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Patterns and determinants of intra-industry trade in Asia

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ABSTRACT

Intra-industry trade (IIT) has gained in importance across Asia as a result of the rapid growth of Asian economies and their key role in the international fragmentation of production. This paper examines the level of IIT for 22 countries in East, Southeast, South, and Central Asia in 2003. IIT is measured as a multilateral trade-weighted index and is reported for ten different categories of goods in the primary and secondary sectors. In addition, the determinants of IIT are investigated using a Tobit regression model. The results indicate that ASEAN and the high-income countries in East Asia exhibit the highest levels of IIT, followed closely by China and India. R&D spending, openness, and a higher share of manufactured exports were found to promote IIT, while geographical distance and the difference in economic size had an adverse effect, especially for manufactured goods. The ASEAN free trade area was most prominently associated with IIT across all SITC categories. Central and South Asian regional trade agreements had a positive influence on IIT in primary products.

1. Introduction

Trade has played a crucial role in the economic success of Asian countries. The rapid growth that countries like Japan, Korea, Taiwan, and Singapore have experienced since the 1960s is closely related to the export-oriented development strategy that they adopted. In Korea, the share of exports in GDP increased from 3 percent in 1960 to 46 percent in 2007, and in Taiwan from 10 to 74 percent over the same period. Similarly, China's ascent from an isolated closed economy to a major trading nation has been a key feature of its reform and growth process over the past 30 years. Furthermore, the free trade area (FTA) created by the Association of Southeast Asian Nations (ASEAN) in 1992 with the goal of promoting trade and economic integration among its members has become one of the major regional trade blocs in the world.

The rapid growth of Asian countries, their export-oriented industrialization, and the international fragmentation of production have contributed to the increasing importance of intra-industry trade (IIT) in Asia. IIT is generally assumed to occur between developed industrialized economies with similar factor endowments and capital-labor ratios, while developing countries typically engage in inter-industry trade by exporting labor-intensive resource-based products in exchange for final manufactured goods. Although the majority of Asian countries have developing or emerging economies, IIT plays an important role in Asia for several reasons. First, Asia has become the major beneficiary of the international fragmentation of production. IIT can emerge from vertical specialization when some countries produce intermediate goods and others assemble them into final products. Both sides end up engaging in IIT when the country exporting (importing) the intermediates imports (exports) the final product at a later stage in the production process (Dixit & Grossman, 1982; Ethier, 1982). The share of East, Southeast, and

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South Asia in world exports and imports of parts and components in 2003 was 39.4 and 38.5 percent, respectively, which was higher than the share of any other continent or trade bloc (Athukorala & Yamashita, 2006).

Second, IIT involves the exchange of vertically differentiated products in terms of quality and price. Due to the low technology available to them, developing countries in Asia have long been producing and exporting low-price, low-quality products in exchange for high-price, high-quality products in the same category of goods (Flam & Helpman, 1987). Third, in developing and emerging economies in Asia the income inequality between urban and rural areas and between regions that have attracted foreign investment and those that have remained isolated is high. The increasingly affluent consumers in the urban areas express preferences for product variety similar to their counterparts in high-income countries which promotes trade in horizontally differentiated products.

The goal of this article is to examine the patterns of IIT across Asia and to identify their determinants. Previous empirical studies on IIT in Asia which are reviewed in the next section share several common features. The IIT index is measured on a bilateral basis and is limited to manufactured goods. The number of Asian countries included in the analysis rarely exceeds ten (China, Hong Kong, Japan, Korea, Taiwan, Indonesia, Malaysia, Philippines, Singapore, and Thailand). Very few studies examine the levels of IIT in Asia for years more recent than 2000. In contrast to previous works, this paper estimates a trade-weighted multilateral IIT index for 2003 which is reported for all ten categories of the Standard International Trade Classification (SITC) including primary goods as well as manufactured products. In addition, we use a much broader sample comprised of 22 countries in East, Southeast, South, and Central Asia. Lastly, a Tobit regression model is employed to estimate the effects of economic size, per capita income, geographical distance, education, product differentiation, openness, foreign direct investment, and regional trade agreements on IIT in Asia.

Our results indicate that ASEAN and the high-income countries in East Asia exhibited the highest levels of IIT, followed closely by the emerging economies of China and India. The IIT index was higher across manufacturing categories than for primary products. The difference in economic size between trading partners had an adverse effect on IIT but only for manufactured products. Moreover, R&D spending, geographical distance, and the share of manufactured goods in exports were found to be significant determinants of IIT in Asia. The free trade area of the ASEAN encouraged IIT across all categories of goods, while regional trade agreements in South and Central Asia had a positive effect mostly for primary products.

