												
China	-	0.3	6.2	0.7	0.3	4.2	0.0	0.1	0.2	3.3	73.1	11.6	100.0
Indonesia	3.8	-	10.5	5.8	1.1	7.3	0.2	1.7	0.9	12.4	4.6	51.6	100.0
Japan	11.3	2.6	-	4.6	1.1	2.4	0.2	0.3	0.8	10.2	1.2	65.3	100.0
Korea	0.3	1.2	19.8	-	0.6	3.7	0.1	0.2	0.3	12.1	1.5	60.2	100.0
Malaysia	6.6	2.9	15.8	4.4	-	19.1	0.2	4.5	2.0	5.7	12.1	26.8	100.0
Taiwan	0.3	1.2	18.8	4.2	0.6	-	0.1	0.4	0.5	12.1	3.4	58.4	100.0
Philippines	1.8	1.5	9.1	3.7	0.8	13.0	-	0.9	0.5	16.0	12.7	40.0	100.0
Singapore	5.9	5.3	19.2	1.7	6.0	14.0	0.1	-	2.2	6.9	9.4	29.4	100.0
Thailand	6.4	1.5	14.8	6.0	1.4	7.2	0.1	1.4	-	10.8	3.3	47.0	100.0
Total[a]	7.2	8.1	7.2	15.3	3.9	18.0	6.7	5.6	4.3	3.9	3.8	16.0	100.0
	2000, in percent												
China	-	1.9	19.4	10.5	0.9	10.3	0.2	0.6	1.0	6.2	7.1	41.8	100.0
Indonesia	6.9	-	9.4	10.1	1.9	8.2	0.2	0.8	1.6	6.6	4.9	49.5	100.0
Japan	16.3	5.1	-	5.3	1.8	2.4	0.2	0.2	2.2	7.8	2.0	56.7	100.0
Korea	18.9	3.5	11.5	-	1.0	3.4	0.1	0.2	1.1	7.7	0.8	51.8	100.0
Malaysia	6.6	4.7	16.8	3.0	-	10.4	0.3	5.3	2.9	8.7	7.9	33.3	100.0
Taiwan	4.5	4.1	18.2	6.6	1.5	-	0.5	0.5	2.1	10.3	1.5	50.2	100.0
Philippines	7.3	3.6	9.1	9.1	1.2	17.0	-	0.8	3.7	7.2	14.1	26.9	100.0
Singapore	7.8	0.9	5.6	3.6	7.1	2.5	0.4	-	2.8	5.3	9.3	54.7	100.0
Thailand	11.0	3.2	13.1	5.7	1.8	7.4	0.3	3.1	-	7.3	2.5	44.6	100.0
Total[a]	26.8	10.3	3.9	15.4	2.0	6.0	9.2	1.8	9.2	2.0	1.9	11.6	100.0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note. a. The total also includes each country's domestic value-added, so it includes all the value-added contributions to final goods made in East Asia and exported to the United States.

Table 5c Decomposition of Wearing Apparel Trade Flow between East Asia and the United States by Countries

