A General Equilibrium Analysis of the Interplay between Foreign Direct Investment and Trade Adjustments

by

Hiro Lee

International Centre for the Study of East Asian Development
11-4 Otemachi, Kokurakita, Kitakyushu, 803-0814, Japan
E-mail: hlee@icsead.or.jp

Dominique van der Mensbrugghe

Development Prospects Group, The World Bank
1818 H Street, NW, Washington, DC 20433, USA
E-mail: dvandermensbrugg@worldbank.org

March 2001
(Revised: July 2001)

Abstract

The theoretical literature on trade and foreign direct investment (FDI) indicates that they could be either substitutes or complements. The empirical evidence on U.S.-Japan and APEC countries suggests that trade and FDI exhibit a complementary relationship. In this paper, we employ a six-region applied general equilibrium model that incorporates FDI to evaluate the impact of APEC trade and investment liberalization on output and the interplay between FDI and trade adjustments. The preliminary results suggest that FDI liberalization would bring about greater benefits to most of the APEC economies than trade liberalization. In the manufacturing sector, trade and FDI are found to be complements in the APEC regions.

JEL classifications: F13; F15; F21; O53

Keywords: APEC liberalization, foreign direct investment, CGE model

1. Introduction

In the past two decades, inflows of foreign direct investment (FDI) have facilitated economic development and technology transfer in many developing countries. During the 1986-99 period, world FDI flows increased at an annual rate of 22.9 percent, significantly faster than the growth rate of world trade (UNCTAD, 2000). Developing countries hosted 30.1 percent of inward FDI stock in 1999, sharply higher than 21.0 percent share in 1990. Among developing countries, East and Southeast Asia hosted 51.4 percent of inward FDI stock in 1999, down slightly from 52.8 percent share in 1997. The relative decline in FDI flows to this region may be attributable to the Asian economic crisis of 1997-98.

FDI is subject to a number of impediments, including restrictions on entry and establishment, ownership and control restrictions, operational restrictions (e.g., local content requirements), and lack of transparency in laws and regulations.[1] Such impediments distort capital allocation across countries, between foreign and domestic investment, and between FDI and portfolio investment (Hardin and Holmes, 1997). Barriers to FDI are relatively high in services, such as finance, insurance, and communications.

Host countries may not benefit from inward FDI when there are domestic distortions. Naya (1990) shows that liberalization of FDI could reduce economic welfare in a protected economy. This is because protection in the host country would induce foreign investors to make non-optimal FDI decisions. Fry (1993) finds that inward FDI contributed significantly to economic growth in East Asian developing countries where the extent of domestic distortions, such as trade controls and financial repression, were relatively low. By contrast, in a group of developing countries with relatively high domestic distortions, inward FDI were associated with a low or negative growth.[2]

FDI and trade can be substitutes or complements. The theoretical literature indicates that they can be either of them depending upon the assumptions (e.g., Mundell,

---

[1] See PECC (1995, Chapter 6) and Hardin and Holmes (1997) for further information on impediments to FDI, particularly in the APEC economies.

[2] Fry (1993) divides the sample of sixteen developing countries between one group consisting of five East Asian countries (Korea, Indonesia, Malaysia, Philippines, and Thailand) and the other consisting of Argentina, Brazil, Chile, Egypt, India, Mexico, Nigeria, Pakistan, Sri Lanka, Turkey, and Venezuela. The estimation period is 1966-88 with the exception of Brazil (1966-85), Chile (1966-84), Indonesia (1967-88), and Pakistan (1968-88).

1957; Markusen, 1983; Neary and Ruane, 1988; Wong, 1986, 1995). The empirical evidence on the United States and Japan suggests that bilateral FDI and trade flows are complements in many manufacturing sectors (Kawai and Urata, 1998; Lee and Roland-Holst, 1998). Petri (1997) finds that not only inward and outward FDI stocks are reduced when investment liberalization is excluded from APEC liberalization but trade flows also tend to decline, particularly for China and ASEAN-4 countries, compared with full liberalization. This result suggests that FDI and trade are likely to be complements at the economywide level in the APEC economies.

To evaluate the impact of APEC trade and investment liberalization on economic welfare and the interplay between FDI and trade adjustments, we use a six-region, three-sector computable general equilibrium (CGE) model. The next section provides an overview of FDI patterns and barriers in the APEC economies. Section 3 contains a brief description of the model used for quantitative assessments. In section 4, we present the aggregate and sectoral results of liberalization experiments, and the final section offers conclusions.

2. FDI Patterns and Impediments in the APEC Economies

2.1 Patterns of FDI

Developing members of APEC have benefited from FDI inflows from more developed members. The growth in FDI flows has generally led to greater diversification of production and higher rates of growth in trade and productivity. Although the Asian financial crisis of 1997-98 caused a sharp decline in real GDP in several East Asian countries, FDI flows to most of the APEC economies have remained at high levels, with the exception of Indonesia.