The paper is organized as follows. The next section provides a brief review of the literature. Section 3 describes the methodology of measuring IIT and the specification of the regression model used to identify the determinants of IIT in Asia. Section 4 presents the results of the estimation for each country in the sample across the ten SITC categories, and Section 5 summarizes the conclusions of the analysis.

2. Brief review of the literature

Previous empirical work on IIT in Asia can be generally divided into two categories. One group of studies has focused on the levels of IIT in specific Asian countries, with China receiving the greatest attention. Hu and Ma (1999), Zhang, Witteloostuijin, & Zhou (2005), and Zhang and Li (2006) estimated the extent and determinants of China's IIT in manufactured goods over the 1990s. Other studies have investigated China's bilateral IIT with the United States (U.S.) (Shen & Gu, 2007), Japan (Xing, 2007), and Korea (Lee & Han, 2008). Besides China, country-specific analysis of IIT has been conducted for Korea (Bhattacharyya, 2005; Byun & Lee, 2005), Japan (Wakasugi, 1997), and India (Das, 2005; Veeramani, 2002).

A second group of studies has investigated IIT at the level of Asian regions or trade blocs focusing mostly on East Asia and the ASEAN. Thorpe and Zhang (2005) estimated East Asia's IIT levels and determinants in manufacturing and showed that the IIT index increased from 24 to 50 percent over the period 1970–1996. This was largely the result of the growing involvement of East Asian countries in vertical specialization and the international fragmentation of production (Ando, 2006; Wakasugi, 2007). In fact, the dependence of East Asia on international specialization has been found to be proportionally larger than in North America and Europe (Athukorala and Yamashita, 2006). Furthermore, IIT appears to promote economic integration within East Asia and among ASEAN member countries (Cortinhas, 2007; Sohn and Zhang, 2005). IIT has been shown to be the major driving force behind the business cycle synchronization in the region through the establishment of regional production networks and supply chains by multinational corporations (Rana, 2006, 2007).

In 2006, the intra-regional IIT levels in Northeast and Southeast Asia (27 and 34 percent, respectively) were second only to the highly integrated regions of North America and Western Europe (55 and 45 percent, respectively), whereas the IIT within South and Central Asia was negligible (Bruelhart, 2008). However, the intra-regional IIT in ASEAN and East Asia taken together (54.4 percent) exceeds the IIT within NAFTA (45 percent) and is close to the levels within the European Union (66.2 percent) (Rana, 2006). As for inter-regional IIT, East Asia was most actively engaged with the group of high-income countries (21 percent) followed by trade with South Asia (8.5 percent) and Latin America (5.9 percent) (Bruelhart, 2008).

3. Methodology and data

The extent of IIT is generally computed using a variant of the standard Grubel–Lloyd index (Grubel & Lloyd, 1975) which takes the following form:

$$IIT_c = 1 - \frac{|X_c - M_c|}{X_c + M_c}$$

Table 1
The major categories of the standard international trade classification system.

SITC code	Product description
0	Food and live animals
1	Beverages and tobacco
2	Crude materials, inedible, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils, fats and waxes
5	Chemicals and related products
6	Manufactured goods classified chiefly by material
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities and transactions not classified elsewhere in the SITC

where X_c and M_c stand for exports and imports of commodity c, respectively. This measure ranges between zero (complete inter-industry trade) and one (complete intra-industry trade). While the Grubel–Lloyd index is the most commonly used IIT measure in the literature, it is prone to aggregation bias. IIT calculations performed at higher levels of aggregation yield inflated estimates of IIT (Gullstrand, 2002). Since it is impossible to eliminate this bias completely, the best solution is to perform the calculations at as high a level of disaggregation as the data allow. Accordingly, all IIT calculations herein are performed at the 4-digit SITC level of disaggregation and then averaged up to the 1-digit level for reporting purposes. The major SITC categories are listed in Table 1. In contrast to previous empirical work on Asia which used a bilateral Grubel–Lloyd index, we employ it as a multilateral measure of IIT for 22 Asian economies in 2003.[1] The averages for each SITC category are calculated using both a simple non-weighted approach as well as a trade-weighted approach. The overall IIT index is the average of the IIT indexes across the ten SITC categories.