Source country	Imports from the U.S. (million $)				Exports to the U.S. (million $)				Share of regional totals (%)			
	Gross trade	Value-added trade			Gross trade	Value-added trade			Exports		Imports	
		Total	Direct	Indirect		Total	Direct	Indirect	Gross	VA	Gross	VA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1990												
China	0.2	0.2	0.2	0	480	403	354	48.7	8.1	8.9	0.1	0.1
Indonesia	0.4	0.5	0.4	0.1	559.2	454.8	416.2	38.7	9.4	10.1	0.3	0.3
Japan	110	157	98	58.7	112	426	99	327	1.9	9.4	85.9	88.1
Korea	3	3	2	0.2	1,450	983	926	56.8	24.5	21.8	1.9	1.4
Malaysia	0	1	0	0.5	320	215	185	29.9	5.4	4.8	0.3	0.4
Philippines	8.6	9	7.7	1.4	760.9	374.6	372.5	2.1	12.8	8.3	6.7	5.1
Singapore	3	5	3	1.6	596	314	297	16.1	10.1	6.9	2.6	2.5
Thailand	1.3	1.3	1.2	0.2	316	239.8	223.2	16.5	5.3	5.3	1	0.8
Taiwan	2	2	1	1.1	1,330	1,105	945	160.6	22.4	24.5	1.2	1.4
Total	128	178	114	64	5,923	4,514	3,818	696	100	100	100	100
2000												
China	2	4	1	3	3,036	2,830	2,583	247	28.8	31.7	0.7	1.4
Indonesia	0.7	0.8	0.6	0.2	1331.8	1,084	1000.2	84.1	12.6	12.2	0.3	0.3
Japan	137	180	115	66	42	409	37	372	0.4	4.6	62.4	66.4
Korea	10	15	9	7	1,964	1,621	1,435	186	18.6	18.2	4.6	5.5
Malaysia	2	2	2	1	474	212	168	44	4.5	2.4	0.9	0.9
Philippines	12	13	10	3.3	1,639	971	965	5.6	15.5	10.9	5.3	4.8
Singapore	20	21	17	4	321	186	148	38	3	2.1	9	7.5
Thailand	33	31	27	3.8	1,201	969	911	58	11.4	10.9	14.9	11.5
Taiwan	4	5	3	2	547	636	372	264	5.2	7.1	1.7	1.7
Total	219	272	183	89	10,555	8,917	7,619	1,299	100	100	100	100

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Table-6a Foreign vs. Domestic Value-added in East Asia Motor vehicles exports to U.S. Market, 1990 and 2000

Source Country	*Total Exports to the U.S.* [a]	*Int. share in gross exports*	*Domestic Value-added*	*Foreign value-added*			*Domestic value-added via others in East Asia*
				From all countries	*From others in East Asia*	*From the U.S.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1990							
China	14	86.1	84.5	15.5	4.5	1.2	-
Indonesia	1	71.5	72.5	27.5	15.3	1.1	-
Japan	28,511	13.8	92.3	7.7	1.2	1.2	0.4
Korea	1,356	13.2	78.2	21.8	8.7	3.5	3.7
Malaysia	4	94.6	57.1	42.9	30.2	1.3	-
Philippines	14	93.9	63.3	36.7	27.7	1.5	-
Singapore	16	87.1	44.8	55.2	27.6	8	440.4
Thailand	12	93.5	54.6	45.4	27.9	2.9	-
Taiwan	320	80.2	69.8	30.2	9.8	5.1	57.3
Total	30,250	14.6	93.1	6.9	0	1.3	1.5
2000							
China	1,401	65.6	81	19	7.1	1.2	42.8
Indonesia	80	94.6	79.4	20.6	9.6	1.3	-
Japan	40,116	24.5	92.1	7.9	2	1.2	0.9
Korea	4,954	12.6	75.3	24.7	8.2	3.1	1.9
Malaysia	37	89.8	57.8	42.2	24.8	3.4	-
Philippines	363	95.1	53.8	46.2	22.3	3	148.4
Singapore	1	93.8	49.2	50.8	19	5.2	-
Thailand	281	95	53.3	46.7	27.7	3	843.5
Taiwan	672	79.6	70.2	29.8	13.1	2.5	65.4
Total	47,904	26.4	92.6	7.4	0	1.5	2.9

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Note: a. in Millions of U.S. Dollars

Table 6b: Tracing Foreign Value Added in Motor Vehicle and Parts Made in East Asian Sold at the U.S. Market