Table 1 provides inward and outward FDI stocks of selected economies in 1995. UNCTAD computes these stock values as the accumulation of FDI flows at historical cost. The original source of the data on FDI inflows and outflows is International Monetary Fund's *Balance of Payments Statistics Yearbook*. For some economies (e.g., Hong Kong), FDI flows are estimated because there are no balance of payments data.[3] The world FDI

[3] See UNCTAD (1999, pp. 465-476). Ramstetter (2000) provides estimates for FDI flows in eleven Asian economies during the 1980-99 period.

stock was about $2.8 trillion in 1995. About 38 percent of inward FDI was hosted by the European Union, 19 percent by the United States, and 5 percent by China. The European Union, the United States, and Japan owned 46, 25, and 8 percent, respectively, of the world FDI stock.

Table 1. Inward and Outward FDI Stocks of Selected Economies, 1995

	Inward FDI Stock		*Outward FDI Stock*	
	US$ million	% of GDP	US$ million	% of GDP
United States	535,553	7.7	696,092	10.0
Canada	123,335	22.0	120,297	21.5
Australia	100,390	28.8	47,186	13.5
New Zealand	26,177	43.8	7,675	12.8
Japan	33,531	0.7	238,452	4.7
China	131,241	18.8	15,802	2.3
Hong Kong	70,951	50.6	85,156	60.7
Korea	10,478	2.3	10,231	2.2
Taiwan	15,736	6.0	25,144	9.7
Singapore	59,582	71.2	35,050	41.9
Indonesia	50,601	25.6	1,295	0.7
Malaysia	27,094	31.8	11,143	13.1
Philippines	6,086	8.2	1,209	1.6
Thailand	17,452	10.5	2,173	1.3
Mexico	41,130	14.3	4,132	1.4
Chile	15,547	23.1	2,815	4.2
European Union	1,066,934	12.7	1,295,941	15.4
World	2,789,585	9.9	2,840,216	10.2

Source: UNCTAD (1999), pp. 489-500, 513-524.

Among the APEC economies, Singapore, Hong Kong, New Zealand, and Malaysia have had high inward FDI stock to GDP ratios. By contrast, Japan has attracted very little FDI relative to the size of its economy. According to the data on the FDI stocks by source and destination regions that are calibrated to the FTAP model (Hanslow et al., 1999), Japan and the United States together accounted for more than 50 percent of inward FDI stocks in Hong Kong, Korea, Philippines, Taiwan, and Thailand in 1995. Singapore and Taiwan each accounted for over 10 percent of Malaysia's inward stock, whereas the EU contributed over 20 percent of inward stock in Singapore. Over a half of inward FDI stock in China was sourced from Hong Kong. It is important to note, however, that a large share

of Hong Kong's outward FDI is undertaken by foreign-owned firms,[4] a sizable portion of which is "round-tripping FDI" that originates from parent firms in China and is then channeled back into China through affiliates in Hong Kong (Low et al., 1996; Ramstetter, 2000).

2.2 Barriers to FDI

According to UNCTAD (1996), barriers to FDI may be classified into the following three categories:

(1) Restrictions on market entry, which include restrictions on the share of foreign ownership, screening and approval, restrictions on the legal form of the foreign entity, minimum capital requirements, and conditions on location.

(2) Ownership and control restrictions, which contain compulsory joint ventures with domestic investors, limits on the number of foreign board members, government approval required for certain decisions, and mandatory transfer of some ownership to locals after a specified time.

(3) Operational restrictions, which include performance requirements (e.g., minimum exports to output ratios), local content requirements, restrictions on imports of labor, capital, and intermediate inputs, and restrictions on repatriation of capital and profits.

Previous studies that estimate barriers to FDI have concentrated on services sectors (e.g., Hoekman, 1995; Hardin and Holmes, 1997; Hanslow et al., 2000, Kaleeswaran et al., 2000; Warren, 2000). This is because commercial presence abroad, primarily through FDI, is the most important means of delivering services to other countries. Hoekman (1995) uses frequency ratios of services barriers to estimate tariff equivalent measures of relative restrictiveness of barriers to services trade across countries and sectors. His estimates are based on judgmental benchmark tariff equivalents for each sector to reflect a country that is highly restricted in market access.

Hoekman's (1995) estimates have been used by Brown et al. (1996) and Petri (1997) in their model simulations. Table 2 summarizes ad valorem equivalents of FDI barriers used by Petri. The rates for the services sector are based on Hoekman's estimates, whereas the rates for the primary and manufacturing sectors are assumed to be one-half as

[4] This pattern is also observed in Singapore.

high (relative to total costs) as tariff equivalents for these sectors that are available in the GTAP database, version 3 (Hertel, 1997).

Table 2. FDI Barriers Used by Petri (1997)

(*percent*)

	UCAN[a]	*Japan*	*NIEs*[b]	*ASEAN-4*	*China*	*ROW*
Primary	6.4	48.3	34.7	14.5	21.6	16.6
Manufacturing	34.6	25.7	22.7	44.6	61.1	32.5
Services	80.7	79.1	70.4	70.1	77.0	76.6

Notes: a) United States, Canada, Australia, and New Zealand.
b) Korea, Taiwan, Hong Kong, and Singapore.

