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" Production Fragmentation in Manufacturing Trade: The Role of East Asia in Cross-border Production Networks "

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Production Fragmentation in Manufacturing Trade: The Role of East Asia in Cross-border Production Networks

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This paper examines the extent, patterns and determinants of international production fragmentation in world manufacturing trade with especial emphasis on countries in East Asian. It is found that, while 'fragmentation trade' has generally grown faster than total world manufacturing trade, the degree of dependence of East Asia on this new form of trade is proportionately larger compared to North America and Europe. Fragmentation-based international exchange has certainly played a pivotal role in 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 reduce the regions dependence on the global economy. On the contrary, growth dynamism based on vertical specialisation depends inexorably on extra-regional trade in final good, and this dependence has in fact *increased* over the years.

JEL classification: F15, F23, O53
Key words: production fragmentation, vertical specialisation, regional integration

Production Fragmentation in World Manufacturing Trade: The Role of East Asia in Cross-border Production Networks*

1. Introduction

International production fragmentation— the geographic separation of activities involved in producing a good (or service) across two or more countries —has been an important feature of the deepening structural interdependence of the world economy in recent decades.[1] After a modest start in electronics and clothing industries in the late 1960s, international production networks have gradually evolved and spread into many industries such as sport footwear, automobile, televisions and radio receivers, sewing machines, office equipment, electrical machinery, power and machine tools, cameras and watches. At the formative stage, outsourcing predominantly involved locating small fragments of the production process in a low cost country and reimporting the assembled components to be incorporated in the final product. Over time, production networks have begun to encompass many countries, resulting in multiple-border crossing of unfinished parts before completion of the final product.

At the early stages of international fragmentation of production, the processes normally involved a multinational enterprise (MNE) building a subsidiary abroad to perform some of the functions that it once did at home (Helleiner 1973). Over the years, MNE subsidiaries have begun to subcontract some activities to local (host-country) firms to which they provide detailed specifications and even fragments of their own technology. Moreover, many MNEs in electronics and related industries have begun to rely increasingly on independent contract manufacturers for the operation of their global-scale production networks – a process that has been facilitated by the standardisation of some components and by advances in modular technology (Sturgeon 2003; Brown and Linden 2005). At the same time, many firms which are not part of MNE networks have begun to procure components globally through arm's-length trade. All the above developments

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[1] This phenomenon has gone under alternative names, such as 'vertical specialisation', 'slicing the value chain', 'international production sharing' and 'outsourcing'.

suggest that an increase in fragmentation-based trade may or may not be accompanied by an increase in the host-country stock of FDI (Brown *et al*. 2004: 305).

International production fragmentation has resulted 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, because parts cross on average the borders several times before the process is completed. This chapter aims to examine patterns and determinants of this new form of trade, directly related to production fragmentation, what we call "fragmentation trade". The analysis concentrates on East Asian countries. To examine such an experience in the wider global context, comparisons are made with two other regions, the North American Free Trade Area (NAFTA) and the European Union (EU). The study is based on a new data set extracted from the UN trade database, which distinguishes trade in parts and components from total trade

There is a vast literature based on the standard trade data analysis (which is essentially based on the traditional notion of horizontal specialisation scenario in which trade is essentially an exchange of goods that are produced from start to finish in just one country) that unequivocally points to a persistent increase in intra-regional trade in East Asia (including as well as excluding Japan) form about the early 1980s (e.g., Kwan 2001, Drysdale and Garnaut 1997, Frankel and Wei 1997, Petri 1993). This evidence figures prominently in the current debate on forming regional trading arrangements covering some or all countries in East Asia. In this chapter we argue that, in a context where component trade is growing rapidly, the standard trade flow 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 international 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 share calculated using reported data can lead to wrong inferences as to the relative importance of the 'region' and the rest of the world for growth dynamism of a given country/region, even controlling for double counting in trade. This is because '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 the final products

predominantly comes from the rest of the world, particularly from North America and countries in the EU (eg. Borrus 1997, Dobson and Chia (1997), McKendrick et al. 2000).

This chapter relates to, and builds on, Ng and Yeats (2001) and Athukorala (2006). Compared to these papers, the present chapter offers both more current and detailed information on the nature, trends and patterns of fragmentation trade. However, 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 component trade in a large sample of bilateral trade relations at the global level.[2] Our approach is essentially empirical by design, but the empirical analysis in carried out in the context of the existing body of theoretical literature.[3]

The chapter is organised as follows. After a brief presentation of this dataset, detailed in Appendix, Section 2 examines the nature and extent of global trade in components and East Asia's role in this form of trade specialisation. This section also deals with the implications of the rapid expansion of production fragmentation for analysing intra- and extra-regional patterns of economic integration of East Asia (and comparison with EU and NAFTA). Section 3 uses a 'modified' gravity model to examine determinants of bilateral trade in parts and components and compare the results with those for trade in final goods (reported trade – parts and components). The final section presents the key inferences.

2. Data Source and Method of Data Compilation

There are two approaches to quantify the magnitude and patterns of manufacturing trade that can be directly attributed to production fragmentation. The first approach, which was commonly used by early studies in this area, uses the records by OECD countries (in particular the US and countries in the European Union) in connection with special tariff provisions provide for overseas processing and assembly of domestically produced components ('outward processing trade (OPT) statistics'). The OPT schemes however cover only a selected list of products and the actual product coverage has varied significantly among countries and within a given country over time. Moreover, and

[2] A few studies have examined the implications of production fragmentation for trade patterns with a specific regional (rather than a global) focus include (Egger and Egger (2003 and 2005), Gorg (2000) and Baldone *et al*. (2001).

perhaps more importantly, the importance of these tariff concessions as a factor in promoting global sourcing (and therefore the actual utilization of these schemes), has significantly been diminished over the years by the process of investment and trade liberalisation in ICs [define] and regional economic integration agreements. The second approach, followed in this chapter, provides a much more comprehensive and consistent coverage of fragmentation trade, as it delineates trade in parts and component from the related final (assembled) goods using individual-country trade statistics recorded on the basis of the Standard International Trade Classification (SITC) of the United Nations (Yeats, 2001).

We make use of data extracted from the UN trade database based on the Revision 3 of the Standard International Trade Classification (SITC, Rev 3). In its original form (SITC, Rev 1), the UN trade data reporting system did not provide for separating fragmentation trade (parts and components) from final manufactured goods. The SITC Revision 2 introduced in the late 1970s (and implemented by most countries only in the early 1980s) adopted a more detailed commodity classification, which provided for separation of parts and components within the machinery and transport sector (SITC 7). There were, however, considerable overlap between some advanced-stage component production/assembly and assembly of final goods in the Revision 2 (Ng and Yeats 2001). Revision 3 introduced in the mid-1980s marked a significant improvement over Revision 2. In addition to providing a comprehensive coverage of parts and components in SITC 7, it also separately reports parts and components of some products belonging to SITC 8 ('miscellaneous manufactures')

SITC Revision 3, despite its significant improvement over the previous version, does not provide for the construction of data series covering the entire range of activities involving production fragmentation. Data reported under SITC 7 do provides a comprehensive coverage of fragmentation trade. But data for SITC 8 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), the related components are recorded under other SITC categorizing (e.g., pieces of textile, parts of furniture, parts of leather soles). Moreover, there is evidence that international production fragmentation has been

[3] Important contributions to the theory of production fragmentation include Arndt (1997), Jones (2000), Grossman and Helpman (2005), Jones and Kierzkowski (1990 and 2001), Venables (1999) and Yi (2003).

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 activates in software trade too have recorded impressive expansion in recent years. These are lumped together with 'special transactions' under SITC 9. So the merriment of trade in parts and components reported used in this paper are presumably downward biased.