Source country	China	Indo-nesia	Japan	Korea	Malay-sia	Taiwan	Philip-pines	Singa-pore	Thai-land	United States	Hong Kong	Rest of World	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1990, in percent												
China	-	0.8	23.9	0.6	1.4	1.3	0.1	0.3	0.9	7.5	10.3	52.8	100.0
Indonesia	1.1	-	49.6	1.7	0.6	1.4	0.1	0.9	0.3	4.1	0.7	39.5	100.0
Japan	2.5	4.2	-	2.3	1.8	1.8	0.9	0.4	1.3	15.2	0.6	69.0	100.0
Korea	0.2	1.6	34.4	-	1.7	1.1	0.2	0.4	0.3	16.2	0.5	43.4	100.0
Malaysia	0.4	0.8	67.1	0.4	-	0.7	0.1	0.6	0.4	3.1	0.2	26.2	100.0
Taiwan	0.2	0.9	28.0	1.9	0.8	-	0.2	0.3	0.2	16.8	1.2	49.4	100.0
Philippines	0.4	0.6	65.3	5.5	1.1	1.5	-	0.5	0.6	4.2	0.6	19.8	100.0
Singapore	1.1	2.1	39.2	0.6	3.8	1.2	0.1	-	1.6	14.6	0.8	34.7	100.0
Thailand	2.4	0.7	52.4	1.4	1.5	1.6	0.2	1.2	-	6.3	0.6	31.6	100.0
Total[a]	0.2	0.3	88.2	3.7	0.1	0.3	0.1	0.0	0.1	1.3	0.0	5.5	100.0
	2000, in percent												
China	-	1.2	23.1	5.4	0.8	5.5	0.2	0.5	0.7	6.4	3.1	53.3	100.0
Indonesia	3.2	-	33.7	2.5	1.5	2.1	0.3	1.1	1.9	6.1	0.5	47.0	100.0
Japan	6.3	4.2	-	3.2	2.1	3.0	1.0	0.6	4.7	15.7	1.2	58.0	100.0
Korea	5.0	2.2	22.7	-	1.1	1.1	0.2	0.5	0.6	12.7	1.4	52.6	100.0
Malaysia	3.2	2.1	41.4	3.0	-	3.1	0.3	3.5	2.1	8.0	1.7	31.6	100.0
Taiwan	3.3	1.5	33.9	2.9	0.9	-	0.4	0.4	0.7	8.5	1.1	46.5	100.0
Philippines	4.2	5.0	22.0	5.9	2.6	4.3	-	2.0	2.2	6.5	2.6	42.7	100.0
Singapore	4.1	1.9	21.7	2.1	5.0	1.3	0.2	-	1.2	10.2	3.1	49.2	100.0
Thailand	2.8	1.4	47.0	2.1	1.6	2.1	1.4	0.9	-	6.5	0.8	33.3	100.0
Total[a]	1.7	0.4	79.8	9.5	0.2	0.5	0.1	0.1	0.4	1.5	0.1	5.8	100.0

Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

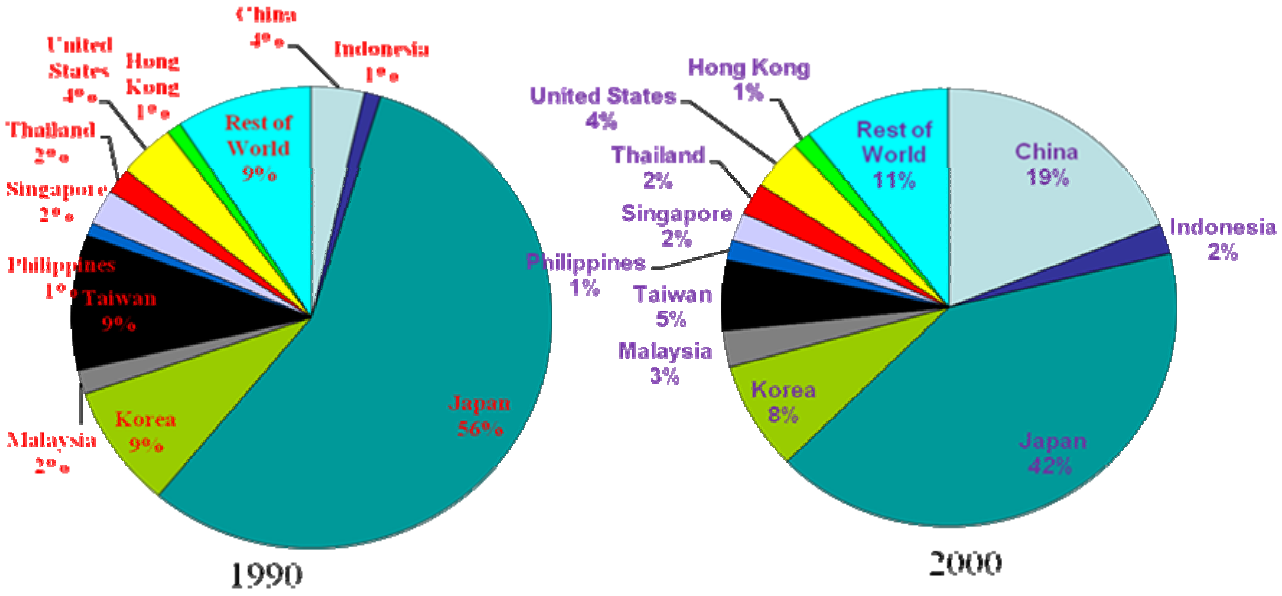
Note. a. The total also includes each country's domestic value-added, so it includes all the value-added contributions to final goods made in East Asia and exported to the United States.