Source: Petri (1997).

Hardin and Holmes (1997) develop alternative indices of the relative restrictiveness of FDI. Their estimates are based upon information on actual restrictions not only on market access but also on other aspects of FDI. The weights on different types of barriers are set to reflect their relative restrictions. It is found that communications and financial services have some of the highest FDI barriers in the APEC economies. In communications, Thailand has the highest restrictiveness index (0.84), followed by China (0.82) and Philippines (0.76). In financial services, countries with high FDI restrictions include Philippines (0.95), Korea and Thailand (both with the value of 0.88).[5]

Hanslow et al. (2000) compute ad valorem equivalents of barriers to establishment (impediments on capital) and those of barriers to ongoing operation (impediments on output) for both domestic and foreign firms. The results are provided in Table 3, which are based on estimates of impediment rates in banking (Kaleeswaran et al., 2000) and telecommunications (Warren, 2000).

Compared with Hoekman's (1995) estimates on relative restrictiveness of barriers to services trade, the rates of impediments to establishment derived by Hanslow et al. (2000) are lower in all regions with the exception of China. Compared with Hardin and Holmes's (1997) FDI restrictiveness indices, these rates are generally lower in all the APEC regions with the exceptions of China and Indonesia. Hanslow et al.'s (2000)

[5] See Hardin and Holmes (1997, pp. 112-113) for detailed results.

estimates have some shortcomings, however, because they are derived from the impediment rates in only banking and telecommunications services.

Table 3. Ad Valorem Equivalents of Barriers to Establishment and Ongoing Operations in the Services Sector

(*percent*)

	Barriers to Establishment		*Barriers to Ongoing Operations*	
	Domestic	Foreign	Domestic	Foreign
United States	0.0	3.8	0.1	1.1
Canada	0.5	6.3	0.3	1.7
Australia	0.6	14.3	0.0	0.7
New Zealand	0.4	4.3	0.0	0.8
Japan	0.3	3.0	3.6	4.7
China	123.4	252.1	19.0	36.6
Hong Kong	1.3	5.2	1.4	2.3
Korea	1.9	22.6	5.1	6.9
Taiwan	1.9	18.7	2.9	4.9
Singapore	2.4	23.9	3.5	8.5
Indonesia	22.7	68.2	13.3	28.2
Malaysia	15.3	37.9	3.6	10.6
Philippines	7.5	53.7	8.5	22.8
Thailand	12.2	36.5	4.7	13.7
Mexico	0.6	11.1	2.2	5.5
Chile	14.1	20.6	3.0	4.1
Rest of Cairns	7.2	19.4	1.0	5.5
European Union	1.3	6.4	0.1	1.2
Rest of World	39.4	87.8	5.0	13.9

Source: Hanslow et al. (2000), Table 4.

3. The Model

Distinguishing between the activities of domestic and foreign-owned firms is an important feature of a CGE model that incorporates foreign direct investment. Petri (1997) assumes that product varieties are differentiated by firms headquartered in different regions. Under his demand structure, a foreign variety can be purchased from the local subsidiary of a foreign firm, the parent abroad, and the foreign firm's subsidiaries located in third countries. A domestic variety can be obtained either from domestic producers or from foreign subsidiaries of the domestic firm.

We have extended a simple world CGE model developed by van der Mensbrugghe (2000) to include features of FDI, closely following those developed by Petri (1997). As in

Petri the model contains six regions – UCAN (consisting of the United States, Canada, Australia, and New Zealand), Japan, NIEs (consisting of Korea, Taiwan, Hong Kong, and Singapore), ASEAN-4, China, and the rest of the world – and three sectors (primary, manufacturing, and services).

The model equations are presented in the Appendix. Products are identified by ownership of capital, and these are called varieties. Thus output, $XP_{r,i,v}$, is identified by region of production (r), by sector (i), and by variety (v). Similar to the simple model, production is modeled as a series of nested CES functions. However, each variable in the nest is associated with both a sector and a variety, and not simply a sector (see Eq. A.1, A.3 and A.5 in the Appendix). The main deviation from the simple model is that foreign-owned production is assumed to import essential imports from its 'home' base. For example, Japanese auto plants in the United States import directly a fixed share (relative to output) of intermediate goods from Japan.

Household and government accounts are consolidated. The consolidated household sector accrues income from factor remuneration as well as tax receipts (Eq. A.11). Gross capital income is distributed three ways. Domestic households receive a share of after-tax capital remuneration. The share is determined by ownership percentage. By definition, domestic-variety capital is 100 percent owned locally. FDI-based capital is assumed to operate as a joint venture, where the share of foreign ownership, χ, is fixed. Thus χ percent of after-tax capital remuneration flows overseas (local re-investment of earnings is not allowed in the current version of the model). The third component of gross capital remuneration is the tax on capital. Impediments to FDI flows are modeled as *ad valorem* taxes on capital, and the capital tax rate, τ^k, is specific to varieties (Eq. A.13).