To examine the possible determinants of intra-industry trade in Asia we estimate the following model:

$$IIT = \beta_0 + \beta_1 DGDP + \beta_2 DCGDP + \beta_3 EDU + \beta_4 R\&D + \beta_5 FDI + \beta_6 MANU + \beta_7 OPEN + \beta_8 DIST + \beta_9 AFTA + \beta_{10} SAPTA + \beta_{11} ECOTA + \varepsilon$$

The dependent variable is the trade-weighted IIT index for 2003. On the right hand sight of the equation, the relative difference in the GDP (*DGDP*) accounts for the effect of economic size on IIT. Helpman and Krugman (1985) have shown that the smaller the difference in the relative size of economies trading with each other, the larger the volume of IIT. As economies become more similar in terms of their market size, the potential for overlapping demand for differentiated products is enhanced. *DGDP* is measured as the natural logarithm of the relative difference between the GDP of the Asian country and its three major trading partners. Following Balassa and Bauwens (1988), we calculate the difference in GDP of Asian country i and its trading partner j as follows:

$$DIFE_{ij} = 1 + \frac{w \ln(w) + (1-w)\ln(1-w)}{\ln 2}$$

where

$$W = \frac{GDP_i}{GDP_i + GDP_j}$$

The resulting bilateral GDP difference measures are converted into a trade-weighted average.

Another important IIT determinant suggested by the Helpman–Krugman model is the similarity in factor endowments between trading countries as proxied by the difference in per capita GDP (*DCGDP*). Furthermore, the difference in per capita GDP captures the extent of variation in demand for differentiated products across trading partners. IIT would tend to be more intense among countries with more similar levels of per capita GDP. For *DCGDP* we first calculate the absolute value of the difference in per capita GDP between an Asian economy and each of its three major trading partners. Then we take the natural logarithm of the trade-weighted average of the three differences.

Education spending (*EDU*) and R&D spending (*R&D*), both measured as shares of GDP, control for the human capital intensity of exports and the degree of product differentiation, respectively. Product differentiation determines the level of horizontal IIT, whereas human capital intensity of exports creates quality differences that promote vertical IIT. Therefore, we expect the coefficients of both variables to be positive. Foreign direct investment (FDI) promotes IIT, especially if foreign affiliates are set up to take advantage of the factor endowments of the host country and their production is subsequently exported back to the home country. Accordingly, we include the net inflows of FDI as a share of GDP (*FDI*) in the model to account for the prominent role of export-oriented FDI and intra-firm trade by multinationals in Asia. The share of

[1] Our sample includes all economies in Central, East, Southeast, and South Asia with the exception of Cambodia, Laos, Vietnam, Myanmar, and Uzbekistan which were dropped due to lack of data.

Table 2
Overall intra-industry trade index by country (in percent), 2003.

	Country	Simple	Trade-weighted	Total trade
		Average	Average	('000 US$)
1	Bangladesh	6.1	3.8	11,854,805
2	Bhutan	3.8	5.3	293,547
3	Brunei	1.5	1.0	5,090,512
4	China	36.6	37.5	850,987,376
5	Hong Kong	6.6	13.1	252,780,554
6	India	37.5	31.7	109,511,888
7	Indonesia	32.1	28.6	93,608,214
8	Japan	34.8	35.1	855,447,467
9	Kazakhstan	22.6	5.6	13,638,892
10	Kyrgyzstan	13.5	18.3	1,293,281
11	Macau	4.9	15.8	4,779,593
12	Malaysia	43.8	54.0	187,709,430
13	Mongolia	3.2	3.8	1,413,023
14	Nepal	3.7	19.3	2,038,427
15	Philippines	21.0	43.9	70,633,573
16	Singapore	56.7	72.3	272,129,719
17	South Korea	41.2	44.1	372,642,672
18	Sri Lanka	13.4	14.7	10,292,087
19	Taiwan	39.3	49.9	270,159,472
20	Tajikistan	5.6	17.3	1,239,659
21	Thailand	35.9	43.0	156,135,034
22	Turkmenistan	2.9	3.0	3,754,579
	Asia average	20.9	24.8	

Source: Authors' calculations using trade data from the United Nations Statistics Division (2003).

manufactured exports in total merchandise exports (*MANU*) and the share of trade in GDP as a proxy for openness (*OPEN*) are also expected to be positively associated with IIT. The reason is that IIT is more prevalent in the manufacturing sector due to the scope of product differentiation and the international fragmentation of production. Trade openness is congruent with lower trade barriers and larger volumes of trade which have been shown to result in higher IIT levels (Bruelhart, 2008).