We reported data from the UN trade database for the period from 1992 to 2005, the most recent year for which trade data are available for all reporting countries. The year 1992 is used as stating point because by this time countries accounting for over 95 per cent of total world manufacturing trade had adopted the new system. The list was prepared by carefully linking the parts and accessaries identified in the United Nations Statistical Division: Classification Registry (http:/unstats.un.org/unsd/cr/registry) with the 5-digit SITC products. The list contains a total of 225 five-digit products—168 products belonging to SITC 7 and 57 belonging to SITC 8.[4] The data are tabulated using importer records, which are considered more appropriate compared to the corresponding exporter records for analysing trade patterns for a number of reasons (Feenstra *et al.*, 2005). Among the countries covered in this study, Taiwan is not covered in the UN data system and Vietnam has not yet begun to make data available according to the standard UN format. Singapore was not reporting data on its bilateral trade with Indonesia because of political reasons. In these cases, the data gaps were filled using the corresponding trading partner records.

3. Trends and Patterns of Production Fragmentation

World trade in parts and components[5] increased from about $527 billion in 1992/93 to over $1500 billion in 2004/05 (Table 1, Figure 1).[6] The share of these products in total world manufacturing exports increased from 20.9% to 24.2% between 1992/93 and 2004/05. Components accounted for nearly a third of the total increment in world manufacturing exports between these two years.

Table 1 about here

[4] The list is available from the authors on request
[5] Henceforth we used the term 'components' in place of 'parts and components' for brevity.

Figures 1 and 2 about here

Developed countries account for the bulk of world component trade (Table 1, Figure 2). However, the share of developing countries has increased sharply over the past decade, form 18.6% to 39.9% between 1992/93 and 2004/05. The share of East Asia (including Japan) in total world exports of components increased persistently from 30% in 1992/93 to 42.6% in 2004/05. This is despite a notable decline in the share accounted for Japan, the dominant economy in the region, in recent year. The share of developing East Asia (East Asia excluding Japan) increased from 14.1% to 31.5% between these two years. Within the group, all reported countries have recorded increases in world market shares.

The growing importance of China is component trade particularly noteworthy. The share of China in total world component exports increased from about 1% to 10% and in total imports from 18.9% to 30.6% between 1992/93 and 2004/05. Contrary to the popular perception of 'crowding out the 'rest' by China', this increase has been within an overall increase in exports from other newcomers in the region. For instance the combined export share of the six main member countries of the ASEAN Free Trade Area (AFTA) more than doubled (from 5.9% to 10.4%) between these two years.

Has the formation of NAFTA and the integration of some of the new countries emerged countries from the former Soviet Union with the rest of the Europe adversely affect the developing East Asia's relative position in world assembly activities? Indeed, proximity to industrial countries and relatively low wages by regional standard (though not compared to some of the East Asian countries) can be considered as added advantages of these countries compared to East Asian countries in production fragmentation based international specialisation (Egger and Egger 2005, Ng and Yeats 2003, Kierzkowski 2001). The data do not, however, point to any dampening effect of exports from these countries on the relative world market position of East Asia, world market shares of Mexico and rest of Europe (EUT less EU) have increased, but at a much slower rate than that of developing East Asia. It seems that in spite of geographical proximity and tariff concessions under FTAs, US producers still find East Asia as a more

[6] Throughout the paper inter-temporal comparison calculations are made for the two-year averages relating to the end points of the period under study so as to reduce the impact of year to year fluctuations of trade flows.

attractive location for outsourcing. A new dimension of regional production sharing in Europe has been added by the economic integration in Europe.

Table 2 presents comparative statistics on the share of component in total manufacturing exports and imports and its contribution to growth of manufacturing trade across these years. It is evident that the share of component trade for East Asia as a group is much higher compared to all other regions in the world. In 2004/05, components accounted for 30.0% of total manufacturing exports from developing East Asia, compared to the world average of 24.2%. Within East Asia, countries belonging to AFTA stand out for their heavy dependence on production fragmentation for export dynamism. In 2004/05 parts and components accounted for 40.3% of total manufacturing exports in AFTA, up from 27.5% in 1992/93. Between these two years, the share of components in total manufacturing exports more than tripled in China (from 5.3% to 19.5%). 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.

Table 2 about here

Disaggregated data (not reported here for brevity) show that in all countries/regions, component trade is heavily concentrated in the machinery and transport equipment sector (SITC 7). This sector accounts for over 90% 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 77) alone accounted for 50% of components exports from East Asia in 2004/05. Adding to these items components of telecommunication equipment (SITC 76) and office and automated data processing machines (SITC 75) increases the concentration ratio to almost 90 per cent of total exports of components. The balance consists largely of electrical machinery (SITC 77 and auto parts (SITC 78). The degree of concentration of component trade on electronics is much larger in AFTA (over 60%) compared to the regional average. These electronics and electrical products are also the major areas of activity in other countries/regions. But trade patterns of these

countries/regions are characterised by a greater presence of other items such as road vehicles (SITC 78) and transport equipment (SITC 79) for which transportation cost is presumably an important consideration for production location. Overall, these differences are consistent with East Asia's competitive edge in component specialisation in electrical and electronic industries.

Table 3 about here

Table 4 compares regional patterns of total manufacturing trade and trade in components. In terms of the conventionally used 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 47.3% in 1992/93 to 54% in 2004/05. Intra-regional trade in developing East Asia increased from 37.1% in 1992/93 to 42.6% in 2004/05 between these two years. For AFTA the magnitude of these figures is much smaller, but they point to an impressive, persistent increase over the years from 17.1% to 20.7% By contrast, intra-regional trade share has declined (from 66.2% to 59%) in EU and increased marginally (from 40% to 40.7%) in NAFTA.

Unlike in EU and NAFTA, the East Asian intra-regional trade ratio hides a significant asymmetry in regional trade patterns on import and export sides. In 2004/05 intra-regional import flows amounted to 68.9% of total manufacturing imports of East Asia, up from 57.8% in 1992/93. Intra-regional share in total regional exports was significantly lower, 40% in 1992/93 and 44.4% in 2004/05. In other words, the region is much more heavily dependent on extra-regional trade for its growth dynamism than is (misleadingly) 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. Japan's trade relations with the rest of East Asia is predominantly in the form of using the region as an assembly base for meeting demand in the region and, more importantly for exporting 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 component, of which the latter is much larger (data not reported for brevity).

Component trade accounts for a significant and growing share of intra-regional trade in manufacturing in East Asia, both on export and import sides. 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 2004/05, components accounted for 60.9% of intra-East Asian exports, compared to 44.4% in 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 AFTA. 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 have 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 total global trade and trade of EU and NAFTA. Firstly, component trade has played a much more important role in trade expansion in East Asia relative to the overall global experience and experiences of countries in other major regions. Second, trade in components accounts for a much larger share in intra-regional trade compared to 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 as to the relative importance of intra-regional trade relations (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 help understand this important point.

Table 5 about here

The intra-regional share of final manufacturing trade in East Asia only marginally increased from 46.2% to 47.5%, in sharp contrast to a notable increase (from 47.3% to 54%) 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 2004/05 only 28% of final goods exports from developing Asia found markets within the region, compared to 36.1% in total

exports. For AFTA the relevant figures were 14.8% and 19.7%, respectively. It is also interesting to note that, unlike in the case of East Asia (or developing East Asia and AFTA), the estimated intra-regional trade share 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 in expanding rapidly, the standard trade flows analysis can lead to misleading inferences regarding the on-going process of economic integration through trade. Production 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 the goods while in process can be a multiple of the final value of that good. Moreover, trade shares calculated using reported data can lead to wrong inferences as to the relative importance of the 'region' and the rest of the world for growth dynamism of a given country/region, even controlling for double counting in trade. 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 dynamism of East Asia, both including and excluding Japan. This is because the rate of expansion of component trade depends crucially on the demand for the related final goods.