One important aspect in which our model differs from Petri is the order of CES nesting of demand for goods. In Petri's demand structure, each agent first allocates expenditures between an aggregate of goods produced by firms headquartered in the home region and an aggregate of those produced by firms headquartered in foreign regions. In our model, as in Figure 1, each agent first allocates expenditures between an aggregate of goods produced domestically, including those produced by foreign plants located in the domestic economy, and an aggregate of all imports (Eq. A.24 and A.25). Aggregate demand for goods produced domestically is split across all plants located domestically (Eq. A.27). At the other nest, we disaggregate by "own" varieties, i.e., those produced by domestic firms located abroad and an aggregate of foreign varieties produced abroad

(Eq. A.29 and A.30). Own varieties are allocated across plant locations (Eq. A.32 and A.33),[6] whereas an aggregate of foreign varieties are first disaggregated by foreign ownership and finally across plant locations (Eq. A.35 and A.37).[7]

The order of our demand nesting appears to be in accord with reality, particularly in services. For example, foreign banks in any given country generally provide services to fulfill the needs of domestic consumers. Thus, goods and services provided by domestic and foreign-owned firms in a given location appear to be closer substitutes than those provided by firms headquartered in the same country but produced in different locations.

The allocation of capital is modeled using the same CET transformation structure as in Petri (1997), which is shown in Figure 2. First, aggregate wealth for each region, W_r, is allocated across sectors as a function of the relative rate of return on capital invested in various sectors (Eq. A.51). Second, capital in each sector is allocated between domestic market and an aggregate of foreign markets (Eq. A.53 and A.54). Finally, foreign capital is allocated across plant locations (Eq. A.56). A reduction in FDI barriers would raise the after-tax rate of return to capital, PK^n, which leads to an increase in the inward FDI stock (Eq. A.53 and A.56). The world capital stock is assumed to be fixed. With finite elasticities of transformation, capital is less than perfectly mobile across regions and sectors.

Labor is assumed to be freely mobile across sectors but not across regions (Eq. A.49). Thus there is a single equilibrium wage rate for each region. The supply of labor is held constant. To produce output overseas, subsidiaries employ local labor, the stock of FDI, inputs sourced from parents, and other intermediate inputs. In the current version of the model, we assume constant-returns-to-scale technology in all sectors and competitive product markets.[8]

---

[6] Equation (A.33) would typically be redundant. However, due to aggregation of regions, intra-regional imports (imports of the domestic variety from *r* to *r*) would be represented by variable $WTF^{a}_{r,i,d,r}$.

[7] The structure of demand nesting is similar to the one adopted in the FTAP model (Hanslow et al., 1999).

[8] It may be more realistic to assume increasing-returns-to-scale and imperfectly competitive product markets. See, e.g., Brown and Stern (1999).