DIST stands for the natural logarithm of the trade-weighted average distance in nautical miles between the capitals of an Asian economy and its three major trading partners. Geographical proximity has been shown to be an important determinant of IIT as it is associated with lower transportation and information costs (Balassa & Bauwens, 1987).

Lastly, the regression equation includes three dummy variables that account for the role of FTAs and economic integration on IIT. *AFTA* takes the value of 1 for the six member countries of the ASEAN Free Trade Area included in the sample (Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand), and 0 otherwise. *SAPTA* stands for the South Asian Association for Regional Cooperation Preferential Trade Agreement and includes the five South Asian economies in the sample (Bangladesh, Bhutan, India, Nepal, Sri Lanka). *ECOTA* denotes the Economic Cooperation Organization Trade Agreement which counts the four Central Asian economies included in the sample (Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan) as its members. Since the major goal of FTAs is to promote trade through the lowering of trade barriers, we expect all FTA dummies to have a positive effect on IIT.

As the IIT index is limited to values between 0 and 1, estimation of the regression via OLS would result in inconsistent estimates. Therefore, we employ a Tobit specification which captures the lower and upper censoring of the dependent variable and produces consistent maximum likelihood estimates.

The computation of the IIT index was based on data from the Personal Computer Trade Analysis System (PC-TAS) which is derived from the COMTRADE database published by the United Nations Statistics Division (2003). Data on GDP, per capita GDP, and openness were obtained from the *Penn World Tables* (Heston, Summers, & Aten, 2006), while the remaining independent variables were collected from the World Bank's *World Development Indicators* and the Asian Development Bank's *Key Indicators*.

4. Results

4.1. The patterns of IIT in Asia

The IIT index for the 22 Asian economies along with their volume of trade for 2003 are displayed in Table 2. The extent of IIT exhibits an enormous amount of regional diversity across Asia with trade-weighted indices ranging from as low as 3 percent (Turkmenistan) to as high as 72 percent (Singapore). Developed countries typically have higher levels of IIT than developing countries because higher levels of GDP per capita are associated with the demand for greater product variety allowing consumers to purchase goods that more closely approximate their preferences. High-income countries, such as Japan, South Korea, Taiwan, and Singapore, are indeed involved in more IIT than low-income countries such as Bangladesh,

Table 3
Trade-weighted intra-industry trade indices by industry, 2003.

SITC category	0		1		2		3		4	
	IIT	%	IIT	%	IIT	%	IIT	%	IIT	%
Bangladesh	2.6	10.8	28.2	0.3	3.3	6.3	9.7	5.0	0.2	3.2
Bhutan	9.0	14.0	17.2	1.8	7.8	3.0	9.8	25.1	0.0	1.5
Brunei	0.6	3.7	0.9	0.5	0.0	0.3	0.5	71.6	0.0	0.2
China	27.6	2.8	52.2	0.2	10.8	4.6	30.1	4.7	3.1	0.4
Hong Kong	5.0	2.8	26.4	0.5	7.6	1.2	7.2	1.9	5.1	0.1
India	19.0	6.6	15.0	0.2	13.3	5.1	1.3	16.6	6.4	1.9
Indonesia	15.6	7.3	32.2	0.4	11.6	8.5	41.9	25.0	1.7	3.3
Japan	8.7	4.8	14.2	0.6	11.2	3.3	3.5	9.7	17.0	0.1
Kazakhstan	8.8	5.8	55.4	0.4	3.3	6.5	4.4	59.3	60.7	0.1
Kyrgyzstan	28.3	7.2	8.4	3.1	10.8	7.3	38.8	19.2	0.1	0.7
Macau	2.2	3.8	19.5	4.1	0.2	0.8	0.0	4.2	0.0	0.1
Malaysia	39.8	3.0	53.1	0.4	24.2	2.5	54.2	8.1	10.1	3.6
Mongolia	0.2	7.1	0.9	1.6	0.2	19.1	7.5	12.2	0.0	0.6
Nepal	14.8	8.6	34.9	0.6	1.4	5.1	0.0	0.5	0.0	2.2
Philippines	15.0	5.2	31.1	0.4	10.3	1.6	16.3	5.2	1.8	0.6
Singapore	53.0	1.7	84.7	0.7	65.4	0.6	62.9	10.9	75.8	0.2
South Korea	35.4	2.8	48.5	0.3	14.1	3.3	27.0	12.2	11.3	0.1
Sri Lanka	7.8	16.1	84.8	0.9	14.8	2.2	1.0	4.1	8.0	0.4
Taiwan	22.8	2.0	8.2	0.4	20.0	2.8	0.5	5.4	13.4	0.1
Tajikistan	0.2	6.5	0.0	0.0	0.5	7.3	73.4	20.2	0.0	0.5
Thailand	15.8	8.9	24.4	0.3	16.8	4.7	27.2	7.1	39.7	0.2
Turkmenistan	1.9	4.9	1.5	0.7	0.5	7.2	0.1	40.4	0.0	0.2
Asia average	15.1	6.2	28.8	0.8	11.3	4.7	18.8	16.6	11.3	1.0