4. Determinants of fragmentation trade

We now turn to a more formal examination of the determinants of inter-country/inter-regional differences in growth of fragmentation trade. The analytical tool used for this purpose is the gravity equation, which has established itself in the empirical trade literature as the most successful model for sorting out the relative importance of Geographical factors versus economic factors in explaining trade patterns. We augment the basic gravity model by incorporating a number of explanatory variables suggested by recent theoretical and empirical advances in the emerging literature on international production fragmentation. Our specification of the gravity model is:

$$lnM_{i,j} = \alpha + \beta_1 lnGDP_i + \beta_{2\ ln} GDP_j + \beta_3\, lnPGDP_i + \beta_3\, lnPGDP_j + \beta_5$$
$$ln\,/\Delta PGDP_{i,j}\,/ + \beta_6 lnDST_{i,j} + \beta_7 LNG_{i,j} + \beta_8\, BRD_{i,j} + \beta_9\, RWG_{i,j} +$$

$$\beta_{10}\, TELE_{i,j} \; + \beta_{11} RTA_{i,J} \; + \; \beta_{12} AFTA_{i,j} \; + \; \gamma\, T \; + \varepsilon_{ij} \qquad (1)$$

Where subscripts *i* and *j* refer to the importing and exporting country in bilateral trade relation and the variables are listed and defined below, with the postulated sign of the regression coefficient for the explanatory variables in brackets.

M	Bilateral trade between *i* and *j*, based on a reporting country's import
GDP	Real gross domestic product (GDP), a measure of the economic size (+)
PGDP	Real GDP per capita (+)
|ΔPGDP|	Absolute difference in GDP per capita (+)
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	Manufacturing wage of *i* relative to that of *j* **(+)**
TELE	telephone mainlines per 1,000 people (+)
ELET	electricity production in kilo-watts (kwh) (+)
RTAINT	A dummy which is unity if both *i* and *j* belong to the same Regional Trade Agreements (*RTA*) (+)
RTAEXT	A dummy taking unity when only *i* belong to an *RTA* (- or +)
AFTAINT	A dummy which is unity if both *i* and *j* are members of AFTA (+)
AFTAEXT	A dummy taking unity when only *i* belong to *AFTA* (- or +)
T	A set of time dummy variables to capture year-specific 'fixed' effects
α	A constant term
ε	An stochastic error term, representing the 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 (monopolistic competition model of trade); one will choose 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 labour can proceed (Jones *et al*. 2004). The size of GDP can also be treated as a proxy for the market thickness (the economic depth of trading nations) which positively impact on the location of outsourcing activity (Grossman and Helpman 2005). There are also reasons to believe that GDP per capita has a positive effect over an above the effect of GDP, as countries grow richer, the scale of output of industries become 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 specialisation. The choice of absolute difference in per capita GDP as an explanatory variable is based on the premise that a pair of countries with dissimilar level of per capita GDP is likely to trade more each other than a pair with similar (hence, the expected sign is positive) (Helpman 1987).

Relative labour cost (adjusted for exchange rate differential) is presumably a major factor impacting on the global spread of fragmentation-based (vertical) specialisation (Jones 2000). Another important determinant of trade flows suggested by the theory of production fragmentation is the cost of service links (Jones 2000). There is no single measure of such costs. We can hypothesise that that GDP per capita has a positive effect over an above the effect of GDP, as countries grow richer, the scale of output of industries become 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 specialisation.[7] We also include three additional variables to capture cost of service links: distance (DST), a common border dummy (*BRD*), and a common language dummy (*LNG*). In the standard gravity model distance (*DST*) 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.[8]

[7] Following Egger and Egger (2005), in experimental runs we included two specific infrastructure variables two infrastructure variables - telephone mainlines per 1,000 people (TELE) and electricity production in kilo-watts (kwh) (ELET). They were dropped from the final estimates because they were found to be highly correlated with PGDP.[7] It seems that there is no need for additional variable for capturing infrastructure quality as it is close correlated with the stage of development as measured by PGDP.

[8] Technological advances during the post-war era has certainly contributed to a 'death of distance' (*a la* Cairncross 1997) when it comes to international communication cost. However, there is evidence that the geographical 'distance' is still a key factor in determining international transport cost, in particular shipping cost (Hummel 1999).

Distance can in fact be a more important influence on component trade compared to final trade because of multiple boarder-crossing involved in the value added chain. A country with better infrastructure (such as well established broadband networking) is presumably a preferable location of global sourcing because of lower cost of establishing service links. The common border dummy (*BRD*) is included to capture possible additional advantages of proximity that are not captured by the standard distance measure (the greater cycle distance between capital cities), A common language dummy (*LNG*) in included to capture the possibility that the use of a common language can facilitate trade by reducing transaction cost and better understanding of each others' culture and legal systems.

We include regional dummy variable *RTAINT and RTAEXT* to capture the possible trade effects of membership in six regional trading agreements (AFTA, EU, NAFTA, and MERCOSUR), with all countries not belonging to any RTAs forming the base group.[9] Two additional dummy variables for AFTA, defined in a same manner, are included to capture the special historical role played by AFTA countries (in particular Malaysia, Thailand and the Philippines) in international production networks compared to the other RTA member countries (Athukorala 2007).

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 goods in process cross a border. Consequently, when 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, because of tariff reduction it may also make more profitable for goods that were previously produced in entirely in one country to now become vertically specialised. Consequently, the trade stimulating effect of FTA would be higher for parts and component trade than for normal trade, other things remaining unchanged. However, in the case of fragmentation trade one can assumes a positive coefficient because any positive effect of an RTA on the depth of regional outsourcing activity has the potential to promote such activities extra-regionally as well (assuming of course the nature of

[9] In experimental runs we tested separate dummies for all RTA, but eventually collapsed into single dummy (with an AFTA dummy added) because before there was no statistically significant differences in the magnitude of individual coefficients other than that on AFTA.

'rules or origin' built into the RTA). Finally, the time-specific fixed effects (T) are included to control for general technological change and other time-varying factors.

The model was estimated using annual bilateral trade data for 41 countries over the period of 1992 to 2004.[10] The trade data relates to the Machinery and Transport Equipment of the UN Standard International Trade Classification system (SITC Section 7). The prime focus of our analysis is on trade in components. However, we estimate the model for final goods trade (reported trade minus vertical trade) as well for the purpose of comparison. Under each category, the bilateral trade based on given reporting countries' import (rather than using a composite trade variables as the dependent variable, as is commonly done in trade flow analysis based on the gravity model) is estimated in order to allow for the possible difference in the nature/magnitude of the postulated impact of a given explanatory variable on bilateral trade flows. We used random effect estimator as our preferred estimation technique. The alternative fixed effect estimator is not appropriate because our model contains a number of time-invariant variables (distance, language, border and RTAs dummies) which are central to our analysis of fragmentation-based trade. A major limitation of the random effect estimator compared to its fixed effect counterpart is that it can yield inconsistent and biased estimates if the unobserved fixed effects are correlated with the remaining component of the error term. However, this is unlikely to be a serious problem in our case, because N (the number of explanatory variables) is larger than T (the number of 'within' observations) (Wooldrige 2001). The random effect estimator also takes care of care of the serial correlation problem. The results are reported in Table.[11] Information on variable construction and the data sources are given in Appendix 2. Countries covered in the analysis are listed in Appendix 2.

In both regressions the coefficients on the two central gravity variables – the level of GDP and the distance – have the expected signs (positive and negative, respectively) and are significant at the 1% level. The coefficient on GDP is similar in magnitude in the two equations suggesting that the market size is an equally important determinant of trade in components as well as the final assembled goods. The magnitude of the coefficient on the exporter per capita GDP is remarkably similar, but markedly different that on the importer per capital GDP, between the two equations. It seems that differences in the

[10] The data set include all countries which accounted for at least 0.1% of total world manufacturing exports in 2000-01.

[11] Alternative OLS estimates are available from the authors on request. The results are remarkable resilient to the choice between OLS and random effect estimater.

stage of economic development among trading partners is important only in explaining inter-country differences in component trade.

The two infrastructure variables (*TELP* and *ELET*) were dropped from the final estimates because they were found to be highly correlated with *PGDP*.[12] It seems that there is no need for additional variable for capturing infrastructure quality as it is close correlated with the stage of development as measured by *PGDP*.

