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# Production fragmentation and trade integration: East Asia in a global context

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## Abstract

This paper examines the implications of international production fragmentation for global and regional trade patterns, with special emphasis on countries in East Asia. It is found that, while trade in parts and components (fragmentation trade) has generally grown faster than total world manufacturing trade, the degree of dependence of East Asia on this new form of international specialization is proportionately larger than in North America and Europe. International production fragmentation has certainly played a pivotal role in the continuing dynamism of the East Asian economies and increasing intra-regional economic interdependence. There is, however, no evidence to suggest that this new form of international exchange has contributed to reducing the region's dependence on the global economy. On the contrary, growth dynamism based on vertical specialization depends inexorably on extra-regional trade in final goods, and this dependence has in fact *increased* over the years.

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## 1. Introduction

International production fragmentation—cross-border dispersion of component production/assembly within vertically integrated production processes, with each country specializing in a particular stage of the production sequence—has been an important feature of the deepening

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structural interdependence of the world economy in recent decades.<sup>1</sup> This phenomenon has been reflected in a rapid growth of trade in parts and components ('middle products' or 'fragments of final goods') at a rate exceeding that of trade in final goods. This paper aims to examine the extent, trends and patterns of this new form of international exchange, and its implications for analyzing regional trade patterns, with special emphasis on East Asia. The study is based on a systematic separation of trade in parts and components from total trade flows, using a new data set extracted from the UN trade database. The East Asian experience is examined in the wider global context, focusing specifically on the comparative experiences of that region, the North American Free Trade Area (NAFTA) and the European Union (EU).

There is a vast literature, based on the horizontal specialization in which trade is essentially an exchange of goods that are produced from start to finish in just one country. That literature unequivocally points to a steady increase in intra-regional trade in East Asia (including as well as excluding Japan) from about the early 1980s (e.g., Drysdale & Garnaut, 1997; Frankel & Wei, 1997; Kwan, 2001; Petri, 1993). This evidence figures prominently in the current debate on regional trading arrangements.

In this paper, we argue that, in a context where component trade is growing rapidly, standard trade analysis can lead to misleading inferences as to the nature and extent of trade integration among countries, for two reasons. First, in the presence of production fragmentation, trade data are double-counted because goods in process cross multiple national borders before getting embodied in the final product. Thus, the total amount of recorded trade could be a multiple of the value of final goods. Second, and perhaps more importantly, trade shares calculated using reported data can lead to wrong inferences as to the relative importance of trade with the 'region' and the rest of the world for growth dynamism of a given country/region. This is because intra/extra regional patterns of trade in parts and components (henceforth referred to as 'fragmentation trade') and trade in related final goods ('final trade') are unlikely to follow the same patterns. There is indeed ample evidence coming from the case-study literature on multinational enterprises operating in the East Asian region that the demand for final products comes predominantly from the rest of the world, particularly from North America and the EU.<sup>2</sup>

This paper relates to, and builds on, Ng and Yeats (2001, 2003) and Athukorala (2003). While the present paper offers both more current and detailed information on the nature, trends and patterns of fragmentation trade, its major novelty is in the analysis of the determinants of fragmentation trade. To the best of our knowledge, this is the first analysis of the determinants of parts and components trade in a large sample of bilateral trade relations at the global level.<sup>3</sup> Our approach is essentially empirical, but it is carried out in the context of the existing theoretical literature.<sup>4</sup>

The paper is organized as follows. Section 2 discusses the data. Section 3 examines the nature and extent of global trade in components and East Asia's role in this form of trade specialization.

<sup>1</sup> This phenomenon has gone under alternative names, such as 'vertical specialization' (Hummels, Ishii, & Yi, 2001; Yi, 2003), 'slicing the value chain' (Krugman, 1995), 'international production sharing' (Ng & Yeats, 2001, 2003; Yeats, 2001), and 'outsourcing' (Grossman & Helpman, 2005).

<sup>2</sup> See, for instance, Borrus (1997), Dobson and Chia (1997), and McKendrick, Doner, and Haggard (2000).

<sup>3</sup> A few studies have examined the implications of production fragmentation for trade patterns with a specific regional (rather than a global) focus, including Egger and Egger (2003, 2005), Gorg (2000) and Baldone, Sdoagati, and Tajoli (2001).

<sup>4</sup> Important contributions to the theory of production fragmentation include Arndt (1997), Jones (2000), Grossman and Helpman (2005), Jones and Kierzkowski (1990, 2001), Venables (1999) and Yi (2003).

This section also deals with the implications of the rapid expansion of production fragmentation for intra- and extra-regional patterns of economic integration in East Asia. Section 4 uses a ‘modified’ gravity model to examine determinants of bilateral trade in parts and components, focusing separately on exports and imports and comparing the results with those for trade in final goods. The final section presents the key inferences.

## 2. Data

This study makes use of data extracted from the UN trade data base (SITC, Rev 3). SITC Revision 3 does not provide for the construction of data series covering the entire range of activities involving production fragmentation. Data reported under SITC 7 (the machinery and transport equipment sector) do provide comprehensive coverage of fragmentation trade. But data for SITC 8 (miscellaneous manufactured articles) do not seem to fully capture fragmentation trade within that commodity category. For instance, for some products such as clothing, furniture, and leather products, in which outsourcing is prevalent (and perhaps has been increasing), relevant components are recorded under other SITC categories (e.g., pieces of textile, parts of furniture, parts of leather soles). The SITC data system does not provide adequate information to separate these components and relate them accurately to the relevant final product. Moreover, there is evidence that international production fragmentation has been spreading beyond SITC 7 and 8 to other product categories, in particular to pharmaceutical and chemical products (falling under SITC 5) and machine tools and various metal products (SITC 6). Assembly activities in software trade, too, have recorded impressive expansion in recent years. These are lumped together with ‘special transactions’ under SITC 9. So, measurement of trade in parts and components reported in this paper is presumably downward biased, causing our estimates to be downward biased, and perhaps the degree of bias may have increased over the years with the gradual spread of production fragmentation to other areas of products beyond SITC 7 and 8.

It is important to note that parts and components trade measured with reported trade data, regardless of the downward bias involved, provides only a proxy measure of fragmentation trade. On the import side, the data capture both intermediate goods used to make goods for export and for domestic consumption. On the export side, fragmentation-based exchange encompasses both parts and components and final goods assembled with imported parts and components. Precise measurement of fragmentation trade requires combining published trade data with data on the input–output structure of trading nations. However, the latter data are not available for a sufficient number of countries to enable us to undertake a more precise analysis of global trade patterns.<sup>5</sup>

We tabulated data from the UN trade database for the period from 1992 to 2003, the most recent year for which trade data are available for all reporting countries. The year 1992 is used as starting point, because by this time countries accounting for over 95 percent of total world manufacturing trade had adopted the new system. Given the prohibitive cost of tabulating data covering the entire period, 1992, 1996 and 2003 are chosen as the most appropriate interim years for the inter-temporal comparison of trade patterns. The list of parts and components identified at the five-digit level for these two sectors provides the basis of our empirical analysis. It contains

<sup>5</sup> See [Hummels et al. \(2001\)](#) for an application of the input-output technique for estimating fragmentation trade for some individual OECD countries.

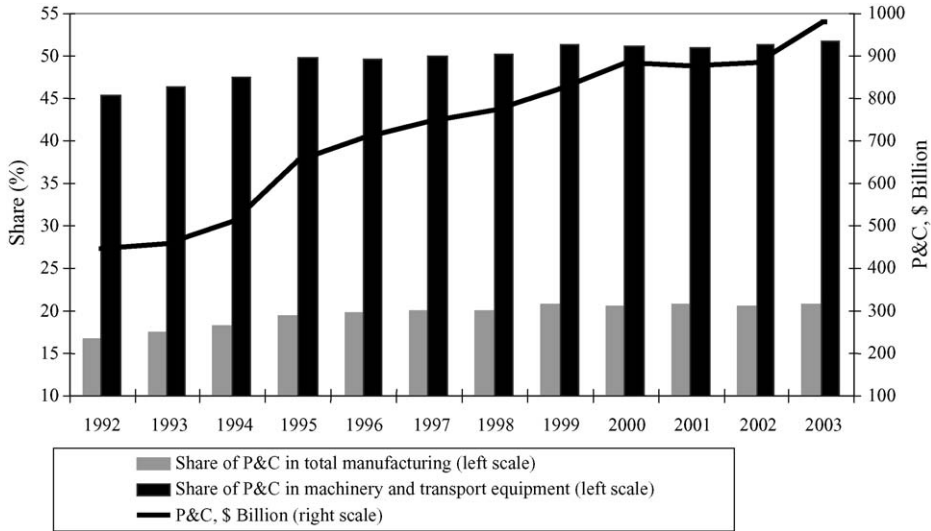


Fig. 1. World trade in parts and components (P&Cs). Source: Based on data compiled from Comtrade database (exporter records).

a total of 225 five-digit products—168 products belonging to SITC 7 and 57 belonging to SITC 8.<sup>6,7,8</sup>

### 3. Trends and patterns of production fragmentation

World trade in parts and components increased from about \$440 billion in 1992 to nearly \$1000 billion in 2003 (Table 1, Fig. 1). The share of these products in total world manufacturing exports increased from 18.5 percent to 22.0 percent between 1992 and 2003. Components accounted for nearly a third of the total increase in world manufacturing exports between these two years.

Developed countries account for the bulk of components trade (Table 1, Fig. 2). However, the share of developing countries has increased sharply over the years (from 14.3 percent to 31.3 percent on the export side and 25.2 percent to 40.8 percent on the import side between 1992 and 2003). The share of East Asia (including Japan) in total world exports of components increased from 29.3 percent in 1992 to 39.2 percent in 2003, despite a notable decline in the share accounted for by Japan. The share of developing East Asia (East Asia excluding Japan) increased from 14.1 percent to 27.3 percent over this period.

<sup>6</sup> The list is available in Athukorala (2003), Appendix A-5.

<sup>7</sup> Historically entrepot trade has accounted for a significant share of Hong Kong’s total trade and this share has increased dramatically in recent years because of its growing importance as a trans-shipment center for mainland China’s booming foreign trade. For instance, re-exports accounted for 92.3 of total exports from Hong Kong in 2004, up from 74.3 percent in 1992. Failure to net out entrepot trade for other countries obviously leads to some double counting of trade flows, but the magnitude of the resulting error is unlikely to be significant, except for Singapore and Hong Kong.

<sup>8</sup> East Asia includes both Japan and the developing countries in the region, namely, the newly industrialized economies (NIEs) South Korea, Taiwan and Hong Kong, China and the six largest economies of the Association of Southeast Asian Nations (ASEAN) Free Trade Area (AFTA). Among the AFTA member countries, only Indonesia, Malaysia, the Philippines, Thailand, Singapore and Vietnam are included.