SITC category	5		6		7		8		9	
	IIT	%	IIT	%	IIT	%	IIT	%	IIT	%
Bangladesh	2.9	6.7	5.8	22.5	1.2	11.9	3.3	33.4	89.2	0.0
Bhutan	2.5	0.7	3.9	22.5	0.4	27.7	7.4	3.7	0.0	0.0
Brunei	0.0	1.8	0.5	6.3	0.0	8.6	9.4	7.0	0.0	0.1
China	32.8	8.1	42.6	15.6	48.2	44.7	19.3	18.7	85.5	0.3
Hong Kong	10.5	5.6	6.2	15.1	4.0	45.4	32.2	25.1	52.6	2.2
India	47.6	10.5	55.9	27.7	40.8	14.6	14.4	11.4	24.5	5.3
Indonesia	38.9	9.3	28.4	16.4	33.2	19.6	11.1	10.0	0.8	0.3
Japan	58.3	8.0	33.7	9.6	41.1	49.2	36.3	11.5	47.8	3.1
Kazakhstan	9.7	2.6	3.0	20.8	34.0	2.7	25.9	0.7	1.9	1.0
Kyrgyzstan	5.1	8.6	18.5	12.8	25.1	14.3	18.9	6.4	1.0	20.5
Macau	8.1	2.6	2.8	19.8	5.4	12.7	25.9	51.9	0.0	0.0
Malaysia	61.4	6.1	51.9	8.3	58.2	58.8	49.0	7.2	70.7	2.2
Mongolia	0.5	3.3	2.4	15.1	3.2	18.5	15.0	12.6	0.0	9.9
Nepal	8.2	11.1	1.0	21.4	1.1	13.3	6.1	13.3	65.6	24.0
Philippines	22.8	4.1	21.1	5.8	37.1	39.3	22.1	4.7	73.2	33.1
Singapore	53.0	9.4	62.5	5.1	79.4	60.1	71.8	8.6	51.1	2.8
South Korea	48.3	9.0	39.8	14.1	48.8	49.3	53.9	7.6	79.4	1.3
Sri Lanka	7.1	5.5	26.5	28.2	11.1	12.9	10.7	28.4	3.7	1.4
Taiwan	51.2	10.3	32.6	14.5	63.9	51.8	43.5	11.9	37.0	0.9
Tajikistan	2.2	19.4	1.5	33.6	14.5	9.3	4.5	1.0	3.6	2.1
Thailand	43.4	8.8	46.4	14.4	54.1	43.7	30.7	9.6	67.3	2.4
Turkmenistan	5.5	4.5	2.2	13.0	0.7	21.2	3.7	4.0	53.1	3.8
Asia average	23.1	7.3	21.6	17.0	26.5	28.0	22.8	13.2	35.2	5.2

Source: Authors' calculations using trade data from the United Nations Statistics Division (2003).

Bhutan, Mongolia, and Turkmenistan, which rank at the bottom of the list. A group of countries that also exhibit relatively high levels of IIT consists of Indonesia, Malaysia, Philippines, and Thailand, which are classified as middle-income countries but have in common that they are members of ASEAN and AFTA and are heavily involved in the trade of intermediate goods (Athukorala & Yamashita, 2006). These economies have specialized in niches of the manufacturing process where they have a comparative advantage and are highly integrated in international production networks. For instance, the production of disk drives in Thailand involves a production network that spans nine Asian countries as well as Mexico and the US (Asian Development Bank, 2008, pp. 62–63).