The coefficient on the relative manufacturing wages (*RWG)* is statistically significant with the expected sign in both 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 the related final products). This may reflect the interconnectedness of components trade and the dependence of final exports on component imports. However, interestingly the magnitude of the coefficient on *RWG* in the parts and component equation is much larger compared to that in the final goods equation. This difference suggests that different layers of value added to the production process at difference stages of component assembly and testing in relatively more labour intensive compared to the final assembly. Interestingly, the coefficient on $|\Delta PGDP|$ is not statistically different from zero in the component equation. This result, when interpreted together with the results for *RWG*, suggests that relative manufacturing wage (*RWG*) plays an important role in fragmentation-based trade regardless of differences/similarities in overall factor endowment. In other words, the Ricardian competitive advantage (as against Hecksher-Ohlin factor endowment differentials) appears to be an important factor diving cross border trade in component (Neary 2003).

The results for the distance variable (*DST*) provide strong support for the hypothesis that cost of transportation and other distance-related costs are an important determinant of trade flows. Interestingly, the distance coefficient for components are larger in magnitude compared to those relating to final trade.[13] This difference is consistent with the hypothesis that vertical specialisation, given the multiple border crossing involved in the production process, is much more sensitive to transport cost. The common language dummy (LNG) is not statistically significant.

There is no evidence to support the hypothesis that RTAs promotes fragmentation trade; the coefficient on both *RTAEXT* and *RTAINT* is statistically insignificant with the

[12] This variable deletion was amply supported by the standard F-test.
[13] The difference is statistically significant in both cases.

unexpected (negative) sign. This result is consistent with the fact that much of the world fragmentation trade takes place under tariff concessions, overseas assembly provisions in developed countries and export promotion schemes in developing countries. Moreover it could well be that rules of origin in FTAs deter firms involved in fragmentation-based trade from utilizing duty concessions offered because of the inherent difficulties in defining the 'product' for duty exemption and because of the transaction costs associated with the bureaucratic supervision of the amount of value added in production coming from various sources (Athukorala 2006).

The coefficients on the two dummy variables for AFTA are highly significant with the positive sign in both equations. In particular, the coefficient on *AFTAINT* suggests that intra-AFTA component trade is about fifty times higher than the level predicted by the other explanatory variables in the model.[14] This unique results for AFTA (compared to the other RTAs) clearly point to the need for going beyond intra-regional tariff reductions (and other variables captured in our model) to understand that 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 (Athukorala 2007). 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 conducive 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 and Lawrence 1999). Moreover, rapid economic expansion for over three decades in a number of countries in the region has presumably brought about 'market thickness' (the economic depth of trading nations) which positively impact on the location of outsourcing activity.

In the previous section we noted that, compared to NAFTA and EU, the East Asian region is unique for the heavy concentration and rapid growth of fragmentation trade. The results of the regression analysis enable us to come up with three explanations

[14] Note that, as the model was estimated in logs, the percentage equivalent for any dummy coefficient is, [exp (dummy coefficient) – 1]* 100.

for this unique East Asian experience. First, the region is well placed to benefit from fragmentation-based specialisation countries in terms of relative wages. Not only manufacturing wages in latecomers to export-oriented industrialization in East Asia (China, Malaysia, Thailand, Vietnam and the Philippines) are low by world standards but also there are significant wage differentials among countries in the region, providing an ideal setting for the operation of cross-border production networks.[15] Second, relative cost advantages arising from these wage patterns seems to have been nicely complemented by cost/coordination advantages arising from geographical proximity among the countries and also perhaps close socio-cultural links among them. Thirdly, 'First comer' advantages – 'market thickness' and 'agglomeration' benefits evolved over a long period of time - also seems to have played a pivotal role. The latter two factors would have jointly brought about significant cost advantages in maintaining 'services links' in production networks in the region.

5. Conclusion

In this chapter we have examined the extend, trends and patterns of production fragmentation in world trade using a new data set constricted by carefully separating parts and components from total trade using finely disaggregated data from the UN trade data reporting system. The major novelty of the study is the econometric analysis of the determinants of inter-country variation in the degree of dependence on this new form of international specialisation using an augmented gravity model. The econometric analysis was undertaken in the context of an in-dept analysis of the implications of production fragmentation for analysing economic integration mong countries through foreign trade, with especial emphasis on the expense of countries in East Asia – a region which is unique in the world for its heavy reliance on fragmentation-based international exchange for its growth dynamism.

International production fragmentation has certainly played a pivotal role in continuing dynamism and increasing intra-regional economic interdependence of the East

[15]The average annual compensation (salary/wage plus other remuneration) per worker in East Asian countries and selected developing countries involved international production networks (annual average in US$ for the period 1992-04): China 5639, Indonesia 5356, Philippines $6955, Thailand 6474, Malaysia 8244, Taiwan 2,420, South Korea 27350, Singapore 22237, Poland 922, Hungary 9030, Czech Republic 8032, Mexico 10836, Spain 37578, Portugal 20613 and Ireland 34471. (Souce: US Bureau of Economic Analysis (BEA) online database, 'Survey of U.S. Direct Investment Abroad' < http://www.bea.doc.gov/bea/uguide.htm#_1_23>

Asian economies. This does not, however, mean that fragmentation-based international specialisation has contributed to reduce the regions 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 specialisation depends inexorably on its extra-regional trade in final good, and this dependence has in fact *increased* over the years. The growing importance of China both 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. In this context, these countries would be better off by upholding universal principles of economic openness.

There is clear evidence that fragmentation trade is expanding more rapidly than conventional final-goods trade. The degree of dependence on this new form of international specialisation is proportionately larger in East Asia compared to North America and Europe. The results from the gravity model estimation suggest that East Asia's unique position in world fragmentation trade is based on relative labour cost advantage (both relatively low wages and notably variability in wages among countries), geographica proximity among countries, and first comer advantages. The results also reveal notable differences between component trade and trade in finally assembled goods with respect to the impact of some of the key determinant trade flows. This finding makes a strong case for treating component trade separately from total trade in trade flow analysis.

References

Athukorala, P. (2006), 'Product Fragmentation and Trade Patterns in East Asia', *Asian Economic Papers*, 4(3), 1-27.

Brown, Clair and Greg Linden (2005), 'Offshoring in the Semiconductor Industry: A Historical Perspective', in Lael Brainard and Susan M. Collins (eds), *The Brookings Trade Forum 2005: Offshoring White-Collar Work: The Issues and Implications*, Washington DC: Brooking Institution Press, 270-333.

Brown, Drusilla K., Alan V. Deardorff and Robert M. Stern (2004), 'The Effect of Multinational Production on Wages and Working Conditions in Developing Countries', in Robert E. Baldwin and L. Alan Winters (ed.), *Challenges of Globalization: Analyzing the Economics*, Chicago: University of Chicago Press, 279-332.

Borrus, M. (1997), 'Left for dead: Asian production networks and the revival of US electronics', in B. Naughton (Ed.), *The China circle: economics and technology in the PRC, Taiwan and Hong Kong* (pp.215-239), Washington DC: Brookings Institution Press.

Cairncross, F. (1997), '*The death of distance: how the communication revolution will change our lives*', London: Orion Business Books.

Dobson, W. & Chia, S. Y. (1997), *Multinationals and East Asian integration*. Singapore: Institute of Southeast Asian Studies.

Drysdale, P. & Garnaut, R. (1997), 'The pacific: an application of a general theory of economic integration', In C. F. Bergsten & M. Noland (Eds.), *Pacific dynamism and the international economic system* (pp.183-224). Washington DC: Institute for International Economics.

Egger, H. & Egger, P. (2005), 'The determinants of EU processing trade', *World Economy*, 28 (2), 147-168.