Table 1  
World Trade in parts and components (P&Cs), 1992–2003 (percent)

|                             | Exports |       |       | Imports |       |       | Trade balance <sup>a</sup> |        |        |
|-----------------------------|---------|-------|-------|---------|-------|-------|----------------------------|--------|--------|
|                             | 1992    | 1996  | 2003  | 1992    | 1996  | 2003  | 1992                       | 1996   | 2003   |
| East Asia                   | 29.3    | 38.2  | 39.2  | 23.8    | 30.8  | 37.9  | 25.9                       | 18.6   | 3.6    |
| Japan                       | 15.2    | 15.5  | 11.9  | 3.5     | 4.8   | 4.7   | 79.2                       | 68.5   | 60.9   |
| Developing East Asia        | 14.1    | 22.7  | 27.3  | 20.4    | 26.0  | 33.2  | -31.2                      | -15.7  | -21.4  |
| China                       | 0.8     | 1.7   | 6.1   | 2.7     | 3.0   | 10.7  | -196.6                     | -77.1  | -76.5  |
| Hong Kong SAR               | 1.3     | 0.8   | 0.2   | 1.8     | 1.8   | 0.5   | -25.3                      | -112.2 | -184.5 |
| Rep. of Korea               | 2.5     | 3.8   | 4.4   | 3.1     | 3.4   | 3.6   | -9.5                       | 9.8    | 17.4   |
| Taiwan                      | 3.0     | 4.5   | 3.4   | 3.1     | 2.9   | 5.6   | 5.6                        | 35.4   | -65.0  |
| AFTA                        | 6.5     | 11.8  | 13.3  | 9.8     | 14.9  | 12.7  | -36.9                      | -27.6  | 4.4    |
| Indonesia                   | 0.1     | 0.3   | 0.4   | 0.9     | 0.9   | 0.3   | -721.5                     | -211.5 | 25.3   |
| Malaysia                    | 2.2     | 3.4   | 3.4   | 2.8     | 3.9   | 3.7   | -12.0                      | -16.0  | -9.0   |
| Philippines                 | 0.2     | 1.2   | 2.1   | 0.5     | 1.5   | 1.9   | -128.2                     | -29.8  | 10.3   |
| Singapore                   | 3.0     | 5.6   | 5.7   | 4.0     | 6.2   | 5.0   | -22.7                      | -11.2  | 13.3   |
| Thailand                    | 0.9     | 1.2   | 1.6   | 1.7     | 2.4   | 1.7   | -72.4                      | -99.0  | -6.3   |
| Vietnam                     | -       | -     | 0.1   | -       | 0.1   | 0.1   | -                          | -      | 0.4    |
| South Asia                  | 0.1     | 0.2   | 0.2   | 0.7     | 0.4   | 0.6   | -538.9                     | -107.7 | -198.9 |
| CER                         | 0.1     | 0.4   | 0.4   | 0.3     | 1.3   | 1.1   | -173.8                     | -237.4 | -149.0 |
| NAFTA                       | 25.9    | 24.0  | 22.8  | 26.0    | 26.6  | 23.7  | 8.4                        | -11.6  | -3.3   |
| USA                         | 20.8    | 18.7  | 17.3  | 18.0    | 18.2  | 15.3  | 21.3                       | 1.7    | 12.0   |
| Canada                      | 3.6     | 3.3   | 2.8   | 6.0     | 5.4   | 4.2   | -53.9                      | -63.6  | -53.3  |
| Mexico                      | 1.5     | 1.9   | 2.9   | 2.0     | 3.0   | 4.1   | -21.7                      | -58.5  | -43.9  |
| MERCOSUR                    | 0.6     | 0.6   | 0.5   | 1.1     | 1.6   | 1.1   | -67.3                      | -176.9 | -99.2  |
| Andean Pact                 | -       | -     | -     | 0.5     | 0.3   | 0.2   | -                          | -      | -      |
| Europe                      | 46.1    | 53.9  | 38.4  | 47.6    | 51.2  | 36.9  | 6.1                        | 4.3    | 4.2    |
| EU                          | 43.8    | 38.0  | 34.2  | 44.3    | 34.8  | 32.1  | 7.9                        | 7.6    | 6.6    |
| Eastern Europe              | 0.3     | 0.9   | 2.5   | 0.5     | 1.4   | 3.0   | -52.1                      | -61.5  | -16.2  |
| Rest of Europe              | 2.0     | 1.7   | 1.7   | 2.8     | 2.2   | 1.9   | -23.2                      | -28.3  | -12.1  |
| World                       | 100.0   | 100.0 | 100.0 | 100.0   | 100.0 | 100.0 |                            |        |        |
| \$ billion <sup>b</sup>     | 438.9   | 728.6 | 986.9 | 447.0   | 735.1 | 983.4 |                            |        |        |
| Memorandum Items            |         |       |       |         |       |       |                            |        |        |
| P&Cs in manufacturing trade | 18.5    | 20.8  | 22.3  | 19.0    | 20.4  | 22.1  |                            |        |        |
| Share in P&C trade          |         |       |       |         |       |       |                            |        |        |
| Developed countries         | 85.7    | 75.7  | 68.7  | 74.8    | 67.4  | 59.2  |                            |        |        |
| Developing countries        | 14.3    | 24.3  | 31.3  | 25.2    | 32.6  | 40.8  |                            |        |        |

Note: Source: Compiled from UN Comtrade database.

<sup>a</sup> Trade balance as a percentage of exports.

<sup>b</sup> By definition, percentage shares in exports and imports for a given year should be identical. The minor differences seem to reflect recording errors and differences in measurement arising from the use of CIF price for reporting imports and FOB price for most reporting exports.

Within the group, all reported countries have recorded increases in their world market shares. The growing importance of China in component trade is particularly noteworthy. The share of China in total world component exports increased from less than one percent to 6.1 percent and in total imports from 2.7 percent to 10.7 percent between 1992 and 2003. Contrary to the popular perception of China's "crowding" out its neighbors, this increase has occurred within an overall increase in exports from other newcomers in the region. For instance, the combined export share

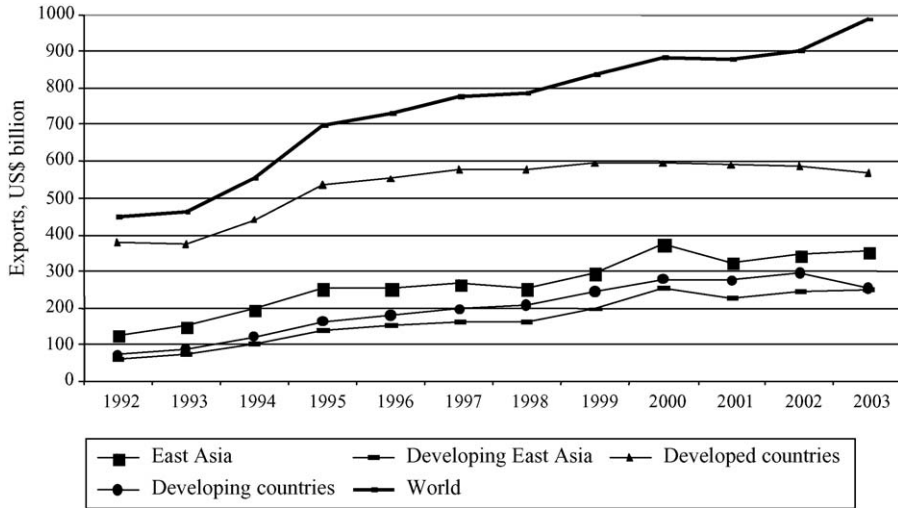


Fig. 2. Parts and components exports (US\$ billion). Source: Based on data compiled from Comtrade database (exporter records).

of the six main member countries of the ASEAN Free Trade Area (AFTA) more than doubled (from 6.5 percent to 13.3 percent). The share of Hong Kong in world component trade has declined steadily as a result of the dramatic relocation of manufacturing to the mainland.

Japan has persistently recorded a large trade surplus in components trade, reflecting the heavy involvement of Japanese companies in overseas assembly activities (mostly in East Asia) to maintain their competitiveness in final trade in third country markets (Table 1, last three columns). The EU and the U.S., too, have recorded modest surpluses. By contrast, China has been a major net importer.<sup>9</sup> This comparison is generally consistent with the hypothesis that high-wage countries are the major supplier of capital-intensive components, while low-wage countries have a comparative advantage in labor-intensive assembly (Ng & Yeats, 2003). However, among individual East Asian countries, the trade balances of the Philippines and Singapore have turned from deficit to surplus in recent years. As we will see later, this reflects growing cross-border trade in components within the region. Members of regional production-sharing networks interact with and supply one another, leading to an expansion of two-way trade in components.

Have formation of NAFTA and enlargement of the European Union adversely affected developing East Asia's relative position in world component trade? While proximity to industrial countries is often considered to be an added advantage, (Egger & Egger, 2005; Kierzkowski, 2001; Ng & Yeats, 2003; USITC, 1999), the data do not reveal any dampening effect of these developments on the relative world market position of East Asia. The world market shares of Mexico and the European accession countries have increased, but at a much slower rate than developing East Asia. It seems that in spite of geographical proximity and tariff concessions under FTAs, U.S. producers still find East Asia a more attractive location for outsourcing.

Table 2 presents comparative statistics on the share of components trade in total manufacturing exports and imports in 1992, 1996 and 2003 and its contribution to growth of manufacturing trade

<sup>9</sup> For an analysis of component trade as an increasingly important vehicle for China's rapid economic integration in the East Asian region, see Athukorala (2005).

Table 2  
Parts and components (P&C) in manufacturing trade

| Country/region       | Value of P&C<br>(\$ billion) |       |       | Share of P&C in<br>mfg. exports |      |      | Growth of mfg.<br>exports<br>1992–2003 | Growth of P&C<br>exports<br>1992–2003 | Contribution of P&C to<br>growth of mfg. exports<br>1992–2003 |
|----------------------|------------------------------|-------|-------|---------------------------------|------|------|--|---------------------------------------|---|
|                      | 1992                         | 1996  | 2003  | 1992                            | 1996 | 2003 |  |                                       |   |
| (a) Exports          |                              |       |       |                                 |      |      |  |                                       |   |
| East Asia            | 128.6                        | 278   | 386.4 | 20.3                            | 31.0 | 27.5 | 3.19                                   | 4.44                                  | 33.5  |
| Japan                | 66.5                         | 106.1 | 117.4 | 21.2                            | 30.2 | 27.9 | 1.17                                   | 2.27                                  | 47.5  |
| Developing East Asia | 62                           | 165   | 269   | 19.3                            | 30.2 | 27.3 | 4.52                                   | 5.97                                  | 31.2  |
| China                | 3.6                          | 9.8   | 59.5  | 5.5                             | 9.8  | 15.2 | 7.32                                   | 11.71                                 | 17.1  |
| Hong Kong SAR        | 5.7                          | 6.1   | 1.8   | 20.2                            | 23.8 | 12.3 | −2.57                                  | −4.45                                 | –   |
| Rep. of Korea        | 11.4                         | 26.7  | 43.4  | 17.1                            | 25.2 | 25.5 | 3.77                                   | 5.42                                  | 30.9  |
| Taiwan               | 12.8                         | 22.4  | 33.6  | 28.3                            | 28.8 | 39.5 | 2.53                                   | 3.88                                  | 52.2  |
| AFTA                 | 28.5                         | 82.9  | 131.2 | 24.7                            | 35.0 | 40.6 | 4.15                                   | 6.21                                  | 49.4  |
| Indonesia            | 0.6                          | 1.7   | 4.3   | 3.7                             | 7.4  | 13.9 | 2.58                                   | 8.09                                  | 25.1  |
| Malaysia             | 10                           | 23.5  | 33.9  | 38.7                            | 42.6 | 42.7 | 4.53                                   | 4.94                                  | 44.6  |
| Philippines          | 0.8                          | 8.8   | 20.7  | 19.8                            | 52.5 | 63.8 | 8.57                                   | 13.71                                 | 70.1  |
| Singapore            | 13                           | 39.4  | 56.5  | 27.0                            | 39.7 | 46.7 | 3.70                                   | 5.97                                  | 59.7  |
| Thailand             | 4.1                          | 9.5   | 15.8  | 19.1                            | 23.4 | 26.7 | 4.08                                   | 5.47                                  | 31.0  |
| South Asia           | 0.6                          | 1     | 2.6   | 2.6                             | 4.9  | 4.0  | 4.17                                   | 5.96                                  | 4.8   |
| CER                  | 0.3                          | 4     | 3.8   | 13.2                            | 18.9 | 17.3 | 9.37                                   | 10.54                                 | 17.8  |
| NAFTA                | 113.5                        | 182.4 | 225.5 | 25.3                            | 27.2 | 25.6 | 2.70                                   | 2.75                                  | 25.9  |
| USA                  | 91                           | 146.2 | 170.6 | 26.8                            | 30.5 | 29.2 | 2.17                                   | 2.51                                  | 32.5  |
| Mexico               | 6.7                          | 13.1  | 28    | 20.7                            | 19.4 | 21.1 | 5.73                                   | 5.81                                  | 21.2  |
| MERCOSUR             | 2.5                          | 3.8   | 4.9   | 13.1                            | 13.5 | 12.2 | 2.98                                   | 2.69                                  | 11.4  |
| Andean Pact          | 0.2                          | 0.2   | 0.4   | 5.0                             | 4.1  | 5.6  | 2.32                                   | 2.77                                  | 6.4   |
| Europe               | 202.4                        | 277.5 | 379.5 | 15.5                            | 16.2 | 16.6 | 2.24                                   | 2.51                                  | 18.1  |
| EU                   | 192.1                        | 258.5 | 337.5 | 15.9                            | 17.7 | 16.7 | 2.05                                   | 2.25                                  | 17.9  |
| Eastern Europe       | 1.5                          | 6.9   | 25.4  | 9.1                             | 13.5 | 20.2 | 8.35                                   | 11.82                                 | 21.9  |
| Rest of Europe       | 8.8                          | 12.2  | 16.7  | 11.1                            | 12.3 | 11.7 | 2.35                                   | 2.56                                  | 12.4  |
| World                | 438.9                        | 728.6 | 986.9 | 18.5                            | 20.8 | 22.0 | 2.54                                   | 3.25                                  | 26.0  |
| Developed countries  | 375.9                        | 552.4 | 677.5 | 18.6                            | 20.4 | 20.2 | 2.02                                   | 2.35                                  | 22.6  |
| Developing countries | 63.0                         | 176.2 | 309.4 | 18.0                            | 22.0 | 27.5 | 4.72                                   | 6.49                                  | 31.8  |