China and India are interesting cases as they combine low per capita GDP with high IIT levels. The size of the two economies as well as their growing share in world trade certainly plays a role. It is evident from Table 2 that the total trade of China in 2003 exceeded by far the trade volume of all other Asian countries but Japan. Larger economies have the ability to produce a wider range of differentiated goods as a result of economies of scale (Helpman, 1981). Moreover, the larger the size of the market, the higher the demand for differentiated goods (Balassa, 1986). As emerging economies, India and China have a growing number of affluent consumers looking for a larger variety of goods, especially in urban areas and in regions that are more integrated with the world economy, such as the coastal provinces of China. However, the predominant reason for the high levels of IIT is that India and China engage in trade that emerges from the production of final goods in a succession of stages. Both countries import intermediate goods that they process before exporting the final products. The share of trade in vertically differentiated goods comprised 81 percent of the total IIT of China for the period 1999–2001 (Zhang et al., 2005) and has been shown to be similarly predominant in the case of India (Veeramani, 1998). However, China experienced a much more rapid increase of trade in intermediate goods as its vertical component of IIT grew from 18 to 31 percent between 1995 and 2003 compared to India's increase from 12 to 13 percent (Wakasugi, 2007).

A special case is Hong Kong which is similar to Singapore in terms of size, income level, and trade volume but has an IIT index of only 13 percent as compared to 72 percent for Singapore. This can be explained by the unique role of Hong Kong as an intermediary in the trade between China and the rest of the world. Over the 1990s re-exports of Chinese goods by Hong Kong accounted for more than half of all Chinese exports and re-exports from third countries to China via Hong Kong comprised slightly less than half of all Chinese imports (Feenstra & Hanson, 2004). In 2003, 93 percent of Hong Kong's total exports and 75 percent of total imports were re-exported. This explains the extremely high bilateral IIT index between China and Hong Kong of close to 90 percent in the late 1990s and early 2000s (Hu & Ma, 1999; Zhang et al., 2005). However, when re-exports are controlled for, the resulting IIT levels are much lower.

Table 3 shows the trade-weighted IIT index by SITC category for the 22 Asian countries along with the share of each category in total trade. SITC categories 0 through 4 contain primary-product industries such as agricultural, forest, and mineral products (see Table 1). On average, these five categories made up less than 30 percent of total trade in Asia. The corresponding IIT levels were also below Asia's overall IIT index of 24.8 percent, with the exception of trade in beverages and tobacco. This is not surprising as primary products are much less differentiated than manufactured goods. Some countries, including Malaysia and Singapore, have consistently high levels of IIT across all five categories, even though primary products comprise a relatively minor fraction of their trade. The reason is that both Malaysia and Singapore import raw goods such as crude oil and refine them for re-export. In contrast, the trade of countries like Brunei, Kazakhstan, and Turkmenistan is dominated by oil and gas which are exported in exchange for imports of manufactured goods and this explains their low IIT index in the SITC 3 category.

SITC 5, 6, 7, and 8 refer to trade in manufactured products which in 2003 comprised more than 65 percent of total trade in Asia. The corresponding industries include chemicals, manufactured goods, machinery and transport equipment, and miscellaneous manufactured articles, respectively. Table 3 reveals that the average IIT index for each of these categories exceeds 20 percent. Industrialized economies such as Japan, Taiwan, South Korea, and Singapore exhibit the highest levels of IIT. China and India which are involved in the trade of manufactured goods at different stages of the production process also rank relatively high, whereas countries lacking developed industrial sectors such as Mongolia, Nepal, and Sri Lanka, or those relying on trade in primary products such as Brunei and the Central Asian economies are at the bottom of the list.

SITC 9 encompasses goods and transactions not classified elsewhere making it difficult to interpret the results. Although the average IIT index in this category is relatively high, it is evident from Table 3 that the corresponding share of trade is negligible for the majority of countries.

4.2. The determinants of IIT in Asia

The estimated coefficients of the regression model used to identify the determinants of IIT in Asia are presented in Table 4. The results of the estimation with the overall IIT index as dependent variable are reported in the first column, followed by the results for the IIT indices of SITC categories 0 through 8. The coefficient for the difference in economic size of trading partners has the expected negative sign indicating that countries similar in size are more likely to engage in IIT. Size matters because of the advantages derived from having a large domestic market. Larger economies can more easily capitalize on economies of scale than smaller ones. This explanation is supported by the results for the different SITC categories which show that the *DGDP* coefficient in the primary-product categories is significant only at the 10 percent level, whereas in the manufacturing categories it achieves a significance level of 1 percent. In general, the agricultural sector has more limited economies of scale than manufacturing.