Feenstra, RC, RE Lipsey, H Deng, AC Ma and H Mo (2005), 'World Trade Flows, 1962-2000', *National Bureau of Economic Research (NBER) Working Paper 11040*, Cambridge, MA: NBER. (http:/www.nber.org/papers/w11040)

Frankel, J. A. & Wei, S. (1997), 'The new regionalism and Asia: impact and policy options', in A. Panagariya, M.G. Quibria & N. Rao (Eds.), *The global trading system and developing Asia* (pp. 83-130). Oxford: Oxford University Press.

Gorg, H. (2000), 'Fragmentation and trade: US inward processing trade in the EU. *Weltwirtschaftliches Archiv*, 136 (3), 403-422.

Grossman, G. M. & Helpman, E. (2005), 'Outsourcing in a global economy', *Review of Economic Studies*, 72 (1), 135-159.

Helleiner, G. K. (1973), 'Manufactured Exports from Less-Developed Countries and Multinational Firms', *Economic Journal*, 83(329), 21-47.

Helpman, E. (1987), 'Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries', *Journal of the Japanese and International Economics*, (1), 62-81.

Hummels, D. (1999), Have international transport cost declined? Graduate School of Business, University of Chicago (paper in progress).

Jones, R. W. (2000), *Globalization and the theory of input trade*. Cambridge, Mass.: MIT Press.

Jones, R. W. & Kierzkowski, H. (2001), 'Globalization and the consequences of international fragmentation', in R. Dornbusch, G. Calvo & M. Obstfeld (Eds.), *Money, factor mobility and trade: the festschrift in honor of Robert A. Mundell* (pp. 365-381). Cambridge, Mass.: MIT Press.

Jones, R. W., Kierzkowski, H. & Lurong, C. (2004), 'What does the evidence tell us about fragmentation and outsourcing', *International Review of Economics and Finance*, 14 (3), 305-316.

Kwan, C.H. (2001), *Yen bloc: toward economic integration in Asia*, Washington DC: Brookings Institution Press.

Kierzkowski, H. (2001), 'Joining the global economy: experience and prospects of the transition economies', in S.W. Arndt & H. Kierzkowski (Eds.), *Fragmentation:*

new production patterns in the world economy (pp. 231-253). Oxford: Oxford University Press.

McKendrick, D. G., Doner, R. F. & Haggard, S. (2000), *From Silicon Valley to Singapore: location and competitive advantage in the hard disk drive industry*. Stanford, Cal: Stanford University Press.

Neary, P. (2003), 'Competitive versus Comparative Advantage', *World Economy*, 26 (4), 457-470.

Ng, F. & Yeats, A. (2001), 'Production sharing in East Asia: who does what for whom, and why?', in L. K. Cheng & H. Kierzkowski (Eds.), *Global production and trade in East Asia* (pp. 63-109), Boston: Kluwer Academic Publishers.

Petri, P. (1993), 'The East Asian trading block: an analytical history. In J. A. Frankel & M. Kahler (Eds.), *Regionalism and rivalry: Japan and the United State in Pacific Asia* (pp. 21-48). Chicago: Chicago University Press.

Rangan, S. & Lawrence, R. (1999), *A prism on globalization*, Washington DC: Brookings Institution Press.

Sturgeon, T.J. (2003) 'What really goes on in Silicon Valley? Spatial clustering and dispersal in modular production networks', *Journal of Economic Geography*, 3: 199–225.

Yi, K. (2003), 'Can vertical specialization explain the growth of world trade', *Journal of Political Economy*, 111 (1), 52-102.

Wooldridge, J. (2001), *Econometric analysis of cross section and panel data*, Cambridge: The MIT Press.

Table 1: World Trade in Parts and Components, 1992/3[1]-2004/5[1] (%)

	1992/3	2004/5	1992/3	2004/5
East Asia[2]	30.7	42.6	22.4	34.8
Japan	16.6	11.1	3.4	4.2
Developing East Asia[3]	14.1	31.5	18.9	30.6
China	1.2	10	2.6	10.8
Hong Kong	1.7	0.9	3.6	5.9
Rep. of Korea	2.1	4.5	2.9	2.9
Taiwan	3.3	5.6	2.4	2.8
AFTA6	5.9	10.4	9.9	10.9
South Asia	0.1	0.3	0.1	0.3
Oceania	0.3	0.3	1.4	0.9
NAFTA	24.8	18.8	27.8	21.8
Mexico	2.4	2.8	2	3.6
Mercosur	0.7	0.6	0.7	0.6
Andean Common Market	0	0	0	0
Europe	41.5	35.6	43.2	36.6
EU15	38.5	30.4	40.1	30.6
Eastern Europe	0.6	3.2	0.6	3.3
Rest of Europe	0.3	0.4	0.3	0.4
World	100	100	100	100
US$ Billion	527	1652	527	1651
Memo items:				
Developed countries	79.9	58.4	79.9	58.4
Developing countries	18.6	39.9	18.6	39.9

Notes:

--- Data not available.

1 Two-year average

2 Japan + Developing East Asia.

3 ASEAN6 + China + Hong Kong SAR, Taiwan, South Korea.

AFTA ASEAN Free Trade Area NAFTA North American Free Trade Area

Source: Compiled from UN Comtrade database.

Table 2 : Parts and Components (PCs) in Manufacturing (Mfg) Trade

(A) Exports

	Value of PCs ($ billions)		Share of PCs in Mfg (%)		Annual average growth of Mfg exports (%)	Annual average growth of PCs exports (%)	Contribution of PCs to growth of Mfg exports (%)
	1992/93	2004/05	1992/93	2004/05	1992-2005	1992-2005	1992/3-2004/5
East Asia	161.8	703.0	21.9	30.0	9.6	12.5	33.7
Japan	87.5	182.9	26.9	32.9	4.3	6.3	41.4
Developing East Asia	74.3	520.0	18.0	29.1	12.4	16.7	32.4
China	6.1	165.3	5.3	19.5	17.4	29.7	21.7
Hong Kong	8.8	15.2	18.8	27.7	0.6	3.4	79.4
Rep. of Korea	11.1	74.3	19.5	31.0	12.2	17.0	34.6
Taiwan	17.3	93.1	21.2	43.5	8.1	14.4	57.2
AFTA6	31.0	172.1	27.5	40.3	11.6	14.7	44.9
South Asia	0.7	5.0	3.6	6.4	12.1	17.9	7.3
Oceania	1.6	4.2	15.7	15.9	8.1	8.1	16.0
NAFTA	130.7	310.7	29.7	29.8	7.2	7.1	29.9
Mexico	12.7	46.2	38.4	30.2	12.5	10.5	27.9
Mercosur	3.6	10.6	14.6	14.4	9.3	9.0	14.3
Andean Common Market	0.2	0.7	5.0	4.7	11.4	10.7	4.6
Europe	218.5	588.3	18.3	19.6	6.5	6.9	20.5
EU15	203.0	501.5	18.8	19.6	6.0	6.2	20.2
Eastern Europe	3.1	53.7	11.3	26.3	16.2	24.1	28.6
Rest of Europe	1.6	6.4	15.6	22.5	7.3	9.9	26.4
World	527.0	1652.0	20.9	24.2	7.8	9.0	26.1

(B) Imports

	Value of PCs ($ billions)		Share of PCs in Mfg (%)		Annual average growth of Mfg exports (%)	Annual average growth of PCs exports (%)	Contribution of PCs to growth of Mfg exports (%)
	1992/93	2004/05	1992/93	2004/05	1992-2005	1992-2005	1992-2005
East Asia	117.9	573.8	22.9	38.0	9.0	13.1	45.8
Japan	18.1	69.1	16.5	25.9	7.0	10.6	32.5
Developing East Asia	99.8	504.7	24.7	40.6	9.5	13.5	48.3
China	13.4	178.6	17.7	38.8	15.6	21.6	43.0
Hong Kong	18.9	97.7	16.4	37.3	6.9	13.8	53.7
Rep. of Korea	15.0	48.2	28.8	32.4	8.3	9.0	34.3
Taiwan	12.7	45.8	29.6	34.4	11.2	13.3	36.7
AFTA6	52.4	180.2	32.6	48.5	7.2	10.5	60.6
South Asia	0.7	5.0	3.6	6.4	12.1	17.9	7.3
Oceania	7.3	15.0	17.3	13.8	7.6	6.0	11.6
NAFTA	146.8	360.5	24.7	22.5	8.1	7.4	21.2
Mexico	10.7	60.0	23.0	34.1	10.7	13.9	38.1
Mercosur	3.6	10.6	14.6	14.4	9.3	9.0	14.3
Andean Common Market	0.2	0.7	5.0	4.7	11.4	10.7	4.6
Europe	227.5	605.0	18.7	19.9	6.4	6.8	20.7
EU15	211.4	505.5	19.1	20.3	5.5	5.9	21.3
Eastern Europe	3.1	53.7	11.3	26.3	16.2	24.1	28.6
Rest of Europe	1.6	6.4	15.6	22.5	7.3	9.9	26.4
World	527.0	1651.2	20.9	24.1	7.8	9.0	26.0

Notes:

--- Data not available.