Figure 1. Structure of Domestic Demand

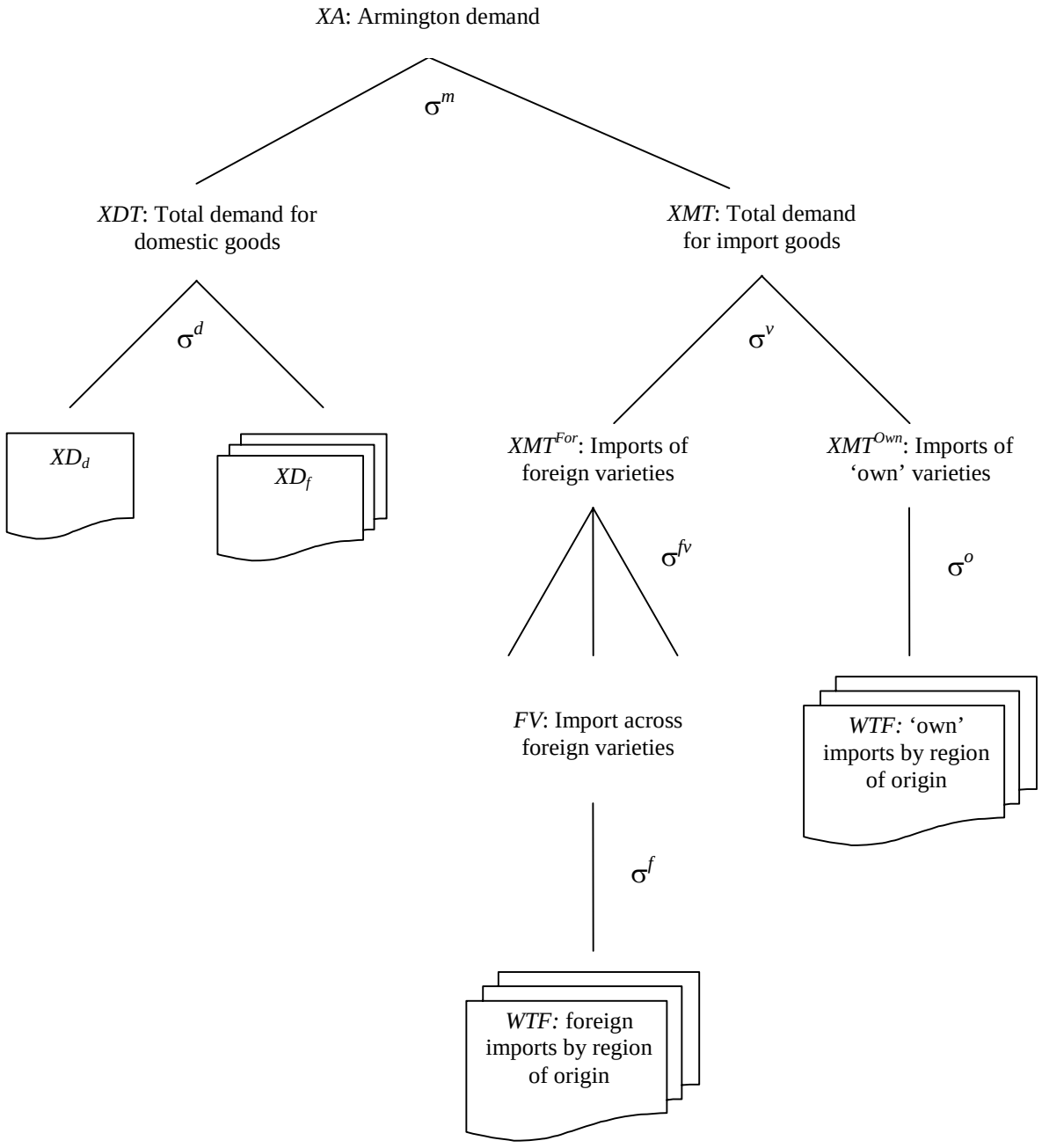
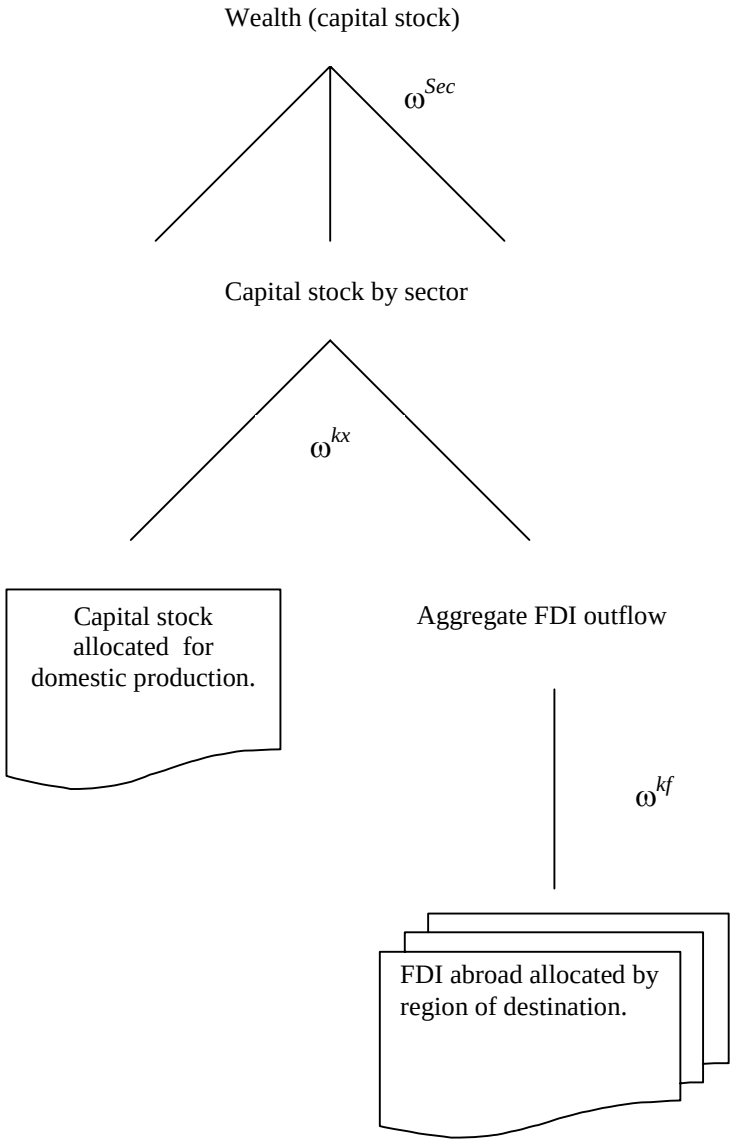


Figure 2. Allocation of Wealth



The model is calibrated to social accounting matrices (SAMs) of the six regions for the year 1992, constructed primarily from the GTAP database, version 3 (Hertel, 1997). We are currently in the process of updating to a more recent database.

Three caveats are needed to interpret the results of APEC trade and FDI liberalization experiments presented in the next section. First, we used the same protection rates on FDI as Petri (1997) in this preliminary version, and we suspect that these estimates are likely to be too high. Second, the process of APEC trade and investment liberalization started in 1997, but some APEC countries reduced trade and FDI barriers significantly between 1992 and 1997. Third, the current model is static and does not account for capital accumulation. However, the capital stock is expected to increase over time, particularly when the real return to capital increases. The first two factors would overestimate the results while the last factor would underestimate them.