Table 2 (Continued)

| Country/region       | Value of P&C<br>(\$ billion) |       |       | Share of P&C in<br>mfg. exports |      |      | Growth of mfg.<br>exports | Growth of P&C<br>exports | Contribution of P&C to<br>growth of mfg. exports |
|----------------------|------------------------------|-------|-------|---------------------------------|------|------|---------------------------|--------------------------|--|
|                      | 1992                         | 1996  | 2003  | 1992                            | 1996 | 2003 | 1992–2003                 | 1992–2003                | 1992–2003  |
| <b>(b) Imports</b>   |                              |       |       |                                 |      |      |                           |                          |  |
| East Asia            | 95.3                         | 226.5 | 372.6 | 21.4                            | 31.3 | 35.3 | 3.46                      | 5.53                     | 45.6   |
| Japan                | 14.1                         | 31.3  | 46.2  | 14.2                            | 19.3 | 21.5 | 3.09                      | 4.80                     | 27.8   |
| Developing East Asia | 81.4                         | 190.9 | 326.7 | 23.5                            | 34.0 | 38.9 | 3.55                      | 5.64                     | 49.8   |
| China                | 10.6                         | 20.8  | 105.3 | 17.6                            | 21.1 | 34.3 | 6.64                      | 9.49                     | 38.4   |
| Hong Kong SAR        | 7.2                          | 13.0  | 5.1   | 28.1                            | 31.6 | 44.2 | −3.10                     | −1.35                    | –  |
| Rep. of Korea        | 12.2                         | 22.6  | 35.5  | 25.2                            | 27.4 | 33.6 | 3.13                      | 4.31                     | 40.7   |
| Taiwan               | 12.4                         | 27.5  | 55.5  | 16.9                            | 35.0 | 37.3 | 2.83                      | 6.10                     | 57.1   |
| AFTA                 | 39.2                         | 102.4 | 125.5 | 28.2                            | 39.3 | 47.1 | 2.60                      | 4.70                     | 67.7   |
| Indonesia            | 3.6                          | 6.7   | 3.1   | 18.5                            | 23.8 | 18.5 | −0.59                     | −0.59                    | 18.5   |
| Malaysia             | 11.0                         | 27.1  | 36.5  | 35.2                            | 47.5 | 55.7 | 2.97                      | 4.85                     | 74.4   |
| Philippines          | 1.9                          | 10.9  | 19.1  | 24.8                            | 43.6 | 63.1 | 5.57                      | 9.54                     | 76.1   |
| Singapore            | 16.0                         | 50.3  | 49.6  | 30.0                            | 42.8 | 49.2 | 2.55                      | 4.57                     | 70.8   |
| Thailand             | 6.8                          | 20.9  | 17.2  | 24.7                            | 32.9 | 32.5 | 2.61                      | 3.73                     | 41.0   |
| South Asia           | 3.0                          | 3.8   | 6.8   | 14.1                            | 14.6 | 12.6 | 3.74                      | 3.28                     | 11.6   |
| CER                  | 1.1                          | 9.0   | 10.0  | 14.6                            | 15.2 | 12.1 | 9.92                      | 9.11                     | 11.8   |
| NAFTA                | 104.2                        | 183.9 | 232.7 | 18.9                            | 23.6 | 17.7 | 3.49                      | 3.22                     | 16.8   |
| USA                  | 71.9                         | 126.0 | 150.3 | 17.5                            | 21.7 | 15.4 | 3.47                      | 2.95                     | 13.9   |
| Mexico               | 8.0                          | 20.7  | 41.1  | 18.7                            | 30.6 | 28.7 | 4.89                      | 6.67                     | 33.0   |
| MERCOSUR             | 4.7                          | 11.0  | 10.5  | 17.9                            | 17.2 | 21.5 | 2.48                      | 3.22                     | 25.7   |
| Andean Pact          | 2.2                          | 2.0   | 2.1   | 12.6                            | 9.7  | 9.1  | 1.11                      | −0.18                    | −1.8   |
| Europe               | 190.3                        | 267.0 | 363.4 | 15.0                            | 16.6 | 17.4 | 1.99                      | 2.59                     | 21.1   |
| EU-15                | 177.3                        | 242.0 | 315.9 | 15.3                            | 18.9 | 17.6 | 1.74                      | 2.31                     | 21.8   |
| Eastern Europe       | 1.9                          | 10.1  | 28.8  | 9.2                             | 14.3 | 20.3 | 7.91                      | 11.33                    | 22.2   |
| Rest of Europe       | 11.1                         | 14.9  | 18.7  | 12.6                            | 12.5 | 12.3 | 2.18                      | 2.08                     | 11.9   |
| World                | 447.0                        | 735.1 | 983.4 | 19.0                            | 20.4 | 20.3 | 2.90                      | 3.16                     | 21.5   |
| Developed countries  | 299.0                        | 462.4 | 582.5 | 16.1                            | 18.4 | 17.0 | 2.45                      | 2.67                     | 18.1   |
| Developing countries | 148.0                        | 272.7 | 400.9 | 30.1                            | 25.1 | 28.2 | 4.28                      | 4.01                     | 27.2   |

Note: 1. By definition, percentage shares in exports and imports for a given year should be identical. The minor differences seem to reflect recording errors and differences in measurement arising from the use of CIF price for reporting imports and FOB price for reporting exports. (–) Not applicable. Source: Compiled from UN Comtrade database.

across these years. It is evident that the share of component trade for East Asia as a group compares well with most other regions in the world. In 2003, components accounted for 27.5 percent of total manufacturing exports from developing East Asia, compared to the world average of 22.0 percent, 16.7 percent for the EU and 25.6 percent for NAFTA. Of the total increase in manufactured exports from East Asia between 1992 and 2003, over one third came from components exports. The comparable figures for the EU and NAFTA were 17.9 percent and 25.9 percent, respectively. Within East Asia, countries belonging to AFTA, in particular Malaysia, the Philippines, Singapore and Thailand, stand out for their heavy dependence on production fragmentation for export dynamism. In 2003, parts and components accounted for 40.6 percent of total manufacturing exports in AFTA, up from 24.7 percent in 1992. Over this period, the share of components in total manufacturing exports more than tripled in China (from 5.5 percent to 15.2 percent). Interestingly, even for Taiwan and Korea, the relative importance of components in total manufacturing exports (and imports) has increased over the years, contradicting the popular belief that these countries had shifted from component production to final good production.

In all countries/regions, component trade is heavily concentrated in the machinery and transport equipment sector (SITC 7) (Table 3). This sector accounts for over 90 percent of the combined component trade of SITC 7 and SITC 8 (miscellaneous manufacturing). Within SITC 7, both component exports and imports of East Asia are heavily concentrated in electronics and electrical industries. Semiconductors and other electronics components (components within SITC 776) alone accounted for 40 percent of components exports from East Asia in 2003. Adding to these items components of telecommunication equipment (SITC 764) and office and automated data processing machines (SITC 759), increases the concentration ratio to almost 90 percent of total exports of components. The balance consists largely of electrical machinery (SITC 778) and auto parts (SITC 784). The degree of concentration of components trade in electronics is much larger in AFTA (over 60 percent) than the regional average. Electronics also dominate component trade in other countries/regions. But trade patterns of these countries/regions are characterized by a greater presence of other items such as engines and motors (SITC 714), specialized industrial machinery (SITC 728), internal combustion machines (SITC 713) for which transportation cost is presumably an important locational consideration. Overall, these differences are consistent with East Asia's competitive edge in component specialization in electrical and electronic industries.

Table 4 compares regional patterns of total manufacturing trade and trade in components. In terms of conventional trade data, intra-regional manufacturing trade (export + imports) in East Asia is significant and growing rapidly. The share of total intra-regional trade in East Asia increased from 44.1 percent in 1992 to 53.2 percent in 2003. Intra-regional trade in developing East Asia increased from 35.1 percent to 40.1 percent over this period. For AFTA, the numbers are much smaller, but they point to an impressive, persistent increase over the years from 16.6 percent to 21.3 percent. By contrast, intra-regional trade has declined (from 65.4 percent to 51.7 percent) in EU and increased marginally (from 39.0 percent to 43.3 percent) in NAFTA.

Unlike the EU and NAFTA, the overall East Asian intra-regional trade ratio camouflages a significant asymmetry in regional trade patterns in imports and exports. In 2003, intra-regional import flows amounted to 65.6 percent of total manufacturing imports of East Asia, up from 55.2 percent in 1992. The intra-regional share in total regional exports was significantly lower, 36.6 percent in 1992 and 45.6 percent in 2003. In other words, the region is much more heavily dependent on extra-regional trade for its growth dynamism than is suggested by the total regional trade share, and this dependence has remained virtually unchanged for the last decade.

This imbalance in intra-regional trade is largely a reflection of the unique nature of Japan's involvement in fragmentation trade in East Asia. As already noted, Japan relies on the rest of East

Table 3  
Percentage composition of parts and components exports and imports by two-digit SITC Categories<sup>a</sup>, 2003