Source: Compiled from UN Comtrade database.

Table 3: Direction of Manufacturing Trade: Total manufacturing and Parts and Components

(a) Exports

		A1: Total Manufacturing Exports								B1: Parts and Components Exports							
Partner	Year	EA	Japan	DEA	China +HK	AFTA	NAFTA	EU15	World	EA	Japan	DEA	China +HK	AFTA	NAFTA	EU15	World
East Asia (EA)	1992/3	40.0	5.2	34.9	18.5	13.0	32.3	20.3	100	44.0	3.4	40.5	14.5	20.8	33.5	17.6	100
	2004/5	44.4	6.7	37.7	23.2	10.6	26.4	17.7	100	60.9	6.4	54.5	32.5	17.6	19.5	12.8	100
Japan	1992/3	32.5	.	32.5	11.9	14.8	34.8	21.4	100	37.3	.	37.3	10.6	19.4	36.9	18.8	100
	2004/5	42.8	.	42.8	22.2	12.7	27.8	17.1	100	53.0	.	53.0	28.1	18.0	25.2	14.8	100
Developing East Asia (DEA)	1992/3	46.0	9.3	36.7	23.6	11.5	30.4	19.5	100	51.8	7.5	44.3	19.0	22.3	29.5	16.1	100
	2004/5	44.9	8.8	36.1	23.5	9.9	25.9	17.9	100	63.7	8.6	55.1	34.1	17.4	17.4	12.2	100
China+HK	1992/3	50.6	7.7	43.0	36.6	4.7	26.1	19.1	100	64.5	4.9	59.5	41.3	13.2	18.5	12.7	100
	2004/5	38.1	9.7	28.5	14.5	5.7	30.0	20.0	100	58.7	9.1	49.6	20.2	11.9	19.5	13.7	100
AFTA	1992/3	41.0	9.3	31.7	8.5	20.8	33.0	22.3	100	52.4	7.2	45.2	8.9	32.8	29.9	16.7	100
	2004/5	50.2	8.7	41.4	19.1	19.4	22.6	17.2	100	65.1	8.0	57.1	27.2	26.1	16.1	13.2	100
NAFTA	1992/3	20.7	7.5	13.2	3.9	6.3	46.9	22.0	100	21.3	6.7	14.6	3.0	8.2	47.8	23.3	100
	2004/5	17.2	4.5	12.6	5.1	5.1	51.5	18.7	100	24.7	5.0	19.7	5.9	10.6	47.8	18.0	100
EU15	1992/3	8.1	2.5	5.5	2.2	2.5	9.7	66.9	100	7.5	1.3	6.2	2.0	3.3	12.0	66.1	100
	2004/5	7.8	1.9	6.0	3.3	1.8	11.3	58.2	100	11.0	1.5	9.5	4.7	3.7	11.2	56.5	100
	2004/5	5.0	0.6	4.4	2.7	0.4	38.5	10.3	100	2.7	0.3	2.4	0.6	1.5	46.6	8.9	100
World	1992/3	20.3	4.3	16.0	7.6	6.4	23.6	43.8	100	22.3	3.3	18.9	6.1	9.9	27.8	40.1	100
	2004/5	22.0	3.9	18.1	10.5	5.4	23.3	36.4	100	34.7	4.2	30.6	16.7	11.0	21.8	30.6	100

(b) Imports

		A1: Total Manufacturing Imports								B1: Parts and Components Imports							
Partner	Year	EA	Japan	DEA	China+ HK	AFTA	NAFTA	EU15	World	EA	Japan	DEA	China+H K	AFTA	NAFTA	EU15	World
East Asia (EA)	Year	57.8	20.6	37.1	16.0	9.0	17.8	17.0	100	60.7	27.8	32.9	8.4	13.8	23.7	13.0	100
	1992/3	68.9	15.8	53.1	22.8	14.2	11.9	13.3	100	74.6	16.9	57.7	21.2	19.5	13.4	9.6	100
Japan	2004/5	35.6	.	35.6	11.6	9.7	30.6	25.4	100	32.0	.	32.0	5.3	12.9	50.4	15.3	100
	1992/3	58.8	.	58.8	32.9	14.1	17.8	17.9	100	64.9	.	64.9	46.5	19.9	22.4	10.8	100
Developing East Asia (DEA)	2004/5	63.7	26.1	37.6	17.2	8.8	14.4	14.8	100	65.7	32.7	33.0	8.9	14.0	19.1	12.6	100
	1992/3	71.0	19.1	51.9	20.7	14.3	10.6	12.3	100	75.9	19.2	56.7	17.7	19.5	12.1	9.4	100
China+HK	2004/5	71.3	20.3	51.0	30.9	5.0	8.9	12.2	100	72.4	28.8	43.7	19.1	8.5	12.0	12.6	100
	1992/3	75.2	17.1	58.1	18.2	11.3	7.4	11.7	100	82.8	18.6	64.2	13.2	17.0	6.7	8.5	100
AFTA	2004/5	59.6	30.0	29.6	4.7	14.6	17.3	16.7	100	64.1	32.4	31.7	3.8	19.4	20.4	13.0	100
	1992/3	66.4	19.0	47.4	13.8	22.2	14.4	12.7	100	68.2	18.2	50.0	11.9	24.9	18.3	10.2	100
South Asia	2004/5	31.6	11.2	20.4	6.8	5.6	13.0	39.5	100	35.4	22.0	13.4	3.4	6.4	18.1	39.1	100
	1992/3	39.7	6.0	33.7	15.7	9.9	10.7	29.7	100	44.6	7.9	36.7	13.4	14.4	14.7	32.1	100
Oceania	2004/5	39.5	21.0	18.4	6.2	5.2	24.4	24.2	100	34.0	22.1	11.9	2.6	3.7	36.1	24.0	100
	1992/3	44.8	13.6	31.1	15.9	9.2	17.6	25.1	100	36.9	11.9	25.0	9.1	10.1	28.7	25.4	100
NAFTA	2004/5	40.2	19.0	21.2	7.1	6.3	34.8	17.7	100	36.9	22.0	14.9	1.9	6.3	42.6	16.7	100
	2004/5	38.6	9.7	29.0	17.0	6.1	33.7	18.1	100	38.0	12.8	25.2	9.8	7.7	41.3	15.6	100
EU15	1992/3	13.6	6.3	7.3	2.8	2.3	8.8	65.5	100	13.4	7.8	5.6	0.9	2.4	14.4	63.5	100
	2004/5	16.6	3.8	12.8	7.2	3.0	7.8	59.8	100	17.9	5.3	12.5	4.9	4.5	11.1	56.1	100
World	1992/93	29.3	12.9	16.4	6.4	4.5	17.5	42.9	100	30.7	16.6	14.1	2.8	5.9	24.8	38.5	100
	2004/05	34.2	8.1	26.1	13.2	6.2	15.2	37.4	100	42.5	11.1	31.5	10.9	10.4	18.8	30.3	100

(c) Total Manufacturing Trade (export + imports)