Table 6c Decomposition of Motor Vehicle and Parts Trade Flow between East Asia and the United States by Countries

Source country	Imports from the U.S. (million $)				Exports to the U.S. (million $)				Share of regional totals (%)			
	Gross trade	Value-added trade			Gross trade	Value-added trade			Exports		Imports	
		Total	Direct	Indirect		Total	Direct	Indirect	Gross	VA	Gross	VA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1990												
China	56.7	52	47	5.1	14	67	11	55.1	0	0.2	3	3.1
Indonesia	22.4	32	18.5	13.5	1.7	99.7	1.2	98.4	0	0.4	1.2	1.9
Japan	842	703	697	5.8	28,511	26,458	26,318	140	94.3	94	44.4	42.4
Korea	153	132	126	6.1	1,356	1,113	1,061	51.9	4.5	4	8	8
Malaysia	19	26	16	10.6	5	48	3	44.8	0	0.2	1	1.6
Philippines	26.1	28.5	21.6	6.9	14	30.2	8.9	21.3	0	0.1	1.4	1.7
Singapore	122	108	101	7.7	16	18	7	11	0.1	0.1	6.4	6.5
Thailand	52.2	62.5	43.2	19.3	12	36.7	6.4	30.3	0	0.1	2.8	3.8
Taiwan	605	513	501	12.4	320	266	224	42.4	1.1	0.9	31.9	31
Total	1,897	1,658	1,571	87	30,249	28,135	27,640	495	100	100	100	100
2000												
China	191	177	154	23	1,401	1,415	1,136	279	2.9	3.2	6.2	6.7
Indonesia	163.7	155.2	132.5	22.7	80.3	241	63.7	176.8	0.2	0.5	5.4	5.9
Japan	2,064	1,704	1,670	34	40,116	37,453	36,936	517	83.7	84.6	67.5	64.4
Korea	285	240	231	9	4,954	3,868	3,731	137	10.3	8.7	9.3	9.1
Malaysia	42	59	34	25	37	112	21	91	0.1	0.3	1.4	2.2
Philippines	77	75	62	12.9	363	233	195	37.3	0.8	0.5	2.5	2.8
Singapore	51	49	42	8	1	32	0	32	0	0.1	1.7	1.9
Thailand	66	76	54	22.3	281	313	150	162.9	0.6	0.7	2.2	2.9
Taiwan	117	110	94	15	672	606	471	134	1.4	1.4	3.8	4.1
Total	3,056	2,645	2,473	172	47,904	44,271	42,705	1,567	100	100	100	100