| SITC code          | Product  | East Asia |       |       |       |      | NAFTA |        | EU   | World |
|--------------------|--|-----------|-------|-------|-------|------|-------|--------|------|-------|
|                    |  | Total     | Japan | Korea | China | AFTA | Total | Mexico |      |       |
| <b>(a) Exports</b> |  |           |       |       |       |      |       |        |      |       |
| 7                  | Machinery and transport equipment                            | 96.1      | 94.4  | 98.8  | 96    | 98.1 | 93.8  | 97     | 94.5 | 94.6  |
| 71                 | Power-generating machinery and equipment                     | 1.3       | 2.8   | 1.1   | 0.7   | 0.7  | 4.6   | 11.3   | 6.2  | 4.0   |
| 72                 | Specialized industrial machinery                             | 2.2       | 2.9   | 2.8   | 2.0   | 1.8  | 4.9   | 3.1    | 7.6  | 5.2   |
| 73                 | Metalworking machinery                                       | 0.5       | 1.0   | 0.4   | 0.5   | 0.1  | 0.8   | 0.2    | 1.4  | 1.0   |
| 74                 | General industrial machinery                                 | 2.0       | 3.0   | 1.4   | 3.0   | 1.1  | 4.4   | 7.5    | 7.2  | 4.5   |
| 75                 | Office machines and automatic data-processing machines       | 18.3      | 12.3  | 19.1  | 30.8  | 17.1 | 10.0  | 0.2    | 9.3  | 13.1  |
| 76                 | Telecommunications and sound-recording equipment             | 12.4      | 8.3   | 14.5  | 21.9  | 5.3  | 6.0   | 12.7   | 5.4  | 8.2   |
| 77                 | Electrical machinery, apparatus and appliances               | 50.1      | 43.8  | 50.2  | 29.8  | 67.3 | 32.4  | 53.7   | 26.7 | 36.9  |
| 78                 | Road vehicles  | 8.4       | 18.8  | 8.7   | 6.4   | 3.1  | 21.0  | 6.1    | 23.4 | 17.0  |
| 79                 | Other transport equipment                                    | 1.1       | 1.4   | 0.5   | 0.8   | 1.5  | 9.7   | 2.2    | 7.3  | 4.8   |
| 8                  | Miscellaneous manufactured articles                          | 3.9       | 5.6   | 1.2   | 4     | 1.9  | 6     | 2.9    | 5.5  | 5.4   |
| 81                 | Prefabricated buildings fixtures and fittings                | 0.1       | –     | 0.1   | 0.4   | –    | 0.1   | –      | 0.6  | 0.3   |
| 82                 | Furniture, and parts thereof                                 | 0.2       | 0.4   | 0.2   | 0.4   | 0.1  | 2.2   | 1.1    | 1.1  | 1.3   |
| 84                 | Apparel and clothing accessories                             | 0.2       | –     | 0.1   | 0.4   | –    | 0.1   | 0.1    | 0.1  | 0.2   |
| 87                 | Professional, scientific instruments.                        | 1.3       | 2.9   | 0.3   | 0.7   | 0.8  | 3.1   | 0.6    | 2.4  | 2.0   |
| 88                 | Photographic apparatus, optical goods and watches and clocks | 1.9       | 2.1   | 0.4   | 1.8   | 0.9  | 0.4   | 0.2    | 0.8  | 1.1   |
| 89                 | Miscellaneous manufactured articles, n.e.s.                  | 0.2       | 0.2   | 0.2   | 0.4   | 0.1  | 1.6   | 0.9    | 0.6  | 0.5   |
| 7 + 8              | Total  | 100       | 100   | 100   | 100   | 100  | 100   | 100    | 100  | 100   |
|                    | U.S.\$ billion   | 399       | 114   | 43    | 59    | 132  | 162   | 17     | 340  | 1047  |
| <b>(b) Imports</b> |  |           |       |       |       |      |       |        |      |       |
| 7                  | Machinery and transport equipment                            | 96        | 91.5  | 95.7  | 97.5  | 97.3 | 93.5  | 95.4   | 93.8 | 94.6  |
| 71                 | Power-generating machinery and equipment                     | 1.9       | 2.2   | 2.6   | 2.2   | 1.8  | 5.3   | 5.1    | 5.8  | 4.6   |
| 72                 | Specialized industrial machinery                             | 2.7       | 3.2   | 2.3   | 2.4   | 3.2  | 3.1   | 1.6    | 5.4  | 4.3   |
| 73                 | Metalworking machinery                                       | 0.6       | 0.7   | 0.8   | 0.9   | 0.4  | 0.5   | 0.3    | 1.1  | 0.9   |
| 74                 | General industrial machinery                                 | 1.8       | 3.0   | 2.0   | 1.6   | 1.7  | 5.4   | 3.3    | 6.0  | 4.2   |
| 75                 | Office machines and automatic data-processing machines       | 13.6      | 16.1  | 5.6   | 11.3  | 15.9 | 13.8  | 11.5   | 13.4 | 13.5  |
| 76                 | Telecommunications and sound-recording equipment             | 9.7       | 10.4  | 6.8   | 11.3  | 4.1  | 6.6   | 8.4    | 5.6  | 7.4   |
| 77                 | Electrical machinery, apparatus and appliances               | 59.6      | 46.0  | 69.5  | 60.6  | 63.9 | 27.2  | 40.9   | 26.2 | 39.1  |
| 78                 | Road vehicles  | 4.8       | 7.1   | 5.1   | 6.1   | 4.4  | 26.6  | 22.4   | 23.8 | 16.9  |
| 79                 | Other transport equipment                                    | 1.4       | 2.7   | 1.0   | 1.2   | 1.8  | 6.2   | 2.7    | 6.4  | 3.7   |
| 8                  | Miscellaneous manufactured articles                          | 4.0       | 8.5   | 4.3   | 2.5   | 2.7  | 6.4   | 4.6    | 6.2  | 5.4   |
| 81                 | Prefabricated buildings fixtures and fittings                | 0.1       | 0.2   | 0.1   | –     | –    | 0.4   | 0.1    | 0.8  | 0.4   |
| 82                 | Furniture, and parts thereof                                 | 0.3       | 1.2   | 0.3   | 0.2   | 0.1  | 2.9   | 1.4    | 1.7  | 1.4   |
| 84                 | Apparel and clothing accessories                             | 0.2       | –     | –     | 0.1   | 0.1  | 0.1   | 0.1    | –    | 0.1   |
| 87                 | Professional, scientific instruments.                        | 1.4       | 3.8   | 2.2   | 0.7   | 1.2  | 1.7   | 1.4    | 2.2  | 1.8   |
| 88                 | Photographic apparatus, optical goods and watches/clocks     | 1.7       | 2.1   | 0.9   | 1.4   | 1.2  | 0.6   | 0.3    | 0.8  | 1.1   |
| 89                 | Miscellaneous manufactured articles, n.e.s.                  | 0.3       | 1.2   | 0.8   | 0.1   | 0.1  | 0.7   | 1.3    | 0.7  | 0.6   |
|                    | Total (SITC 7 + 8)   | 100       | 100   | 100   | 100   | 100  | 100   | 100    | 100  | 100   |
|                    | U.S.\$ billion   | 367       | 46    | 35    | 105   | 126  | 233   | 41     | 317  | 1047  |

Notes: (–) Zero or negligible (less than 0.05 percent); Source: Compiled from UN Comtrade database.

<sup>a</sup> 5-digit SITC parts and components items aggregated at the 2-digit level.

Table 4  
Direction of parts and components trade

| Exports                          |      | A 1: Total manufacturing exports (X) |       |      |      |      |       |      |       | B1: Parts and components exports (X) |       |      |      |      |       |      |       |
|----------------------------------|------|--------------------------------------|-------|------|------|------|-------|------|-------|--------------------------------------|-------|------|------|------|-------|------|-------|
|                                  |      | EA                                   | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total | EA                                   | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total |
| East Asia (EA) <sup>1</sup>      | 1992 | 36.6                                 | 4.7   | 31.9 | 17.1 | 11.5 | 30.3  | 19.6 | 100   | 44.4                                 | 4.2   | 40.3 | 13.3 | 22.0 | 34.1  | 15.7 | 100   |
|                                  | 1996 | 43.8                                 | 7.4   | 36.5 | 16.4 | 15.9 | 27.6  | 16.6 | 100   | 52.3                                 | 6.3   | 45.9 | 13.9 | 27.5 | 29.1  | 14.3 | 100   |
|                                  | 2003 | 45.6                                 | 7.4   | 38.2 | 22.2 | 11.6 | 25.8  | 15.7 | 100   | 64.9                                 | 7.0   | 57.9 | 31.8 | 20.7 | 17.7  | 12.1 | 100   |
| Japan                            | 1992 | 25.1                                 | 0.0   | 25.1 | 9.0  | 11.2 | 32.7  | 20.8 | 100   | 30.2                                 | 0.0   | 30.2 | 6.7  | 16.7 | 36.6  | 16.6 | 100   |
|                                  | 1996 | 34.4                                 | 0.0   | 34.4 | 10.7 | 17.0 | 30.8  | 16.2 | 100   | 39.8                                 | 0.0   | 39.8 | 9.2  | 23.8 | 32.9  | 13.5 | 100   |
|                                  | 2003 | 35.9                                 | 0.0   | 35.9 | 17.8 | 11.5 | 28.7  | 14.9 | 100   | 49.6                                 | 0.0   | 49.6 | 23.6 | 18.3 | 24.0  | 12.5 | 100   |
| Developing                       | 1992 | 44.0                                 | 8.6   | 35.5 | 23.2 | 11.0 | 25.9  | 17.1 | 100   | 55.7                                 | 8.8   | 46.9 | 19.5 | 25.3 | 26.2  | 12.3 | 100   |
| East Asia (DEA)                  | 1996 | 46.8                                 | 11.5  | 35.3 | 19.0 | 14.4 | 24.1  | 16.0 | 100   | 57.3                                 | 10.6  | 46.6 | 16.4 | 27.8 | 23.7  | 13.7 | 100   |
|                                  | 2003 | 47.3                                 | 10.1  | 37.2 | 23.2 | 11.2 | 23.7  | 15.4 | 100   | 68.2                                 | 9.6   | 58.7 | 34.0 | 20.5 | 14.4  | 11.4 | 100   |
| Greater China (GCH) <sup>2</sup> | 1992 | 56.4                                 | 2.7   | 53.8 | 45.3 | 6.5  | 19.1  | 14.7 | 100   | 80.5                                 | 28.1  | 52.4 | 25.0 | 10.6 | 14.6  | 14.8 | 100   |
|                                  | 1996 | 46.2                                 | 8.8   | 37.4 | 26.5 | 7.5  | 25.9  | 18.8 | 100   | 83.0                                 | 31.7  | 51.3 | 15.1 | 14.7 | 14.7  | 13.7 | 100   |
|                                  | 2003 | 39.1                                 | 8.7   | 30.4 | 19.0 | 6.9  | 27.7  | 20.9 | 100   | 95.6                                 | 26.5  | 69.1 | 16.0 | 23.6 | 8.6   | 11.0 | 100   |
| AFTA                             | 1992 | 36.8                                 | 8.8   | 28.0 | 7.1  | 19.3 | 27.2  | 19.7 | 100   | 47.3                                 | 9.0   | 38.3 | 7.1  | 29.3 | 28.3  | 13.7 | 100   |
|                                  | 1996 | 45.0                                 | 11.1  | 33.9 | 8.2  | 23.6 | 23.5  | 16.0 | 100   | 51.8                                 | 9.5   | 42.3 | 7.7  | 32.6 | 22.6  | 14.3 | 100   |
|                                  | 2003 | 48.0                                 | 10.0  | 38.0 | 13.5 | 21.3 | 20.7  | 14.2 | 100   | 60.0                                 | 9.3   | 50.6 | 17.8 | 28.3 | 14.5  | 12.4 | 100   |
| NAFTA                            | 1992 | 16.3                                 | 6.5   | 9.8  | 3.0  | 4.6  | 44.6  | 20.2 | 100   | 18.6                                 | 5.9   | 12.7 | 2.6  | 7.4  | 46.2  | 18.8 | 100   |
|                                  | 1996 | 18.6                                 | 6.8   | 11.8 | 3.2  | 5.6  | 48.0  | 16.0 | 100   | 23.9                                 | 7.3   | 16.6 | 3.2  | 9.8  | 43.5  | 17.0 | 100   |
|                                  | 2003 | 14.9                                 | 4.4   | 10.5 | 3.8  | 4.5  | 55.2  | 14.4 | 100   | 23.2                                 | 4.5   | 18.8 | 5.2  | 10.0 | 48.6  | 13.8 | 100   |
| EU                               | 1992 | 5.8                                  | 1.9   | 3.9  | 1.5  | 1.8  | 8.2   | 64.1 | 100   | 6.3                                  | 1.2   | 5.1  | 1.8  | 2.7  | 9.2   | 62.1 | 100   |
|                                  | 1996 | 8.0                                  | 2.4   | 5.7  | 2.1  | 2.6  | 8.4   | 59.4 | 100   | 9.6                                  | 1.6   | 7.9  | 2.3  | 4.4  | 10.1  | 55.9 | 100   |
|                                  | 2003 | 6.7                                  | 1.7   | 5.0  | 2.6  | 1.6  | 11.4  | 50.8 | 100   | 9.9                                  | 1.4   | 8.5  | 4.1  | 3.5  | 10.1  | 49.1 | 100   |
| World                            | 1992 | 15.4                                 | 3.4   | 12.0 | 5.8  | 4.7  | 20.6  | 42.9 | 100   | 18.9                                 | 3.1   | 15.8 | 4.9  | 8.7  | 25.0  | 37.3 | 100   |
|                                  | 1996 | 19.3                                 | 4.4   | 14.9 | 6.2  | 6.6  | 21.2  | 37.6 | 100   | 22.9                                 | 4.4   | 18.5 | 1.5  | 9.9  | 48.3  | 13.8 | 100   |
|                                  | 2003 | 19.0                                 | 3.7   | 15.3 | 8.5  | 4.9  | 23.5  | 32.9 | 100   | 32.3                                 | 4.0   | 28.3 | 14.4 | 10.9 | 21.0  | 26.8 | 100   |