		A1: Total Manufacturing Trade								B1: Parts and Components Trade							
Partner:	Year	EA	Japan	DEA	China+ HK	AFTA	NAFTA	EU15	World	EA	Japan	DEA	China+ HK	AFTA	NAFTA	EU15	World
East Asia (EA)	Year	47.3	11.5	35.8	17.5	11.3	26.4	19	100	51	13.7	37.3	11.9	17.9	29.4	15.6	100
	1992/3	54	10.2	43.7	23	12	20.7	16	100	67.1	11.1	56	27.4	18.5	16.7	11.4	100
Japan	2004/5	33.2	.	33.2	11.8	13.6	33.7	22.4	100	36.4	.	36.4	9.7	18.3	39.1	18.2	100
	1992/3	48	.	48	25.6	13.2	24.6	17.4	100	56.3	.	56.3	33.1	18.5	24.4	13.7	100
Developing East Asia (DEA)	2004/5	54.7	17.6	37.1	20.5	10.2	22.5	17.2	100	59.8	21.9	37.8	13.2	17.6	23.5	14.1	100
	1992/3	55.6	13	42.6	22.3	11.7	19.6	15.6	100	69.7	13.8	55.9	26	18.4	14.8	10.8	100
China+HK	2004/5	61.8	14.5	47.3	33.5	4.8	16.8	15.4	100	69.9	21.2	48.7	26.1	10	14	12.6	100
	1992/3	54.6	13	41.6	16.2	8.2	20	16.3	100	73.3	14.9	58.4	16	15	11.8	10.5	100
AFTA	2004/5	51.9	21.5	30.4	6.3	17.1	23.8	19	100	59.7	23.1	36.7	5.7	24.3	23.9	14.4	100
	1992/3	57.7	13.5	44.2	16.7	20.7	18.8	15.1	100	66.7	13.2	53.5	19.4	25.5	17.2	11.7	100
South Asia	2004/5	24.6	8.6	16	6.2	5.5	23	39.9	100	34.2	18.2	16.1	3.4	9.6	17.8	38.1	100
	1992/3	28	3.9	24.1	12	7.6	20.5	31.3	100	36.8	6.5	30.3	11.1	12.8	18.5	32.4	100
Oceania	2004/5	40.2	18.8	21.4	6.7	8.1	22.9	22.2	100	35.2	19.8	15.4	3.1	6.7	33.5	24	100
	1992/3	41.6	11.9	29.7	14.6	9.4	17.9	23.2	100	36.3	9.7	26.6	8.9	11.5	27.3	24	100
NAFTA	2004/5	31.9	14.1	17.8	5.7	6.3	40	19.5	100	29.6	14.8	14.8	2.4	7.2	45	19.8	100
	2004/5	30.2	7.6	22.5	12.3	5.7	40.7	18.3	100	31.8	9.2	22.7	8	9.1	44.3	16.7	100
EU15	1992/3	10.9	4.4	6.4	2.5	2.4	9.2	66.2	100	10.5	4.6	5.9	1.4	2.9	13.3	64.7	100
	2004/5	12.2	2.8	9.4	5.2	2.4	9.6	59	100	14.4	3.4	11	4.8	4.1	11.1	56.3	100
World	1992/3	24.8	8.6	16.2	7	5.4	20.5	43.4	100	26.5	10	16.5	4.5	7.9	26.3	39.3	100
	2004/5	28.1	6	22.1	11.9	5.8	19.3	36.9	100	38.6	7.6	31	13.8	10.7	20.3	30.5	100

Source**:** Complied from *UN Comtrade Database* using the commodity/country classification described in the text (Section 3).

Table 4 Intra-Regional Trade Shares: Total Manufacturing, Parts and Components, and Final Trade (%), 1992/93 and 2004/05[1]

A: Total Manufacturing		East Asia	Developing East Asia	AFTA	NAFTA	EU 15
Exports (X)	1992/93	40.0	36.7	20.8	46.9	66.9
	2004/05	44.4	36.1	19.4	51.5	58.2
Imports (M)	1992/93	57.8	37.6	14.6	34.8	65.5
	2004/05	68.9	51.9	22.2	33.7	59.8
Trade (X+M)	1992/93	47.3	37.1	17.1	40.0	66.2
	2004/05	54.0	42.6	20.7	40.7	59.0
B: Parts and Components						
Exports(X)	1992/93	44.0	44.3	32.8	47.8	66.1
	2004/05	60.9	55.1	26.1	47.8	56.5
Imports (M)	1992/93	60.7	33.0	19.4	42.6	63.5
	2004/05	74.6	56.7	24.9	41.3	56.1
Trade (X+M)	1992/93	51.0	37.8	24.3	45.0	64.7
	2004/05	67.1	55.9	25.5	44.3	56.3
C: Final goods						
Exports(X)	1992/93	38.9	35.1	16.2	46.5	67.0
	2004/05	37.3	28.3	14.8	53.1	58.7
Imports (M)	1992/93	56.9	39.0	12.2	32.3	66.0
	2004/05	65.3	48.6	19.7	31.5	60.7
Trade (X+M)	1992/93	46.2	37.0	13.9	38.1	66.5
	2004/05	47.5	35.8	16.9	39.5	59.7

Source**:** Complied from *UN Comtrade Database*.

Table 5:
Determinants of World Trade in Machinery and Transport Equipment (SITC7): Regression Results , 1992-2003[1]

Explanatory variables[2]	(1) Parts and Components		(2) Final go	
	Coefficient	SE	Coefficient	SI
Log GDP, importer	0.984	0.127***	0.875	0.
Log GDP, exporter	0.915	0.029***	0.979	0.
Log per capita GDP, importer	0.328	0.126***	0.248	0.
Log per capita GDP, exporter	0.357	0.036***	0.361	0.
Log absolute per capita GDP differences	0.055	0.041	0.078	0.
Log relative labour cost (RWG)[3]	0.544	0.093***	0.164	0.
Log distance (DST)	-0.970	0.073***	-1.070	0.
Common language dummy (*LNG*)	0.931	0.121***	0.656	0.
Common land border dummy (BRD)	0.206	0.180	0.054	0.
RTA dummies				
Intra RTA trade (RTAINT)[4]	-0.122	0.380	-0.032	0.
Extra RTA trade of RTA member countries (RTAEXT)	-0.239	0.373	-0.187	0.
Intra AFTA trade (AFTAINT)[5]	3.940	0.588***	2.490	0.
Extra AFTA trade of AFTA member countries (AFTAEXT)	1.470	0.471***	0.888	0.
Constant	-36.700	3.810***	-33.700	2.
R^2 (overall)	0.630		0.630	
(Within)	0.592		0.585	
(Between)	0.784		0.832	
F	9738.350		16751.340	
Number of observations	19445		19390	

Note:

1 Estimated by applying the random effect estimator to annual data on bilateral trade of 41 countries over the period 1992 to 2003. The standard errors (SEs) of the regression coefficients have been derived using the Huber-While consistent variance-covariance ('sandwich') estimator. Statistical significant (based on the standard t-test) is denoted as ***1%, **5%, and *10%. Results for the time dummies are not reported.