The difference in per capita GDP between trading partners was found not to be significantly associated with IIT in Asia. This was the case for the overall IIT levels as well as for all SITC categories. The result is surprising because numerous empirical studies have shown that IIT tends to be more intense among countries with similar income levels. In this context, GDP per capita represents the level of development, consumer patterns, and factor endowments. Larger differences between trading partners across these dimensions encourage specialization and trade based on comparative advantage leaving less room for IIT. A look at the data reveals two possible explanations for the result. First, several countries such as China, Indonesia, and the Philippines combine high trade-weighted income differences with high IIT levels which is likely due to their intense trade in vertically differentiated products with high-income countries such as Japan, Singapore, and the US. Second, a number of countries exhibit low levels of IIT coupled with relatively minor income differences with their trading partners. This is specifically the case for two groups of countries (Nepal, Bangladesh, Bhutan and Kazakhstan, Turkmenistan, Tajikistan) that trade with their regional economic power (India and Russia, respectively) which itself has an income level

Table 4
Determinants of intra-industry trade in Asia.

Variable	IIT	SITC 0	SITC 1	SITC 2	SITC 3
Constant	−0.112	−0.204	−3.365***	−0.422	0.780
	(0.490)	(0.511)	(1.316)	(0.342)	(1.020)
DGDP	−0.042	−0.030	−0.165*	−0.045*	−0.125*
	(0.038)	(0.039)	(0.101)	(0.026)	(0.088)
DCGDP	0.038	0.070*	0.024	0.022	0.124
	(0.038)	(0.039)	(0.101)	(0.026)	(0.077)
EDU	1.551	3.113*	0.561	−0.084	3.450*
	(1.000)	(1.042)	(2.673)	(0.697)	(2.087)
R&D	11.651***	11.795***	7.648	11.119***	6.314
	(2.410)	(2.512)	(6.452)	(1.679)	(5.073)
FDI	−0.177	0.208	0.687	1.248***	0.213
	(0.637)	(0.664)	(1.701)	(0.444)	(1.339)
MANU	0.385***	0.192**	0.004	0.084	0.277
	(0.088)	(0.092)	(0.236)	(0.062)	(0.191)
OPEN	0.074*	0.077*	0.222*	0.088***	0.124
	(0.045)	(0.046)	(0.119)	(0.031)	(0.097)
DIST	−0.121**	−0.157***	0.274*	−0.057	−0.414***
	(0.056)	(0.058)	(0.151)	(0.039)	(0.113)
AFTA	0.278***	0.227***	0.098	0.211***	0.342***
	(0.055)	(0.057)	(0.146)	(0.038)	(0.116)
SAPTA	0.102	0.222***	0.545***	0.225***	0.059
	(0.066)	(0.068)	(0.176)	(0.046)	(0.139)
ECOTA	0.160*	0.204**	0.217	0.109**	0.254
	(0.079)	(0.082)	(0.210)	(0.055)	(0.167)
R^2	0.38	0.34	0.36	0.27	0.25
Variable	SITC 4	SITC 5	SITC 6	SITC 7	SITC 8
Constant	−2.376**	−0.873	−1.182**	−0.827	−0.944***
	(1.006)	(0.633)	(0.578)	(0.766)	(0.399)
DGDP	−0.195**	−0.138***	−0.201***	−0.180***	−0.008
	(0.086)	(0.049)	(0.044)	(0.059)	(0.031)
DCGDP	−0.006	0.014	0.066	0.066	0.029
	(0.060)	(0.049)	(0.045)	(0.059)	(0.031)
EDU	−2.900*	2.257*	3.192***	1.105	1.041
	(1.703)	(1.291)	(1.178)	(1.562)	(0.814)
R&D	9.873***	13.395***	11.135**	14.184***	15.729***
	(3.559)	(3.111)	(2.839)	(3.764)	(1.961)
FDI	3.475***	−1.261	−0.599	−0.062	0.687
	(1.133)	(0.823)	(0.750)	(0.995)	(0.518)
MANU	0.124	0.152	0.124	0.235*	0.105
	(0.208)	(0.115)	(0.104)	(0.139)	(0.072)
OPEN	0.074	0.077	0.141***	0.115*	0.117***
	(0.086)	(0.057)	(0.052)	(0.070)	(0.036)
DIST	0.222**	0.021	−0.064	−0.092	0.009
	(0.093)	(0.072)	(0.066)	(0.087)	(0.045)
AFTA	0.211**	0.159**	0.183***	0.247***	0.132***
	(0.083)	(0.071)	(0.064)	(0.086)	(0.045)
SAPTA	0.193**	0.083	0.240***	0.093	0.126**
	(0.098)	(0.085)	(0.077)	(0.103)	(0.053)
ECOTA	0.430**	0.036	0.055	0.172	0.129**
	(0.176)	(0.102)	(0.093)	(0.124)	(0.064)
R^2	0.19	0.34	0.34	0.34	0.38