Table 4 (Continued)

| Imports                          |      | A2: Total manufacturing imports (M) |       |      |      |      |       |      |       | B2: Parts and components imports (M) |       |      |      |      |       |      |       |
|----------------------------------|------|-------------------------------------|-------|------|------|------|-------|------|-------|--------------------------------------|-------|------|------|------|-------|------|-------|
|                                  |      | EA                                  | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total | EA                                   | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total |
| East Asia (EA) <sup>2</sup>      | 1992 | 55.2                                | 21.2  | 34.1 | 19.5 | 9.7  | 20.4  | 19.2 | 100   | 59.3                                 | 28.3  | 31.0 | 9.8  | 16.5 | 25.2  | 13.6 | 100   |
|                                  | 1996 | 55.7                                | 19.7  | 35.9 | 17.3 | 13.1 | 20.7  | 19.1 | 100   | 59.7                                 | 26.3  | 33.3 | 7.9  | 18.8 | 25.2  | 13.2 | 100   |
|                                  | 2003 | 65.6                                | 18.1  | 47.0 | 22.7 | 16.4 | 15.3  | 15.5 | 100   | 69.7                                 | 22.0  | 47.7 | 14.5 | 24.6 | 17.0  | 10.9 | 100   |
| Japan                            | 1992 | 29.0                                | 0.0   | 29.0 | 11.9 | 9.5  | 30.9  | 27.3 | 100   | 26.9                                 | 0.0   | 26.9 | 4.0  | 13.7 | 49.4  | 14.6 | 100   |
|                                  | 1996 | 36.8                                | 0.0   | 36.8 | 17.4 | 13.8 | 29.0  | 22.5 | 100   | 37.0                                 | 0.0   | 37.0 | 8.3  | 17.2 | 42.9  | 10.3 | 100   |
|                                  | 2003 | 49.5                                | 0.0   | 49.5 | 29.8 | 14.0 | 20.2  | 18.2 | 100   | 52.8                                 | 0.0   | 52.8 | 18.7 | 21.4 | 23.2  | 9.4  | 100   |
| Developing                       | 1992 | 61.9                                | 27.1  | 34.8 | 21.3 | 9.5  | 16.6  | 16.3 | 100   | 64.5                                 | 33.1  | 31.4 | 10.8 | 16.8 | 20.4  | 13.2 | 100   |
| East Asia (DEA)                  | 1996 | 59.9                                | 25.5  | 34.4 | 16.7 | 12.3 | 17.6  | 17.5 | 100   | 62.9                                 | 31.0  | 31.9 | 7.7  | 18.7 | 21.3  | 13.6 | 100   |
|                                  | 2003 | 66.9                                | 22.8  | 44.1 | 20.1 | 16.2 | 13.6  | 14.3 | 100   | 70.7                                 | 24.9  | 45.8 | 13.6 | 24.4 | 15.7  | 10.9 | 100   |
| Greater China (GCH) <sup>2</sup> | 1992 | 78.9                                | 34.1  | 44.7 | 28.0 | 4.3  | 8.4   | 18.1 | 100   | 80.5                                 | 28.1  | 52.4 | 25.0 | 10.6 | 14.6  | 14.8 | 100   |
|                                  | 1996 | 71.7                                | 25.2  | 46.5 | 25.1 | 6.4  | 10.8  | 25.0 | 100   | 83.0                                 | 31.7  | 51.3 | 15.1 | 14.7 | 14.7  | 13.7 | 100   |
|                                  | 2003 | 74.2                                | 26.1  | 48.0 | 22.8 | 5.9  | 8.4   | 22.7 | 100   | 95.6                                 | 26.5  | 69.1 | 16.0 | 23.6 | 8.6   | 11.0 | 100   |
| AFTA                             | 1992 | 52.7                                | 29.0  | 23.7 | 4.8  | 14.4 | 18.5  | 17.6 | 100   | 60.4                                 | 31.2  | 29.2 | 3.9  | 21.0 | 20.4  | 12.5 | 100   |
|                                  | 1996 | 53.8                                | 26.3  | 27.5 | 5.8  | 17.1 | 18.1  | 17.4 | 100   | 59.4                                 | 28.0  | 31.4 | 4.5  | 21.5 | 20.9  | 12.7 | 100   |
|                                  | 2003 | 58.7                                | 20.0  | 38.7 | 12.0 | 21.4 | 16.6  | 12.5 | 100   | 59.6                                 | 19.7  | 39.9 | 9.9  | 24.8 | 19.8  | 10.0 | 100   |
| NAFTA                            | 1992 | 35.7                                | 19.2  | 16.5 | 7.0  | 6.1  | 34.4  | 18.0 | 100   | 34.7                                 | 22.5  | 12.2 | 1.9  | 7.2  | 42.7  | 14.1 | 100   |
|                                  | 1996 | 33.7                                | 14.9  | 18.8 | 8.0  | 7.8  | 38.5  | 16.7 | 100   | 38.4                                 | 19.4  | 19.0 | 2.9  | 10.4 | 39.5  | 13.1 | 100   |
|                                  | 2003 | 33.8                                | 10.1  | 23.7 | 14.3 | 6.1  | 35.3  | 18.0 | 100   | 35.1                                 | 13.4  | 21.7 | 7.9  | 9.6  | 41.5  | 13.8 | 100   |
| EU                               | 1992 | 11.8                                | 6.3   | 5.5  | 2.6  | 2.0  | 8.6   | 66.8 | 100   | 11.2                                 | 7.3   | 3.9  | 0.7  | 2.5  | 11.9  | 67.4 | 100   |
|                                  | 1996 | 12.4                                | 5.1   | 7.3  | 3.3  | 3.0  | 9.5   | 63.5 | 100   | 15.2                                 | 7.2   | 8.0  | 1.4  | 4.8  | 14.3  | 59.7 | 100   |
|                                  | 2003 | 14.7                                | 4.1   | 10.6 | 6.2  | 3.0  | 9.0   | 52.8 | 100   | 16.7                                 | 5.3   | 11.4 | 4.2  | 5.5  | 11.2  | 52.8 | 100   |
| World                            | 1992 | 24.8                                | 12.0  | 12.8 | 6.5  | 4.2  | 17.4  | 44.9 | 100   | 27.1                                 | 15.4  | 11.7 | 3.0  | 6.5  | 23.6  | 40.3 | 100   |
|                                  | 1996 | 26.2                                | 10.4  | 15.8 | 7.3  | 6.0  | 19.5  | 40.3 | 100   | 34.5                                 | 13.2  | 21.4 | 0.5  | 9.4  | 40.7  | 14.8 | 100   |
|                                  | 2003 | 29.4                                | 8.5   | 20.9 | 11.5 | 6.2  | 17.3  | 34.3 | 100   | 36.8                                 | 12.1  | 24.7 | 8.2  | 12.0 | 19.5  | 27.8 | 100   |

Table 4 (Continued)

| Trade (M + X)                    |      | A3: Total manufacturing trade (M + X) |       |      |      |      |       |      |       | B3: Parts and components trade (M + X) |       |      |      |      |       |      |       |
|----------------------------------|------|---------------------------------------|-------|------|------|------|-------|------|-------|--|-------|------|------|------|-------|------|-------|
|                                  |      | EA                                    | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total | EA                                     | Japan | DEA  | GCH  | AFTA | NAFTA | EU   | Total |
| East Asia (EA) <sup>1</sup>      | 1992 | 44.1                                  | 11.2  | 32.8 | 18.0 | 10.9 | 26.4  | 19.5 | 100   | 50.9                                   | 14.5  | 36.4 | 11.8 | 19.7 | 30.3  | 14.8 | 100   |
|                                  | 1996 | 50.1                                  | 12.8  | 36.2 | 16.8 | 14.8 | 24.6  | 17.7 | 100   | 55.7                                   | 15.4  | 40.3 | 11.2 | 23.6 | 27.3  | 13.8 | 100   |
|                                  | 2003 | 53.2                                  | 11.7  | 41.4 | 22.4 | 13.7 | 21.6  | 15.6 | 100   | 67.3                                   | 13.8  | 53.5 | 23.9 | 22.7 | 17.4  | 11.5 | 100   |
| Japan                            | 1992 | 26.1                                  | 0.0   | 26.1 | 9.7  | 10.8 | 32.2  | 22.4 | 100   | 29.6                                   | 0.0   | 29.6 | 6.3  | 16.2 | 38.7  | 16.3 | 100   |
|                                  | 1996 | 35.2                                  | 0.0   | 35.2 | 12.9 | 15.9 | 30.2  | 18.3 | 100   | 39.1                                   | 0.0   | 39.1 | 9.0  | 22.3 | 35.2  | 12.7 | 100   |
|                                  | 2003 | 40.5                                  | 0.0   | 40.5 | 21.8 | 12.3 | 25.8  | 16.0 | 100   | 50.5                                   | 0.0   | 50.5 | 22.2 | 19.2 | 23.8  | 11.6 | 100   |
| Developing                       | 1992 | 52.7                                  | 17.6  | 35.1 | 22.3 | 10.2 | 21.4  | 16.7 | 100   | 60.8                                   | 22.7  | 38.0 | 14.5 | 20.4 | 22.9  | 12.8 | 100   |
| East Asia (DEA)                  | 1996 | 53.2                                  | 18.3  | 34.9 | 17.9 | 13.4 | 20.9  | 16.7 | 100   | 60.3                                   | 21.7  | 38.6 | 11.7 | 22.8 | 22.4  | 13.6 | 100   |
|                                  | 2003 | 55.6                                  | 15.5  | 40.1 | 21.9 | 13.3 | 19.4  | 15.0 | 100   | 69.5                                   | 17.3  | 52.2 | 23.7 | 22.5 | 15.0  | 11.1 | 100   |
| Greater China (GCH) <sup>2</sup> | 1992 | 71.3                                  | 23.6  | 47.8 | 33.8 | 5.1  | 12.0  | 17.0 | 100   | 33.9                                   | 15.8  | 18.0 | 4.8  | 7.1  | 24.5  | 41.0 | 100   |
|                                  | 1996 | 62.7                                  | 19.4  | 43.3 | 25.6 | 6.8  | 16.2  | 22.8 | 100   | 41.3                                   | 15.9  | 25.4 | 5.6  | 10.6 | 25.5  | 33.1 | 100   |
|                                  | 2003 | 57.9                                  | 18.1  | 39.8 | 21.0 | 6.3  | 17.3  | 21.8 | 100   | 50.4                                   | 12.7  | 37.7 | 13.5 | 13.0 | 20.5  | 28.3 | 100   |
| AFTA                             | 1992 | 45.5                                  | 19.9  | 25.6 | 5.8  | 16.6 | 22.4  | 18.6 | 100   | 54.9                                   | 21.8  | 33.0 | 5.3  | 24.5 | 23.8  | 13.0 | 100   |
|                                  | 1996 | 49.7                                  | 19.1  | 30.6 | 6.9  | 20.1 | 20.6  | 16.7 | 100   | 56.0                                   | 19.7  | 36.3 | 5.9  | 26.5 | 21.6  | 13.4 | 100   |
|                                  | 2003 | 52.9                                  | 14.5  | 38.3 | 12.8 | 21.3 | 18.8  | 13.4 | 100   | 59.8                                   | 14.4  | 45.4 | 13.9 | 26.6 | 17.1  | 11.2 | 100   |
| NAFTA                            | 1992 | 27.0                                  | 13.5  | 13.5 | 5.2  | 5.4  | 39.0  | 19.0 | 100   | 26.4                                   | 13.9  | 12.5 | 2.3  | 7.3  | 44.5  | 16.5 | 100   |
|                                  | 1996 | 26.9                                  | 11.3  | 15.6 | 5.8  | 6.8  | 42.8  | 16.4 | 100   | 31.2                                   | 13.4  | 17.8 | 3.0  | 10.1 | 41.5  | 15.1 | 100   |
|                                  | 2003 | 26.2                                  | 7.8   | 18.4 | 10.1 | 5.4  | 43.3  | 16.6 | 100   | 29.3                                   | 9.0   | 20.3 | 6.6  | 9.8  | 45.0  | 13.8 | 100   |
| EU                               | 1992 | 8.7                                   | 4.1   | 4.6  | 2.0  | 1.9  | 8.4   | 65.4 | 100   | 8.7                                    | 4.1   | 4.6  | 1.3  | 2.6  | 10.5  | 64.6 | 100   |
|                                  | 1996 | 10.0                                  | 3.6   | 6.4  | 2.7  | 2.8  | 8.9   | 61.3 | 100   | 12.3                                   | 4.3   | 7.9  | 1.8  | 4.6  | 12.2  | 57.7 | 100   |
|                                  | 2003 | 10.5                                  | 2.9   | 7.6  | 4.3  | 2.3  | 10.3  | 51.7 | 100   | 13.2                                   | 3.3   | 9.9  | 4.1  | 4.5  | 10.6  | 50.9 | 100   |
| World                            | 1992 | 20.1                                  | 7.7   | 12.4 | 6.1  | 4.5  | 19.0  | 43.9 | 100   | 22.8                                   | 9.0   | 13.9 | 4.0  | 7.7  | 24.3  | 38.7 | 100   |
|                                  | 1996 | 22.7                                  | 7.4   | 15.4 | 6.7  | 6.3  | 20.4  | 39.0 | 100   | 28.9                                   | 8.9   | 20.0 | 1.0  | 9.6  | 44.4  | 14.3 | 100   |
|                                  | 2003 | 24.2                                  | 6.1   | 18.1 | 10.0 | 5.6  | 20.4  | 33.6 | 100   | 34.5                                   | 8.0   | 26.5 | 11.3 | 11.4 | 20.3  | 27.3 | 100   |