2 Other variables included in the model but deleted from the final estimate (because their high correlation with PGDP):

TELE Telephone mainlines per 1000 people

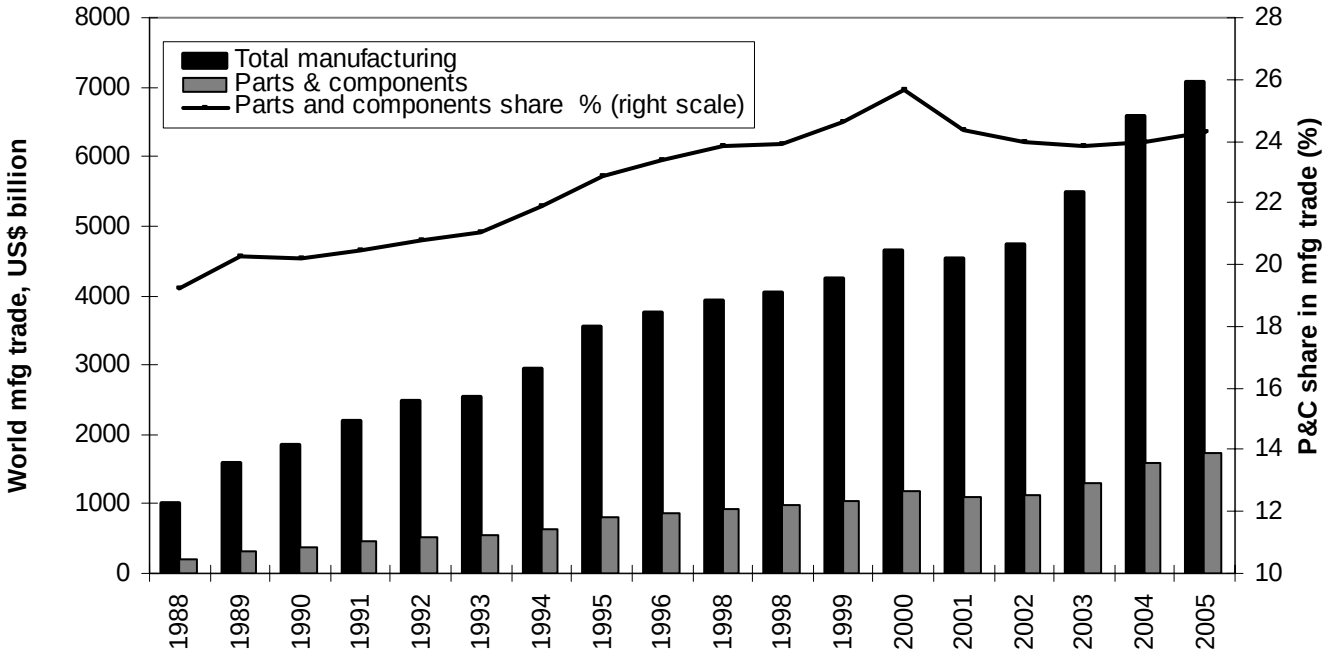
ELET Per capital electricity production in kilo-watt

3 Manufacturing wage of partner (importing) country relative to that of reporting (exporting) country adjusted for the bilateral exchange rate.

4 Captures membership in six regional trading agreements (ASEAN Free Trade Agreement (AFTA), European Union (EU), North American Free Trade Agreement (NAFTA) and the Common Market of South America (MERCOSUR), with all countries not belonging to ANY RTA forming the base group.

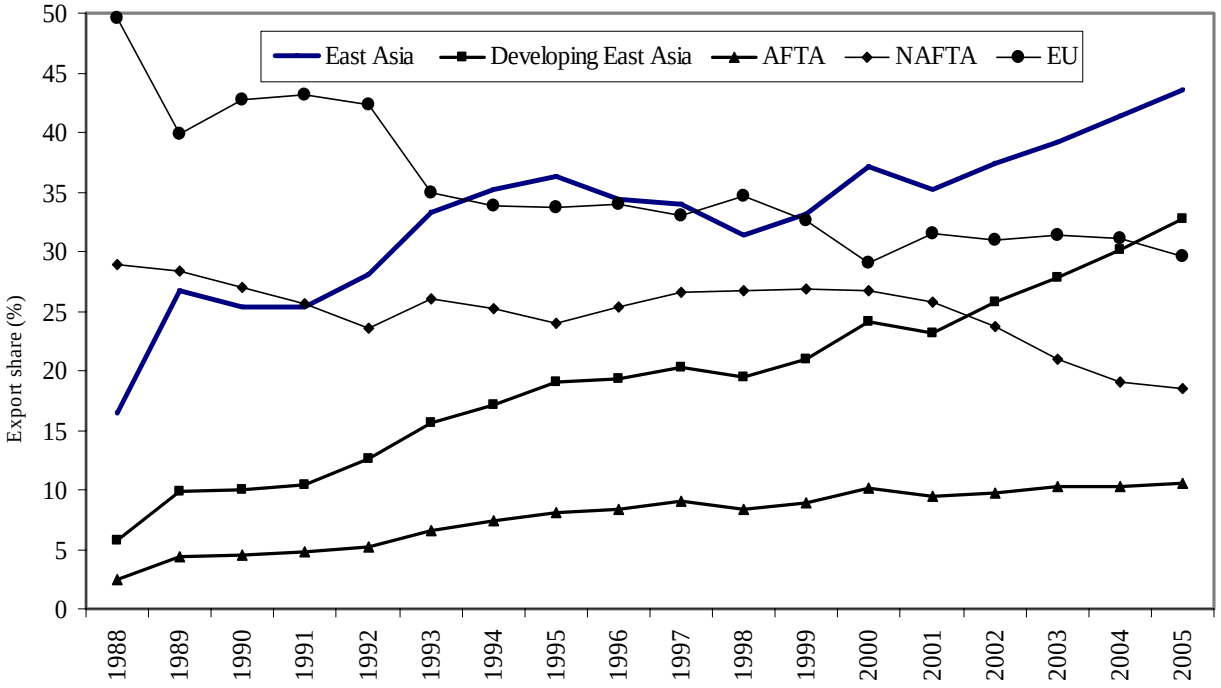
5 Including AFTA

Figure 1: World Manufacturing Trade, 1988-2005



Source: Based on data compiled from Comtrade database (exporter records)

Figure 2: Share of Parts and Component in Manufacturing Exports by Region, 1988-2005 (%)



Source: Based on data compiled from Comtrade database (exporter records)

Appendix 1: Definition of Variables and Data Source Used in Regression Analysis

Variable	*Definition*	*Data Source*
M	Bilateral trade flows ('Component' and 'Final Goods' trade) at constant (1995) dollar	Trade flows: UN-COMTRADE, online database Exchange rates: IMF, *International Financial Statistics* (line rf)
GDP	Real GDP (at 1995 price)	World Development Indicator, The World Bank
DIST	The Great Circle distance between capital cities of two countries	Joe Haveman's International Trade Data, at <http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html>
RWG	Relative labour cost in the manufacturing, adjusted for exchange rate changes: $RWG_{ij} = \frac{W_i}{W_j} E_{ij}$ where, W = manufacturing wage index (1992 = 100) *E* = nominal bilateral exchange rate expressed as the value of *i*'s currency in terms of *j*'s currency. By construct, an increase (decrease) in RWG_{ij} indicates a deterioration (improvement) in *i*'s cost competitiveness vis a vis *j*	Annual manufacturing wages data for USA: 'Interactive database of National Income and Product Accounts Tables' at <http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp?Selected=N#S6> under Section 6 - Income and Employment by Industry All other countries: US Bureau of Economic Analysis (BEA) online database, 'Survey of U.S. Direct Investment Abroad' < http://www.bea.doc.gov/bea/uguide.htm#_1_23>. Bilateral exchange rates: derived from bilateral US$ exchange rates obtained from IMF, International Financial Statistic.

Appendix 2: Country coverage

Argentina	Finland	Mexico	South Africa
Australia	France	Netherlands	Spain
Austria	Germany	Norway	Sweden
Belgium	Hungary	Philippines	Switzerland
Brazil	India	Poland	Thailand
Canada	Indonesia	Portugal	Turkey
China	Ireland	Rep. of Korea	United Kingdom
China, Hong Kong SAR	Israel	Russian Federation	USA
Costa Rica	Italy	Singapore	
Czech Rep.	Japan	Slovakia	
Denmark	Malaysia	Slovenia	

Of which, RTA member countries:

AFTA	**EU15**	**NAFTA**	**MERCOSUR**
Indonesia	Austria	Canada	Argentina
Malaysia	Belgium/Luxemburg	USA	Brazil
Philippines	Denmark	Mexico	
Singapore	Finland		
Thailand	France		
	Germany		
	Ireland		
	Italy		
	Netherlands		
	Norway		
	Portugal		
	Spain		
	Sweden		
	United Kingdom		