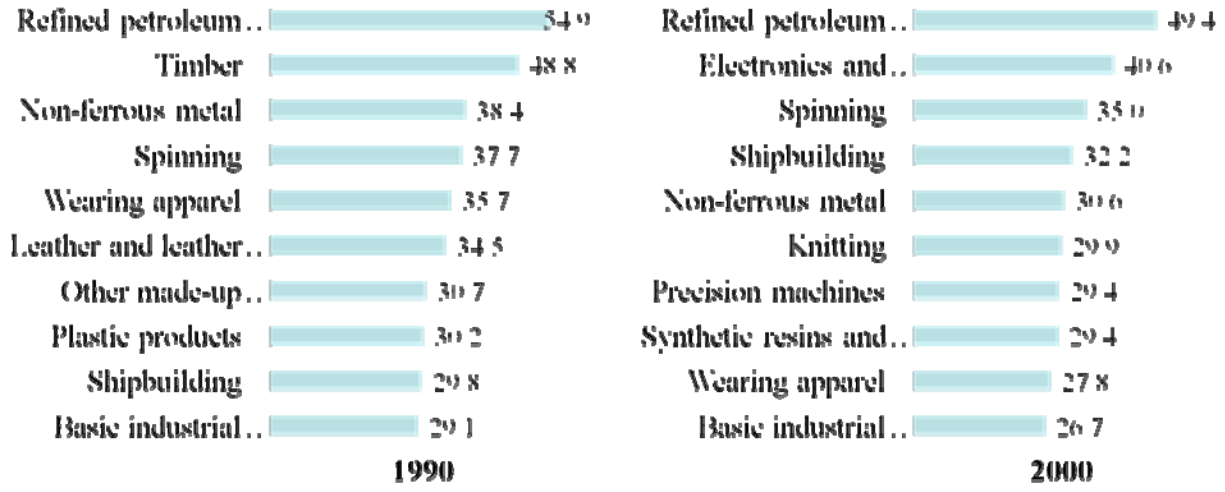
Data Source: Author computed from Asia Input-Output Table, compiled by the Institute of Development Economics, Ministry of Economics, Trade, and Industry, Japan.

Figure 1: Net Value Added Contribution by Source to Manufacturing Products Made in East Asia Sold in the U.S. Market



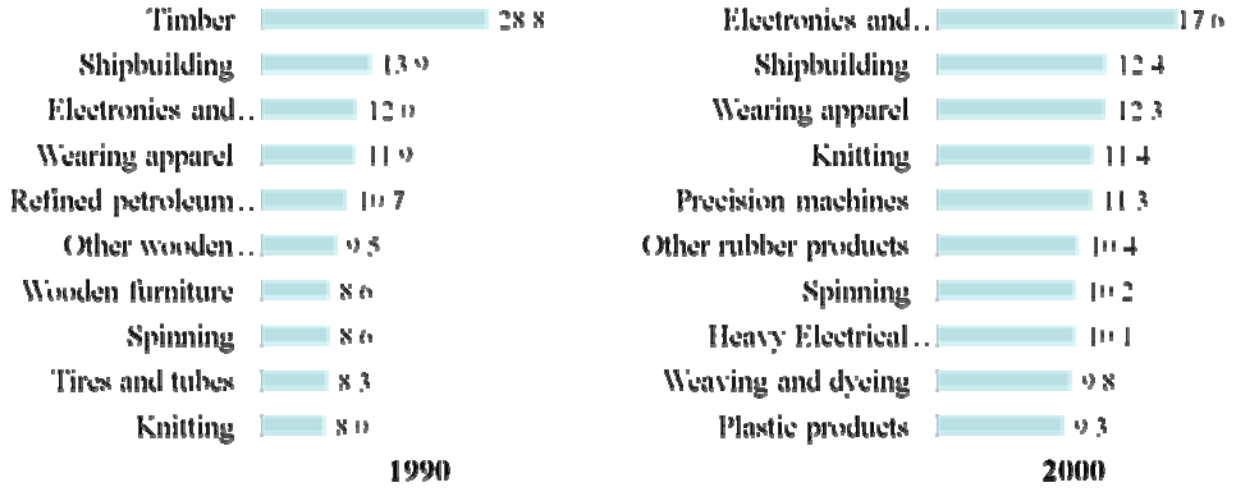
Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 2a: Top 10 Industries with the Highest Foreign Value-added in East Asian Manufacturing Exports to the United States