4. Computational Results

We have conducted three APEC liberalization experiments: (1) the five APEC regions remove trade barriers on a Most-Favored Nation (MFN) basis, (2) they reduce barriers to FDI by 50 percent on an MFN basis, and (3) the combination of (1) and (2). We first examine aggregate results in section 4.1, followed by assessments of sectoral results in section 4.2.

4.1 Aggregate Results

Table 4 summarizes aggregate results from three APEC liberalization experiments. In the aggregate, world real GDP would gain $100 billion from trade liberalization, $339 billion from FDI liberalization, and $441 from the combination of the two. These estimates should be interpreted with caution because the ad valorem equivalents of FDI barriers used in the model may be biased upward, particularly for UCAN.

All five APEC regions would realize gains in real GDP from trade liberalization, ranging from 0.2 percent for UCAN to 2.5 percent for ASEAN-4 (column 4). Both imports and exports increase substantially with the exception of the rest of the world (ROW). It may be puzzling at first why ROW's GDP and exports fall despite APEC trade liberalization is nondiscriminatory toward ROW. It is mainly caused by a large decline in its exports of primary products to Japan and NIEs. UCAN is the leading supplier of

primary products to these regions, and its exports of primary products surge after the removal of trade barriers. This is because the export price of UCAN relative to that of ROW falls, resulting from a reduction in the average cost brought about by a fall in the price of imported intermediate inputs.

Table 4. Aggregate Results from APEC Liberalization

	Absolute changes ($bn)			Percentage changes		
	Trade Lib.	*FDI Lib.*	*Trade and FDI Lib.*	*Trade Lib.*	*FDI Lib.*	*Trade and FDI Lib.*
	(1)	(2)	(3)	(4)	(5)	(6)
			Real GDP			
UCAN[a]	13.8	324.2	341.8	0.2	4.7	5.0
Japan	48.6	-5.7	37.0	1.3	-0.2	1.0
NIEs[b]	20.4	28.5	48.4	2.2	3.1	5.3
ASEAN-4	9.0	38.9	53.7	2.5	10.7	14.9
China	10.6	20.9	35.2	2.1	4.2	7.1
ROW	-2.7	-67.9	-74.9	0.0	-0.6	-0.7
World	99.7	338.9	441.2	0.4	1.5	1.9
			Aggregate Imports			
UCAN	189.9	2.0	194.1	23.4	0.3	23.9
Japan	130.7	18.9	154.2	40.0	5.8	47.2
NIEs	92.2	12.5	109.6	19.8	2.7	23.5
ASEAN-4	36.2	10.9	53.9	27.4	8.2	40.8
China	57.3	5.3	65.5	64.8	6.0	74.2
ROW	25.6	30.7	61.6	1.6	1.9	3.8
			Aggregate Exports			
UCAN	177.6	99.6	281.7	23.2	13.0	36.9
Japan	121.4	-24.9	95.2	31.5	-6.5	24.7
NIEs	94.2	15.1	112.2	23.8	3.8	28.4
ASEAN-4	44.7	28.5	85.9	32.3	20.6	62.1
China	64.4	13.3	84.0	46.4	9.5	60.5
ROW	-14.7	-56.8	-72.4	-1.0	-4.0	-5.1
			Inward FDI Stocks			
UCAN	2.4	60.0	62.9	3.8	93.6	98.1
Japan	0.2	2.3	2.5	5.3	51.8	57.4
NIEs	0.9	7.1	8.1	4.5	34.9	40.1
ASEAN-4	0.8	8.5	10.2	4.0	41.5	50.3
China	1.0	3.2	4.7	22.1	70.5	104.1
ROW	-1.6	-4.3	-6.1	-1.3	-3.7	-5.2
			Outward FDI Stocks			
UCAN	-0.4	13.2	12.7	-0.6	19.2	18.4
Japan	1.8	22.2	25.0	4.7	57.8	64.9
NIEs	0.7	4.6	5.7	6.0	39.8	49.1
ASEAN-4	0.1	0.4	0.5	11.4	40.0	54.7
China	0.0	0.1	0.1	13.2	55.3	72.5
ROW	1.6	36.2	38.5	1.4	32.4	34.4

Notes: a) United States, Canada, Australia, and New Zealand.
b) Korea, Taiwan, Hong Kong, and Singapore.

The real GDP effect of FDI liberalization depends upon whether a region attracts or loses foreign capital, which in turn is affected by the magnitude of initial FDI barriers, the share of output produced by multinational firms in total output, and the initial stock of inward FDI relative to outward FDI, among many factors. UCAN, NIEs, ASEAN-4, and China would realize gains in real GDP because the increase in the inward FDI stock is larger than the increase in the outward FDI stock while the opposite is the case for Japan and ROW (column 2 of Table 4).[9] In percentage terms the impact on real GDP is extremely large in ASEAN-4 largely because the share of output produced by multinational firms in total output is the highest among the APEC regions.[10] A large injection of new foreign capital to the already high initial inward FDI stock relative to the total capital stock would substantially expand output of multinational firms located in ASEAN-4.