Notes: (1) Including Japan (2) Hong Kong SAR + China + Taiwan; Source: Compiled from *UN Comtrade Database* using the commodity/country classification described in the text (Section 3).

Asia not only for component production, but as an assembly base to meet regional demand and, more importantly, to export to the rest of the world. Japan has persistently maintained a trade surplus with all East Asian countries in both total manufacturing trade and trade in components, of which the latter is much larger (data not reported for brevity).

Components trade accounts for a significant and growing share of intra-regional trade in manufacturing in East Asia, in both exports and imports. Moreover, the share of components in intra-regional trade is much larger than the comparable figures for the region's extra-regional trade (Table 4). In 2003, components accounted for 65 percent of intra-East Asian exports, compared to 46 percent of the region's total exports. The significance of component trade looms even larger for developing East Asia and, in particular, for the member countries of the ASEAN. According to country-level data (not reported here), cross-border component trade accounts for more than half of total imports and exports in Singapore, Malaysia and the Philippines, and more than a third in Thailand. Korea and Taiwan are also involved in sizable cross-border trade with the other countries in the region. For all East Asian countries, the share of components in both intra-regional exports and imports has increased at a much faster rate than in exports to and imports from countries outside the region.

So far, we have noted two important peculiarities of trade patterns in East Asia, compared to total global trade and trade of the EU and NAFTA. First, component trade has played a much more important role in trade expansion in East Asia relative to the overall global experience and to experiences of countries in other major regions. Second, trade in components accounts for a much larger share in intra-regional trade than in the region's trade with the rest of the world. Given these two peculiarities, trade flow analysis based on reported trade data is bound to yield a misleading picture of the relative importance of intra-regional trade (as against global trade) in the growth dynamism of East Asia (and AFTA and other subregional groupings therein). Data reported in Table 5 on intra-regional shares of trade in total manufacturing, components and final goods for various regional economic groupings underscore this important point.

The intra-regional share of final manufacturing trade in East Asia declined from 52.5 percent in 1992 to 47.6 percent in 2003, in sharp contrast to a notable increase (from 44.1 percent to 53.2 percent) recorded by the conventionally used trade share (which covers both components and final goods). While the difference between intra-regional shares of final and total trade is observable for both exports and imports, the magnitude of the difference is much larger on the export side. The difference in magnitude between regional trade shares estimated in gross and net terms is much larger for developing East Asia and ASEAN compared to estimates for the entire region. In 2003 only 30 percent of final goods exports from developing Asia found markets within the region, compared to 37.6 percent in total exports. For AFTA the relevant figures were 17.0 percent and 21.7 percent, respectively. Moreover, as already noted, for all East Asian countries Japan is a much smaller market for final goods exports, accounting for less than 10 percent in all cases in 2003, compared to the USA and the EU. It is also interesting to note that, unlike East Asia (or developing East Asia and AFTA), the estimated intra-regional trade shares for NAFTA, the EU and the other regional groupings are remarkably resilient to the inclusion or exclusion of component trade.

In sum, the estimates presented in this section support the hypothesis that, in a context where fragmentation-based trade is expanding rapidly, standard trade analysis can lead to misleading inferences regarding the on-going process of economic integration. Product fragmentation leads to double-counting of trade flows in published trade data, because goods in process cross multiple international borders in the course of their production sequence. The total amount of trade involving goods in process can be a multiple of the final value of these goods. Moreover, trade shares

Table 5  
Intra-regional trade shares: total manufacturing, parts and components, and final trade (percent), 1992, 1993 and 2003<sup>1</sup>

|                                |      | East Asia | Developing East Asia | AFTA | South Asia | CER  | NAFTA | EU   | CEEC | EFTA | MERCOSUR | ANDEAN |
|--------------------------------|------|-----------|----------------------|------|------------|------|-------|------|------|------|----------|--------|
| <b>A: Total manufacturing</b>  |      |           |                      |      |            |      |       |      |      |      |          |        |
| Exports (X)                    | 1992 | 36.6      | 35.6                 | 19.5 | 2.8        | 24.6 | 44.6  | 64.1 | 1.4  | 1.4  | 21.4     | 25.4   |
|                                | 1996 | 43.8      | 35.6                 | 23.8 | 3.3        | 25.5 | 48.0  | 59.4 | 6.8  | 1.7  | 34.5     | 35.5   |
|                                | 2003 | 45.6      | 37.6                 | 21.7 | 3.0        | 25.3 | 55.2  | 50.8 | 6.9  | 1.5  | 18.4     | 26.6   |
| Imports (M)                    | 1992 | 55.2      | 34.7                 | 14.4 | 2.1        | 5.5  | 34.4  | 66.8 | 1.1  | 1.4  | 15.3     | 3.9    |
|                                | 1996 | 55.7      | 34.7                 | 17.3 | 2.8        | 6.0  | 38.5  | 63.5 | 4.3  | 1.4  | 15.2     | 9.3    |
|                                | 2003 | 65.6      | 45.4                 | 22.7 | 3.0        | 5.3  | 35.3  | 52.8 | 5.4  | 1.4  | 14.0     | 8.5    |
| Trade (X + M)                  | 1992 | 44.1      | 35.3                 | 16.8 | 2.5        | 9.6  | 39.0  | 65.4 | 1.2  | 1.4  | 17.9     | 7.3    |
|                                | 1996 | 50.1      | 36.2                 | 21.5 | 3.1        | 10.5 | 42.8  | 61.3 | 5.3  | 1.5  | 21.1     | 14.8   |
|                                | 2003 | 53.2      | 40.4                 | 21.6 | 3.0        | 9.5  | 43.3  | 51.7 | 6.1  | 1.5  | 16.0     | 12.6   |
| <b>B: Parts and components</b> |      |           |                      |      |            |      |       |      |      |      |          |        |
| Exports (X)                    | 1992 | 44.4      | 46.9                 | 29.3 | 4.8        | 24.2 | 46.2  | 62.1 | 1.7  | 1.3  | 23.6     | 24.3   |
|                                | 1996 | 52.3      | 46.8                 | 32.7 | 4.6        | 22.5 | 43.5  | 55.9 | 5.5  | 1.5  | 36.8     | 24.4   |
|                                | 2003 | 64.9      | 58.9                 | 28.5 | 3.8        | 19.0 | 48.6  | 49.1 | 5.1  | 0.9  | 15.4     | 20.0   |
| Imports (M)                    | 1992 | 59.3      | 31.4                 | 21.0 | 0.9        | 4.4  | 42.7  | 67.4 | 1.0  | 1.2  | 14.7     | 1.5    |
|                                | 1996 | 59.7      | 32.0                 | 21.7 | 0.7        | 3.0  | 39.5  | 59.7 | 3.6  | 1.1  | 12.4     | 2.5    |
|                                | 2003 | 69.7      | 45.9                 | 24.9 | 1.2        | 3.5  | 41.5  | 52.8 | 3.8  | 1.0  | 6.6      | 3.6    |
| Trade (X + M)                  | 1992 | 50.9      | 38.1                 | 24.6 | 1.6        | 18.9 | 44.5  | 64.6 | 1.3  | 1.2  | 17.9     | 3.1    |
|                                | 1996 | 55.7      | 38.8                 | 26.7 | 1.5        | 9.2  | 41.5  | 57.7 | 4.4  | 1.3  | 18.7     | 4.6    |
|                                | 2003 | 67.3      | 52.5                 | 27.0 | 1.9        | 7.9  | 45.0  | 50.9 | 4.4  | 1.0  | 9.3      | 6.2    |
| <b>C: Final goods</b>          |      |           |                      |      |            |      |       |      |      |      |          |        |
| Exports (X)                    | 1992 | 35.0      | 33.7                 | 16.3 | 2.7        | 24.2 | 44.1  | 64.4 | 1.4  | 1.4  | 21.0     | 25.5   |
|                                | 1996 | 41.2      | 32.5                 | 19.3 | 3.2        | 26.3 | 49.6  | 60.0 | 6.9  | 1.7  | 34.2     | 35.9   |
|                                | 2003 | 38.8      | 30.1                 | 17.0 | 3.0        | 26.5 | 57.3  | 51.1 | 7.3  | 1.5  | 18.8     | 26.9   |
| Imports (M)                    | 1992 | 54.3      | 35.7                 | 11.9 | 2.3        | 5.4  | 32.6  | 66.7 | 1.1  | 1.5  | 15.5     | 4.2    |
|                                | 1996 | 54.1      | 35.4                 | 14.5 | 3.1        | 6.5  | 38.2  | 64.3 | 4.4  | 1.5  | 15.7     | 9.9    |
|                                | 2003 | 61.9      | 43.3                 | 18.7 | 3.3        | 5.5  | 34.1  | 52.8 | 5.8  | 1.5  | 15.9     | 8.9    |
| Trade (X + M)                  | 1992 | 52.5      | 44.6                 | 23.9 | 2.5        | 9.4  | 37.6  | 65.5 | 1.2  | 1.4  | 17.9     | 7.8    |
|                                | 1996 | 46.8      | 33.9                 | 16.8 | 3.2        | 10.8 | 43.2  | 62.0 | 5.5  | 1.6  | 21.6     | 15.7   |
|                                | 2003 | 47.6      | 35.2                 | 17.7 | 3.1        | 9.7  | 42.9  | 51.9 | 6.5  | 1.5  | 17.3     | 13.2   |

calculated using reported data can lead to wrong inferences about the relative importance of the ‘region’ and the rest of the world for the growth performance of a given country/region, even when controlling for double counting in trade. This is because the rate of expansion of component trade depends crucially on the demand for final goods. When data on component trade are excluded from trade flows, our estimates suggest that extra-regional trade is much more important than intra-regional trade for continued growth. Thus, the ongoing process of product fragmentation seems to have strengthened the case for a global, rather than a regional, approach to trade and investment policymaking.