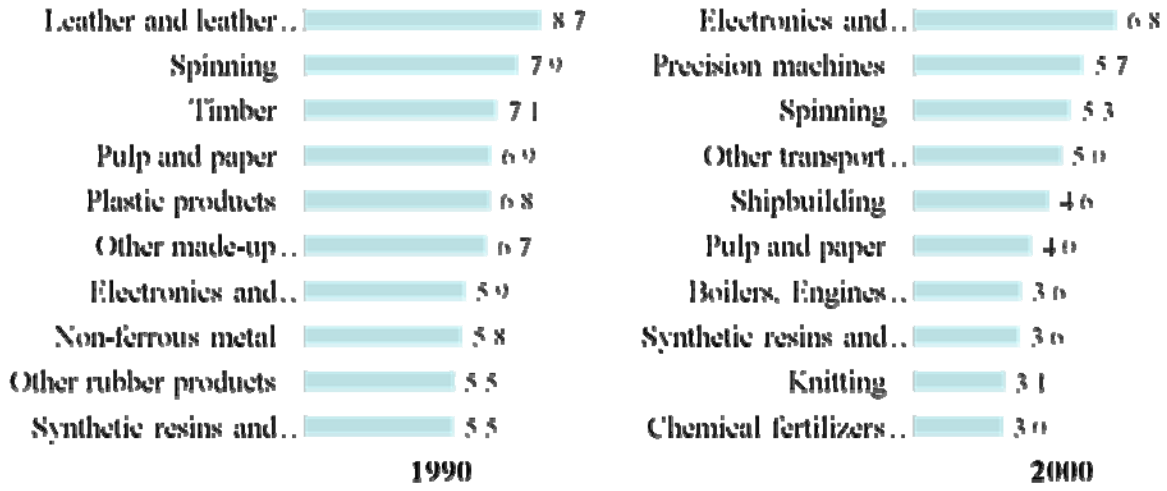
Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 2b: Top 10 Industries with the Highest VS1 (Indirect Domestic Value-added via other Asian countries) in East Asian Manufacturing Exports to the United States



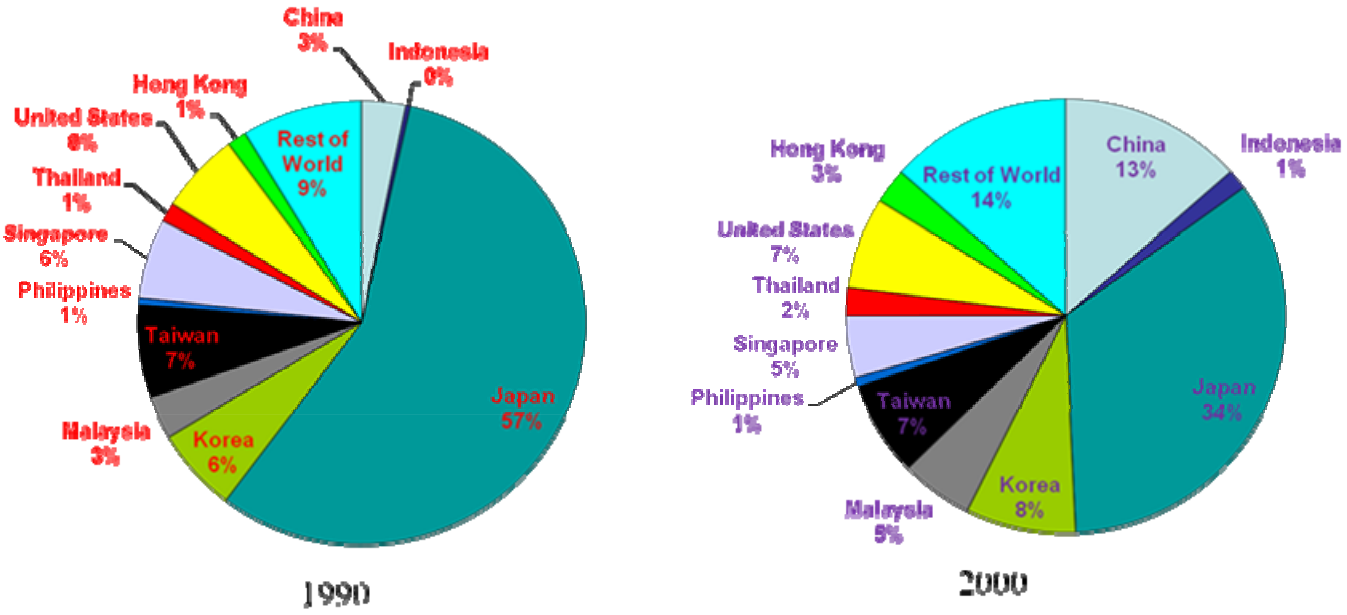
Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 2c: Top 10 Industries with the Highest U.S. Domestic Content in East Asian Manufacturing Exports to the United States