The results reported in Table 4 suggest that at the aggregate level, trade and FDI exhibit a complementary relationship. That is, an increase in imports resulting from trade liberalization leads to an increase in inward FDI (column 4), and a rise in inward FDI resulting from FDI liberalization induces an expansion of imports (column 5). Home sourcing of intermediate inputs by foreign subsidiaries can partly explain the latter causality. We have no strong reason to believe why the removal of trade barriers would attract foreign capital at the aggregate level, and we postpone our assessment until we examine the sectoral results.

4.2 Sectoral Results

Tables 5 and 6 present each region's sectoral adjustments in output, trade, and inward and outward FDI stocks for the three experiments. Not only the magnitude of the adjustments but the sign often changes with the transition to a more microeconomic perspective. The removal of trade barriers is expected to lead to large contractions in output of primary products in Japan and NIEs, resulting from a sharp increase in demand for imported goods. Since UCAN and China export relatively large shares of their primary

[9] FDI liberalization would raise after-tax rate of return to capital in APEC regions relative to ROW. This induces capital to move from ROW to APEC regions, reducing the capital stock and output produced in ROW.

[10] For individual APEC economies, this share is the highest in Singapore, followed by Hong Kong. For the regional aggregation used in this paper, however, the share is significantly higher in ASEAN-4 than the NIEs.

products to Japan and NIEs, export expansion resulting from trade liberalization would sharply raise domestic output. This appears to cause a strong resource-pull effect in UCAN and China. As the primary sector expands substantially in these regions, factors of production would be diverted from the manufacturing and services sectors, causing an output contraction in these sectors. However, this assumes that labor is homogeneous and perfectly mobile across sectors. If labor demand was disaggregated by type and skill, however, limited labor mobility might dampen contraction in non-primary sectors.

The manufacturing output in Japan, NIEs, and ASEAN-4 increases, driven by export expansion. Had more disaggregated data been available, we would expect that output of some labor-intensive sectors (such as processed food and apparel) to contract in Japan and that output of some capital-intensive sectors (such as steel and transportation equipment) to decline in ASEAN-4.[11]

FDI liberalization leads to an expansion of output in all three sectors in UCAN, NIEs, ASEAN-4, and China (Table 5). As already mentioned in section 4.1, the regions that attract net inward FDI experience a positive output effect. Extremely large percentage increases in both inward and outward FDI in services are observed (Table 6). This is because the rates of FDI protection are highest in the services sector in every region. Although not reported in Table 6, the absolute change in the services sector's inward FDI stock is larger than that in its outward FDI stock in every APEC region except Japan.[12] An increase in output of services in Japan may be attributable to inter-sectoral domestic capital mobility. With primary production declining, capital installed in that sector moves to manufacturing and services, with the latter more important than the net decline in FDI. Note that in ASEAN-4 output of manufactures is expected to rise more drastically than output of services mainly because the share of output produced by multinational firms in total output is several times greater in manufactures (0.69) than in services (0.09). There might also be some feedback from 'home' inputs from FDI installed abroad although the magnitude is probably not large.

---

[11] Because of data limitations on FDI, we were not able to disaggregate the manufacturing sector further. See Lee, Roland-Holst, and van der Mensbrugghe (1999) for the sectoral output effects of APEC trade liberalization at a 20-sector level of disaggregation.

[12] In Japan the inward FDI in services increases from $0.5 billion to $2.1 billion, whereas the outward FDI in services increases from $10.7 billion to $28.6 billion.

Table 5. Sectoral results from APEC liberalization

(*percentage changes*)

		UCAN[a]	*Japan*	*NIEs*[b]	*ASEAN-4*	*China*	*ROW*
				Output			
Trade liberalization	Primary	11.8	-32.7	-20.3	-7.4	5.9	-1.9
	Manufacturing	-3.8	4.2	10.0	10.3	-5.6	-0.1
	Services	-0.1	0.8	0.5	1.7	-0.8	0.3
FDI liberalization	Primary	3.5	-2.3	7.4	5.3	1.2	-1.5
	Manufacturing	4.3	-1.2	1.3	18.9	5.0	-1.1
	Services	5.3	0.3	2.8	9.2	4.3	-0.3
Trade & FDI liberalization	Primary	15.6	-35.0	-13.3	-2.4	6.9	-3.3
	Manufacturing	0.6	2.8	11.4	35.0	0.8	-1.4
	Services	5.2	1.1	3.3	10.7	3.5	0.0
				Imports			
Trade liberalization	Primary	13.8	79.7	59.9	39.5	39.5	-0.3
	Manufacturing	28.4	35.2	15.8	27.8	71.2	2.6
	Services	-0.9	5.6	4.1	-10.5	-5.1	-0.2
FDI liberalization	Primary	-0.5	1.8	-0.3	14.3	8.8	0.9
	Manufacturing	1.7	8.1	3.5	8.0	5.7	1.8
	Services	-8.9	6.3	0.1	-5.3	4.0	3.0
Trade & FDI liberalization	Primary	14.5	83.6	61.6	61.2	52.3	0.6
	Manufacturing	30.2	45.9	20.4	40.8	80.3	4.9
	Services	-9.2	10.5	4.4	-13.4	-1.3	2.7
				Exports			
Trade liberalization	Primary	136.0	26.3	13.2	-12.7	155.4	-12.2
	Manufacturing	9.6	36.6	32.5	50.3	35.1	2.1
	Services	1.9	-7.0	-5.3	27.4	22.6	0.9
FDI liberalization	Primary	10.5	-0.5	33.4	-0.2	-0.1	-4.9
	Manufacturing	12.8	-6.0	2.2	31.5	11.5	-3.5
	Services	15.1	-10.5	-1.8	4.5	-3.8	-4.8
Trade & FDI liberalization	Primary	150.3	32.5	49.4	-15.8	150.4	-16.3
	Manufacturing	22.9	29.8	35.5	98.1	52.6	-1.8
	Services	16.0	-14.6	-7.2	27.8	18.4	-3.8