Heteroscedasticity-consistent standard errors in parenthesis.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

not very different than its neighbors. The satellite countries mostly export primary products and import manufactured goods, which explains the low IIT levels.

Educational spending is positively but not significantly associated with overall IIT. However, the coefficient is significant at the 1 percent level for IIT in manufactured goods (SITC 6) where human capital intensity mostly matters. Furthermore, the results indicate that product differentiation as proxied by R&D spending is a significant determinant of IIT in Asia. The same is true for the share of manufactured goods which has universally been established in the literature as a major factor for IIT. FDI inflows appear to have no significant effect, except in the categories SITC 2 and 4. A possible explanation is that a considerable share of FDI in Asia is aimed at serving the domestic market of the host country motivated by trade costs, such as transportation and tariffs. This type of FDI inflows tends to promote horizontal IIT rather than trade in vertically differentiated goods which is more important in the case of East Asia. Zhang and Li (2006) have shown for China, the world's largest recipient of FDI, that FDI inflows have a significantly positive effect on horizontal IIT but are not significantly associated with vertical IIT, rendering the effect on total IIT insignificant.

The coefficient for geographical distance yielded the expected negative sign and is statistically significant. Across SITC categories, it seems that transportation costs are more relevant for primary products than for manufactured goods. Predictably, lower levels of protection represented by the openness variable were found to encourage IIT. The coefficient was significant at the 1 percent level for one of the five primary sector categories and for two of the four manufacturing categories. The results further indicate that among regional trade agreements AFTA members exhibit significantly higher levels of IIT than the rest of Asia. This is due to the intense trade in parts and components among AFTA members as well as between ASEAN and the rest of the world. In 2003, parts and components accounted for 40 percent of manufacturing exports and 47 percent of manufacturing imports of AFTA (Athukorala & Yamashita, 2006). Approximately 60 percent of AFTA's total trade in parts and components is with East Asian countries and about 30 percent among AFTA members. The evidence from the other two regional trade agreements included in the model is mixed. Although the dummy for SAPTA is not significant for overall IIT, the South Asian trade agreement promotes IIT in four of the five primary sector categories and in two of the manufacturing sector categories. Lastly, the Central Asian members of ECOTA have significantly higher IIT indices in three primary sector categories but only in one of the manufacturing categories.

5. Conclusions

The deepening international fragmentation of production and the rapid export-oriented growth of numerous Asian economies have raised the importance of IIT in Asia. This paper estimated the extent of IIT in a broad sample of Asian economies and explored the determinants of two-way trade in the region. The trade-weighted IIT indexes which were also developed for each of the ten SITC categories displayed a considerable degree of regional heterogeneity. The results indicate that ASEAN and the developed East Asian economies exhibit the highest levels of IIT across most SITC product categories. The emerging economies of India and China rank equally high reflecting their key role in vertical specialization and production fragmentation. The developing economies of South and Central Asia were generally the least involved in IIT.

R&D spending and the share of manufactured goods in exports emerged as the major positive determinants of overall IIT in Asia. Geographical distance had the expected negative effect which was particularly relevant across primary-product categories. The difference in the economic size of trading partners was also negatively associated with IIT but only for manufactured goods. Although high-income countries had higher IIT levels, the trade-weighted difference in per capita income between trading partners was not a significant factor. Among the regional trade agreements, AFTA was most prominently associated with IIT across all SITC categories. The South and Central Asian trade agreements do not seem to promote overall IIT but had a positive effect across most primary-product categories.

The increasing globalization, international production fragmentation, and the continued dynamism of regional economies are likely to further boost the importance of IIT in Asia in the future. Furthermore, China's entry into the WTO and its emergence as a major economic power as well as the establishment of the South Asian Free Trade Area will contribute to economic integration in Asia and encourage intra-regional IIT.

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