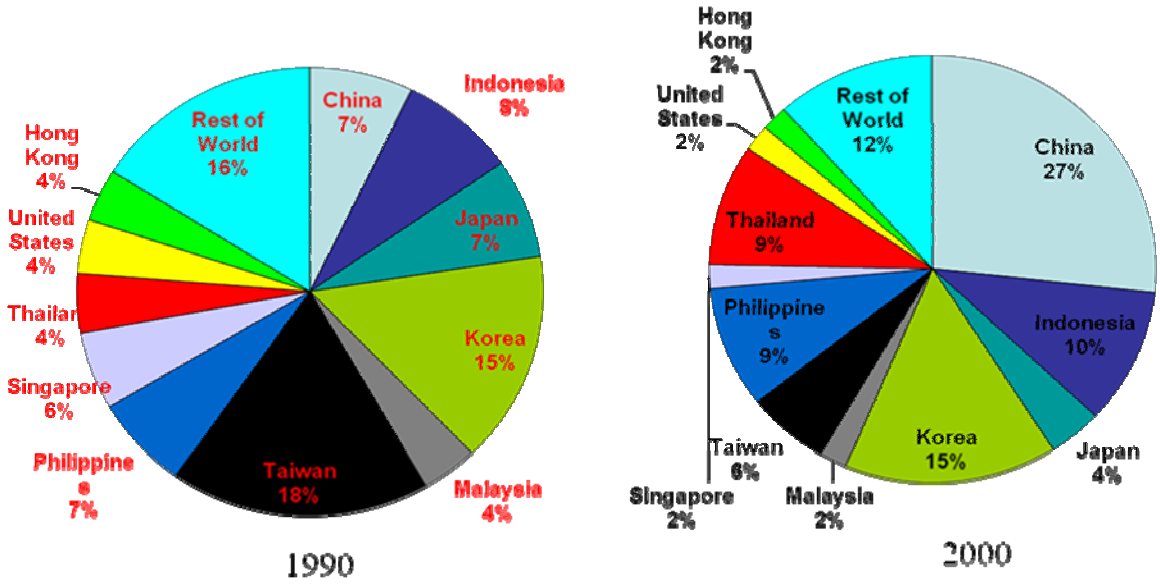
Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 3: Net Value Added Contribution by Source to Electronics Products Made in East Asia Sold in the U.S. Market