#### 4. Determinants of fragmentation trade

We observed in the previous section the growing importance of fragmentation trade for trade expansion in East Asia relative to the overall global experience and experiences of countries in other major regions. We now turn to a more formal examination of what forces shape inter-country/inter-regional differences in the growth of fragmentation trade. The analytical tool used for this purpose is the standard gravity model of bilateral merchandise trade that has been widely used as the ‘workhorse’ for empirical analysis of international trade flows. The standard gravity model postulates that trade between two countries is a function of their economic size and of the geographic distance between them. We augment this basic structure by adding a number of explanatory variables drawn from the theory of international production fragmentation. Our specification of the gravity model is:

$$\begin{aligned} \ln XM_{i,j} = & \alpha + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln PGDP_i + \beta_4 \ln PGDP_j \\ & + \beta_5 \ln |\Delta PGDP_{i,j}| + \beta_6 \ln DST_{i,j} + \beta_8 LNG_{i,j} + \beta_9 BRD_{i,j} + \delta_1 RWG_i \\ & + \sum_k \eta_1 \text{int}RTAINT_{i,j,k} + \sum_k \eta_2 RTAEXT_{i,j,k} + \delta_1 SING + \delta_2 IRE \\ & + \phi_1 EASINT + \phi_2 EASEXT + \gamma T + \varepsilon_{i,j}, \end{aligned}$$

where subscripts *i* and *j* refer, respectively, to the reporter and the partner country in bilateral trade and the variables are listed and defined below, with the postulated sign of the regression coefficient for the explanatory variables in brackets.

- XM* Bilateral trade (exports or imports) between *i* and *j*
- GDP* Real gross domestic product (GDP), a measure of economic size (+)
- PGDP* Real GDP per capita (+)
- $|\Delta PGDP|$  Absolute difference in GDP per capita (– or +)
- DST* The distance between *i* and *j* (–)
- LNG* A dummy variable, which is unity if *i* and *j* have a common language and zero otherwise (+)
- BRD* A dummy variable, which is unity if *i* and *j* share the same border (+)
- RWG* An index of relative manufacturing wage of *i* (manufacturing wage in *i* relative to that of *j*, adjusted for the bilateral exchange rate) (– for exports, + for imports)
- RTAINT* A dummy, which is unity if both *i* and *j* belong to the same *k*th regional trade agreements (*RTA*) (+)
- RTAEXT* A dummy taking unity when only *i* belong to *k*th *RTA* (– or +)

- SING* A dummy variable taking unity for bilateral trade involving Singapore and zero otherwise (– or +)
- IRE* A dummy variable taking unity for bilateral trade involving Ireland and zero otherwise (– or +)
- EASINT* A dummy variable which is unity if *i* and *j* are situated in East Asia (+)
- EASEXT* A dummy taking unity when only *i* is in East Asia (– or +)
- T* A set of time dummy variables to capture year-specific ‘fixed’ effects
- $\alpha$  A constant term
- $\varepsilon$  A stochastic error term, representing omitted other influences on bilateral trade

The use of GDP as an explanatory variable of bilateral trade flows is normally justified by the modern theory of trade under imperfect competition; one will chose to trade more with a large country than with a small country because it has more variety to offer and customers like variety. The use of this variable is also consistent with the theory of international production fragmentation, which predicts that the optimal degree of fragmentation depends on the size of the market, because the scale of production would determine the length to which such division of labor can proceed (Jones, Kierzkowski, & Lurong, 2004). The size of GDP can also be treated as a proxy for market thickness (the economic depth of trading nations) which positively impacts on the location of outsourcing activity (Grossman & Helpman, 2005). There are also reasons to believe that GDP per capita has a positive effect over and above the effect of GDP: as countries grow richer, the scale of output of industries becomes conducive to fragmentation. In addition, more developed countries have better ports and communication systems that facilitate trade by reducing the cost of maintaining ‘services links’ involved in vertical specialization.<sup>10</sup>

The choice of absolute difference in per capita GDP and relative manufacturing wage (*RWG*) as explanatory variables is based on the standard comparative advantage explanation of trade. The former variable aims to capture technology differences between countries in explaining trade patterns. Relative labor cost (adjusted for the exchange rate differential) is presumably a major factor impacting on the global spread of fragmentation-based (vertical) specialization (Jones, 2000).

Distance is included as a proxy for transport (shipping) costs and other costs associated with time lags such as Internet charges, spoilage and costs associated with physical distance such as ignorance of foreign customs and tastes. Technological advances during the post-war era have contributed to the ‘death of distance’ (*a la Cairncross, 1997*), when it comes to international communication costs. However, there is evidence that geographical ‘distance’ is still a key factor in determining international transport costs, in particular shipping costs (Hummels, 1999). Distance can, in fact, be a more important influence on vertical trade than on final trade, because of multiple border-crossing involved in the value-added chain.

<sup>10</sup> In gravity-model analysis of bilateral trade flows, the GDP variables are usually presented in two multiplicative terms, i.e.,  $GDP_i * GDP_j$  and  $PGDP_i * PGDP_j$ . This practice has the advantage of avoiding the statistical problems of possible multicollinearity, and heteroskedasticity (resulting from the presence of effects between extremely large countries and extremely small ones) in model estimation. But there is no theoretical justification for constraining changes in partner country and reporting country GDP and PGDP to have the same degree of effect on bilateral trade flows, particularly when it comes to trade in components. In this study we, therefore, include reporting- and partner-country GDP and PGDP as separate variables. In this we closely follow Soloaga and Winters, 2001. This variable specification is, in fact, amply supported by our estimation results (Table 6); the homogeneity restriction does not hold for the coefficients on  $GDP_i$  and  $GDP_j$ , and  $PGDP_i$  and  $PGDP_j$  in all four equations.

A common border dummy (*BRD*) is included to account for possible additional advantages of proximity that are not captured by the standard distance measure. A common language dummy (*LNG*) is included to capture the possibility that the use of a common language can facilitate trade by reducing transaction cost and better understanding of each other's culture and legal systems.

We include intra- and extra-regional dummy variables (*RTAINT*) to capture the possible trade effects of membership in six regional trading agreements—AFTA, EU, NAFTA, MERCOSUR, ANDEAN and CER (with CER treated as the base dummy). Under international product fragmentation, parts and components (goods in process) cross multiple international borders before production of the final good is completed. For each RTA, the “intra” (insider) captures the implication of membership for trade within the RTA and the “extra” (outsider) dummy the likely implications for trade with the rest of the world. A positive coefficient on *RTAINT* suggests that the RTA tends to generate more trade among its members. The coefficient for extra-bloc trade (*RTAEXT*) indicates the trade-diverting effects of the RTA. The sign of the regression coefficient on this variable can go either way.

Component trade is postulated to be relatively more sensitive to tariff changes (under an RTA or otherwise) compared to final trade or total trade as captured in published trade data (Yi, 2003). Normally a tariff is incurred each time a good in process crosses a border. Consequently, with a one percentage point reduction in tariff, the cost of production of a vertically-integrated good declines by a multiple of this initial reduction, in contrast to a one percent decline in the cost of a regular traded good. Moreover, a tariff reduction may make it more profitable for goods previously produced in their entirety in one country to now become vertically fragmented. Consequently, the trade-stimulating effect of an RTA would be higher for parts and components trade than for normal trade, other things remaining unchanged. In the case of final trade, the coefficient of the extra-regional dummy variable can go either way. However, in the case of fragmentation trade one can assume a positive coefficient, because any positive effect of an RTA on the depth of regional outsourcing has the potential to promote such activities extra-regionally as well (assuming the nature of ‘rules or origin’ built into the RTA).

Dummy variables are added for Singapore and Ireland to capture their pivotal role as outsourcing centers in Asia and Europe, respectively. This variable choice is rooted in the new economic geography view that postulates agglomeration of activity in a few more developed sites, until rising wages (and other cost disadvantages) outweigh the advantages of being located near other firms and make it worthwhile for the marginal firm to set up elsewhere (Krugman, 1995; Navaretti & Venables, 2004).

Finally, intra- and extra-regional dummy variables are included for the entire East Asian region to test whether the striking importance of the region as a center of vertical trade (as observed in Section 3) still holds after controlling for the other relevant variables.

An important variable suggested by the theory of production fragmentation (Jones, 2000; Jones & Kierzkowski, 1990), but not included in our set of explanatory variables, is the cost of service links. Changes in such costs are associated with technological improvements that are quite similar across countries, and therefore cannot be explicitly captured in an empirical analysis of the determinants of bilateral trade flows. In our model, the impact of such changes is accounted for as part of the time-specific fixed effects (T).

We estimate the model with annual data for 36 countries (see Appendix Table A.2) for the period 1992 to 2001. The trade data cover machinery and transport equipment (SITC Section 7). As already noted, the separation of components from final goods is incomplete for other Sections of the SITC system. By focusing solely on SITC 7, we aim to minimize any bias in estimates arising from this incomplete commodity coverage of the original data. The prime focus of our

analysis is on trade in components. However, we estimate the model for reported (total) trade and final trade (reported trade–vertical trade) for purposes of comparison. Under each category, exports and imports are treated separately (rather than using a composite trade variable as the dependent variable, as is commonly done in trade analysis based on the gravity model), to allow for possible differences in the nature/magnitude of the impact of a given explanatory variable on bilateral imports and exports.

The model was estimated using ordinary least squares (OLS) with country dummies to capture country-specific fixed effects. Since there was strong evidence of heteroskedasticity, we derived consistent variance-covariance standard errors of the regression coefficients using the Huber-White ‘sandwich’ estimator. The results are reported in Table 6. Information on variable construction and data source is summarized in Appendix Table A.1. The countries covered and the classifications used in the construction of regional and RTA dummies are given in Appendix Table A.2.

As in many other applications of the gravity model to bilateral trade, in all six regressions the coefficients on the two central gravity variables—the level of GDP and distance—have the expected signs (positive and negative, respectively) and are significant at the 1 percent level. However, the magnitude of the coefficient is far from homogeneous across the three types of trade flows (components, final goods and total trade) and between exports and imports under each type. For instance, GDP of the partner country seems to have a much larger effect on imports compared to exports. For parts and component trade, this result is consistent with the fact (as observed in Section 3) that countries generally tend to specialize in a narrow range of product lines.

The results for the distance variable provide strong support for the hypothesis that transportation and other distance-related costs are an important determinant of trade flows. As can be expected, the magnitude of the coefficient is remarkably similar for exports and imports. Interestingly, the coefficients on both imports and exports for components are much larger than those relating to final trade.<sup>11</sup> This difference is consistent with the hypothesis that vertical specialization, given the multiple border crossings involved in the production process, is much more sensitive to transport costs. The common language dummy is statistically significant, with the expected positive sign in all cases.

The coefficient on *RWG* is statistically significant with the expected sign in both export and import equations. Thus, there is strong empirical support for the hypothesis that relative wage differentials are a significant determinant of cross-border trade in components (as well as in the related final products). Interestingly, the magnitude of the coefficient is remarkably similar across all equations. This may reflect the interconnectedness of components imports and exports and the dependence of final exports on component imports. The coefficient on  $|\Delta PGDP|$  is statistically significant in both equations, but its sign suggests that bilateral trade flows are related *negatively* to inter-country differences in the level of technological advancement.<sup>12</sup> This unexpected result may reflect the fact that developed countries still account for much of world trade in both components and final goods.

Among the regional/RTA dummies, both the intra- and extra-regional dummies are highly significant for AFTA with the expected positive sign in all regressions. The coefficient in the component import equation suggests that intra-AFTA trade is about eleven times higher than

<sup>11</sup> The difference is statistically significant in both cases.

<sup>12</sup> The overall regression results are not sensitive to the exclusion/inclusion of this variable.