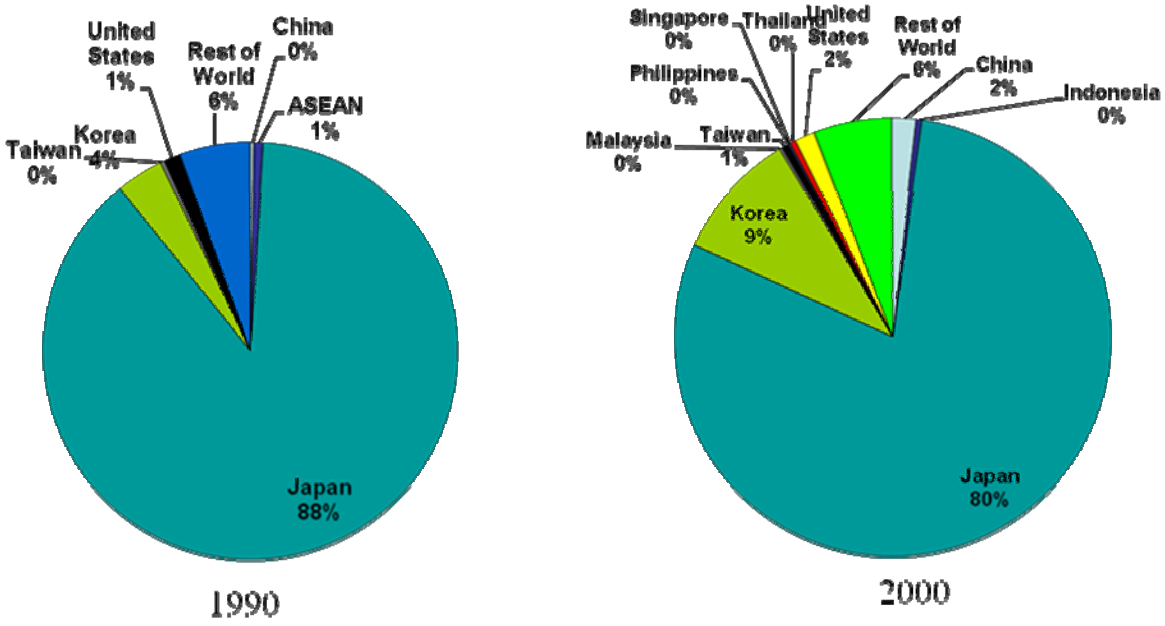
Source. Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 4: Net Value Added Contribution by Source to Wearing Apparel Made in East Asia Sold at the U.S. Market



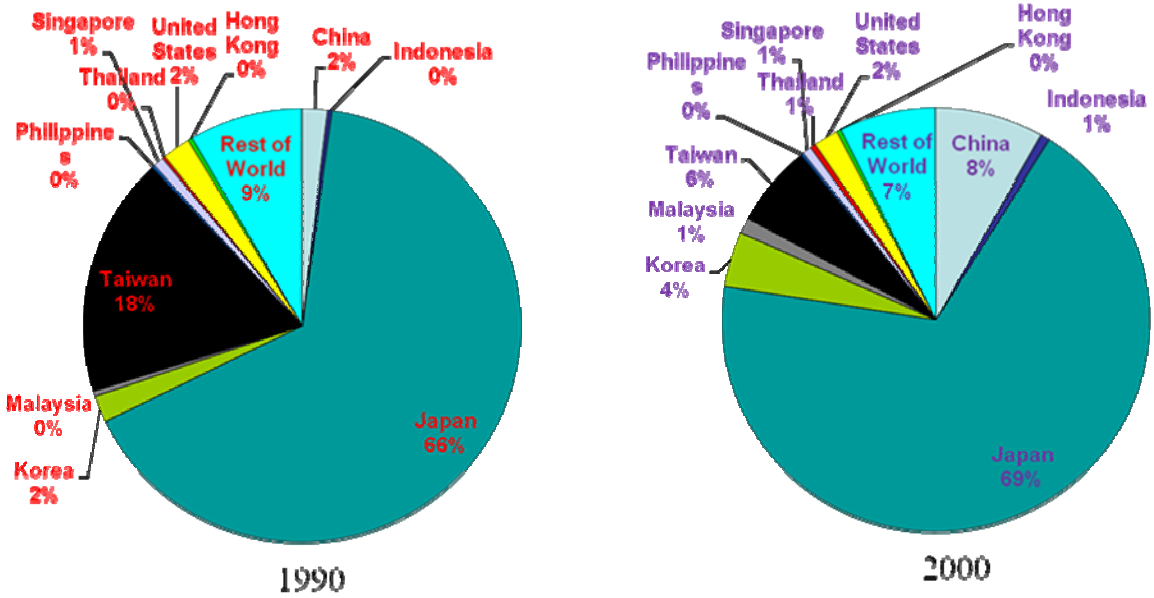
Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 5: Net Value Added Contribution by Source to Automobile and Parts Made in East Asia Sold at the U.S. Market



Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Figure 8: Net Value Added Contribution by Source to Machinery Made in East Asia Sold at the U.S. Market



Source: Author's estimate based on Asian IO table compiled by IDE of Japan