Table 6  
Regression estimates of the determinants of bilateral trade flows<sup>1</sup>

| Explanatory variables           | Parts and components   |           |                        |           | Final goods           |           |                        |           |
|---------------------------------|------------------------|-----------|------------------------|-----------|-----------------------|-----------|------------------------|-----------|
|                                 | Eq. (1) log of imports |           | Eq. (2) log of exports |           | Eq. (3) log of import |           | Eq. (4) log of exports |           |
|                                 | Coefficient            | S.E.      | Coefficient            | S.E.      | Coefficient           | S.E.      | Coefficient            | S.E.      |
| Log GDP, reporter               | 0.78                   | [0.02]*** | 1.25                   | [0.01]*** | 0.72                  | [0.01]*** | 1.16                   | [0.01]*** |
| Log GDP, partner                | 1.40                   | [0.01]*** | 0.88                   | [0.01]*** | 1.37                  | [0.01]*** | 0.76                   | [0.01]*** |
| Log per capita (PGDP), reporter | 0.11                   | [0.03]*** | 0.66                   | [0.02]*** | −0.01                 | [0.02]    | 0.56                   | [0.02]*** |
| Log per capita GDP, partner     | 0.44                   | [0.02]*** | 0.06                   | [0.01]*** | 0.38                  | [0.01]*** | −0.00                  | [0.01]    |
| Log absolute PGDP difference    | −0.06                  | [0.01]*** | −0.06                  | [0.01]*** | −0.05                 | [0.01]*** | −0.08                  | [0.01]*** |
| Log relative labor cost         | 0.29                   | [0.05]*** | −0.16                  | [0.04]*** | 0.26                  | [0.06]*** | −0.22                  | [0.04]*** |
| Log distance                    | −1.19                  | [0.04]*** | −1.46                  | [0.03]*** | −1.06                 | [0.04]*** | −1.21                  | [0.03]*** |
| Common language dummy           | 0.58                   | [0.06]*** | 1.08                   | [0.05]*** | 0.36                  | [0.05]*** | 0.94                   | [0.04]*** |
| Common land border dummy        | −0.09                  | [0.07]    | 0.14                   | [0.08]*   | −0.01                 | [0.07]    | 0.36                   | [0.08]*** |
| Regional/country dummies        |                        |           |                        |           |                       |           |                        |           |
| AFTA insiders                   | 2.58                   | [0.17]*** | 2.39                   | [0.16]*** | 1.63                  | [0.13]*** | 0.90                   | [0.12]*** |
| AFTA outsiders                  | 0.89                   | [0.09]*** | 0.79                   | [0.08]*** | 0.56                  | [0.08]*** | −0.13                  | [0.07]*   |
| EU insiders                     | −1.11                  | [0.13]*** | −1.00                  | [0.10]*** | −1.25                 | [0.13]*** | −0.17                  | [0.10]**  |
| EU outsiders                    | −0.29                  | [0.09]*** | 0.58                   | [0.06]*** | −0.84                 | [0.09]*** | 0.69                   | [0.07]*** |
| NAFTA insiders                  | 0.24                   | [0.14]*   | 0.21                   | [0.08]**  | −0.57                 | [0.14]*** | −0.14                  | [0.09]    |
| NAFTA outsiders                 | 0.35                   | [0.13]*   | 0.34                   | [0.09]*** | −0.25                 | [0.10]**  | 0.01                   | [0.08]    |
| MERCOSUR insiders               | −0.68                  | [0.21]**  | −0.52                  | [0.22]**  | −0.26                 | [0.17]    | 0.14                   | [0.19]    |
| MERCOSUR outsiders              | −0.64                  | [0.10]*** | −0.88                  | [0.09]*** | −0.78                 | [0.10]*** | −1.19                  | [0.09]*** |
| ANDEAN insiders                 | −0.71                  | [0.14]*** | −0.05                  | [0.15]    | −0.74                 | [0.14]*** | 0.11                   | [0.17]    |
| ANDEAN outsider                 | −1.13                  | [0.11]*** | −2.49                  | [0.10]*** | −1.08                 | [0.11]*** | −2.41                  | [0.10]*** |
| Singapore                       | 1.20                   | [0.13]*** | 0.84                   | [0.12]*** | 0.99                  | [0.12]*** | 0.68                   | [0.10]*** |
| Ireland                         | 0.35                   | [0.15]**  | 1.37                   | [0.10]*** | −0.13                 | [0.12]    | −0.18                  | [0.08]**  |
| East Asia insiders              | 0.50                   | [0.15]*** | 1.45                   | [0.10]*** | −0.43                 | [0.14]*** | 1.53                   | [0.09]*** |
| East Asia outsider              | −0.55                  | [0.11]*** | 1.90                   | [0.74]*** | −1.02                 | [0.11]*** | 2.56                   | [0.07]*** |
| Constant                        | −35.08                 | [0.82]*** | −33.70                 | [0.66]*** | −31.28                | [0.76]*** | −28.40                 | [0.60]*** |
| N. of observations              | 11580                  |           | 11160                  |           | 11546                 |           | 11296                  |           |
| R <sup>2</sup>                  | 0.70                   |           | 0.78                   |           | 0.69                  |           | 0.79                   |           |
| F                               | 1036.89                |           | 1172.15                |           | 836.97                |           | 1091.63                |           |
| RMSE                            | 1.94                   |           | 1.59                   |           | 1.82                  |           | 1.45                   |           |

Notes: The standard errors (SEs) of the regression coefficients have been derived using the Huber-White consistent variance-covariance ('sandwich') estimator. RMSE=Root Mean Square Errors. Statistical significance (based on the standard t-test) is denoted as \*\*\*1 percent, \*\*5 percent, and \*10 percent.

predicted by the other explanatory variables in the model.<sup>13</sup> According to the results for the extra-regional dummy, AFTA members' trade with the rest of the world is about three times higher than the norm set by the other explanatory variables in the model. It seems that the rapid expansion of component trade within AFTA (as noted in Section 3) is complementary to its involvement in vertical specialization at the global level. The regression coefficient of the Singapore dummy is also statistically significant, suggesting that the level of component trade in that country is about twice that of the regression norm (including the overall AFTA factor).

Interestingly, the results for the dummy variables (both extra- and intra-regional) for the other four RTAs are rather mixed. In most cases, the coefficients carry the unexpected (negative) sign and many coefficients are not statistically different from zero. Overall, there is no evidence to support the hypothesis that RTAs promote vertical specialization. This result is consistent with the fact that much of the world's fragmentation trade since the 1960s has taken place under tariff concessions (overseas assembly provisions of developed countries and export promotion schemes of developing countries). Formation of RTAs would therefore have simply resulted in substituting for the existing tariff concessions rather than generating new incentives for fragmentation trade (Egger & Egger, 2005).

Against this backdrop, the unique results for AFTA (and Singapore) clearly point to the need to look beyond intra-regional tariff reductions (and other variables captured in our model) in order to understand a region's unique dynamic role in fragmentation trade. Perhaps the explanation lies in economic history, the early choice of the region (firstly Singapore and subsequently Malaysia and other countries) by MNEs as a location of outsourcing activities. It is well known that there is a general tendency for MNE affiliates to become increasingly embedded in host countries the longer they are present there and the more supportive the overall investment climate of the host country becomes over time. They may respond sluggishly to relative cost changes once they have invested substantial resources in domestic production facilities and in establishing information links. Moreover, site selection decisions of MNEs operating in assembly activities are strongly influenced by the presence of other key market players in the given country (Rangan & Lawrence, 1999).

Finally, there is no evidence to suggest that East Asia is a 'natural trading bloc' for fragmentation trade. After controlling for intra-AFTA trade, the coefficient on the intra-regional East Asia dummy in the component export equation is statistically significant with a *negative* sign, whereas it is not statistically different from zero in the import equation. These estimates are consistent with our earlier inference (Section 3) that regional components trade is lopsided in that its growth dynamism comes predominantly from extra-regional trade.

## 5. Conclusion

There is clear evidence that fragmentation trade is expanding more rapidly than conventional final-good trade. The degree of dependence on this new form of international specialization is proportionately larger in East Asia than in North America and Europe. This seems to be the result of the relatively more favorable policy setting for international production, agglomeration benefits arising from early entry into this new form of specialization, and considerable inter-country wage differentials in the region. A notable recent development in international production fragmentation

<sup>13</sup> Note that, as the model was estimated in logs, the percentage equivalent for any dummy coefficient is,  $[\exp(\text{dummy coefficient}) - 1] * 100$ .

in the region has been the rapid integration of China into regional production networks. This development is an important counterpoint to the popular belief that China’s global integration would crowd out other countries’ opportunities for international specialization.

International production fragmentation has certainly played a pivotal role in the continuing dynamism of the East Asian economies and increasing intra-regional economic interdependence. This does not, however, mean that the process has reduced the region’s dependence on the global economy. The high intra-regional trade reported in recent studies reflects rapidly expanding intra-regional trade in components. There is no evidence of rapid intra-regional trade integration in terms of final products. In fact, the region’s growth dynamism based on vertical specialization depends inexorably on its extra-regional trade in final goods, and this dependence has in fact *increased* over the years. The growing importance of China as a regional exporter and importer has begun to change the picture in recent years, but extra-regional trade is likely to remain the engine of growth of the region in the foreseeable future. Put simply, growing trade in components has made the East Asia region increasingly reliant on extra-regional trade for its growth dynamism.

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**Appendix A**

Table A.1 Definition of variables and data source

| Label       | Definition   | Data Source  |
|-------------|--|--|
| <i>XM</i>   | Bilateral trade flows (‘Component’ and ‘Final Goods’ trade) at constant (1995) dollars   | Trade flows: UN-COMTRADE, online database<br>Exchange rates: IMF, International Financial Statistics (line rf)   |
| <i>GDP</i>  | Real GDP (at 1995 prices)  | World Development Indicator, The World Bank  |
| <i>DIST</i> | The Great Circle distance between capital cities of two countries  | Jon Haveman’s International Trade Data, at<br>< <a href="http://www.maclester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html">http://www.maclester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html</a> >  |
| <i>RWG</i>  | Relative labor cost in manufacturing, adjusted for exchange rate changes: $RWG_{ij}=(W_i/W_j)E_{ij}$   | Annual manufacturing wages data for USA: ‘Interactive database of National Income and Product Accounts Tables’ at<br>< <a href="http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=N#S6">http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=N#S6</a> > under Section 6 Income and Employment by Industry   |
|             | where <i>W</i> = manufacturing wage index (1992 = 100),<br><i>E</i> = nominal bilateral exchange rate expressed as the value of <i>i</i> ’s currency in terms of <i>j</i> ’s currency. By construct, an increase (decrease) in $RWG_{ij}$ indicates a deterioration (improvement) in <i>i</i> ’s cost competitiveness vis a vis <i>j</i> | All other countries: U.S. Bureau of Economic Analysis (BEA) online database, ‘Survey of U.S. Direct Investment Abroad’<br>< <a href="http://www.bea.doc.gov/bea/uguide.htm#_1.23">http://www.bea.doc.gov/bea/uguide.htm#_1.23</a> ><br>Bilateral exchange rates: derived from bilateral U.S.\$ exchange rates obtained from IMF, International Financial Statistic |

Table A.2 Country groups/Regional trading arrangements (RTAs) Covered in the Study<sup>1</sup>

| AFTA        | East Asia        | CER         | EU          | EFTA*        | CEEC*       | NAFTA  | MERCOSUR  | ANDEAN    |
|-------------|------------------|-------------|-------------|--------------|-------------|--------|-----------|-----------|
|             | AFTA             | Australia   | Austria     | Iceland*     | Bulgaria*   | USA    | Argentina | Bolivia   |
| Indonesia   | Japan            | New Zealand | Belgium     | Norway*      | Croatia*    | Canada | Brazil    | Colombia  |
| Philippines | Korea, Rep. Of   |             | Denmark     | Switzerland* | Czech Rep*  | Mexico | Paraguay  | Ecuador   |
| Malaysia    | China            |             | Finland     |              | Hungary*    |        | Uruguay   | Peru*     |
| Singapore   | Hong Kong, China |             | France      |              | Poland*     |        |           | Venezuela |
| Thailand    | Taiwan*          |             | Germany     |              | Romania*    |        |           |           |
| Vietnam*    |                  |             | Ireland     |              | Russia*     |        |           |           |
|             |                  |             | Italy       |              | Slovak Rep* |        |           |           |
|             |                  |             | Netherlands |              |             |        |           |           |
|             |                  |             | Greece      |              |             |        |           |           |
|             |                  |             | Portugal    |              |             |        |           |           |
|             |                  |             | Spain       |              |             |        |           |           |
|             |                  |             | Sweden      |              |             |        |           |           |
|             |                  |             | UK          |              |             |        |           |           |

Notes: 1. All country groups listed below except East Asia and CEEC are under RTAs. Countries marked with asterisks (\*) are not covered in the gravity model estimation. Legend: AFTA: ASEAN Free Trade Area; EFTA: European Free Trade Area; ANDEAN: Andean Pact; EU: European Union; CER: Closer Economic Relations agreement; MERCOSUR: The Common Market of the South; CEEC: Central and Eastern European Countries; NAFTA: North American Free Trade Agreement.

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