Notes: a) United States, Canada, Australia, and New Zealand.
b) Korea, Taiwan, Hong Kong, and Singapore.

For UCAN and China, expansions of the manufacturing and services sectors under FDI liberalization are larger than contractions of these sectors under trade liberalization, resulting in expansions of all three sectors in these regions when both trade and FDI are liberalized. For Japan, NIEs, and ASEAN-4, the combination of trade and FDI liberalization leads to expansions of manufacturing and services output.

Table 6. Sectoral FDI impacts results from APEC liberalization

(*percentage changes*)

		UCAN[a]	*Japan*	*NIEs*[b]	*ASEAN-4*	*China*	*ROW*
				Inward FDI stock			
Trade liberalization	Primary	10.7	-27.5	-12.4	-9.1	51.7	-4.4
	Manufacturing	3.0	8.6	15.6	15.5	8.4	-0.3
	Services	-1.4	1.8	1.8	-5.0	-5.7	-0.7
FDI liberalization	Primary	4.5	57.2	37.9	14.8	16.1	-2.1
	Manufacturing	26.2	15.2	9.7	35.3	76.1	-3.1
	Services	294.3	291.6	150.0	140.0	200.3	-11.1
Trade & FDI liberalization	Primary	15.5	14.4	22.6	4.6	74.4	-6.4
	Manufacturing	31.4	24.8	27.3	61.4	103.4	-3.6
	Services	291.7	298.0	157.0	133.7	189.6	-11.9
				Outward FDI stock			
Trade liberalization	Primary	-4.2	31.4	12.2	1.9	-3.4	-0.3
	Manufacturing	2.6	6.4	4.9	18.6	19.9	2.4
	Services	-1.0	-2.7	-4.7	3.1	0.9	0.0
FDI liberalization	Primary	12.2	-1.2	8.4	14.3	64.9	1.6
	Manufacturing	7.3	16.1	38.8	14.7	10.2	5.4
	Services	100.1	168.8	113.9	235.7	329.9	204.9
Trade & FDI liberalization	Primary	7.2	31.0	22.5	16.2	65.6	1.3
	Manufacturing	10.3	26.8	49.9	37.6	33.6	8.7
	Services	98.7	163.8	106.3	246.3	337.3	206.0

Notes: a) United States, Canada, Australia, and New Zealand.
b) Korea, Taiwan, Hong Kong, and Singapore.

Finally, we examine whether trade and FDI are complements at the sectoral level. Trade liberalization leads to an increase in the inward and outward FDI stocks of the manufacturing sector in every APEC region, whereas it has an ambiguous effect on the FDI stocks in the primary and services sectors (Tables 5 and 6). At the same time, FDI liberalization leads to an increase in imports and exports of manufactures in every APEC region with the exception of Japanese exports. Again, the effect on the primary and services sectors is ambiguous.

The results are consistent with our a priori expectation that horizontal FDI is the most prevalent in the manufacturing sector, where trade and FDI linkages are extensive. Thus the removal of trade barriers in host economies is likely to promote production of foreign subsidiaries. In the primary sector, motives of FDI might include securing energy and/or natural resources for the home country, and this type of FDI is expected to be less sensitive to changes in the height of trade barriers in the host country. In the services

sector, a change in trade regime is unlikely to affect the level of FDI extensively because FDI is often the only means to provide foreign services to local consumers.

5. Conclusions

Despite a significant economic setback experienced by several East Asian economies during 1997-99, the Asia-Pacific region has been the fastest growing multilateral trading area of the world. In this paper, we have evaluated the impact of APEC trade and investment liberalization using a CGE model that incorporates FDI. The preliminary results suggest that FDI liberalization would bring about greater benefits to most of the APEC economies than trade liberalization. More accurate estimates of FDI barriers would be helpful in assessing the benefits of APEC liberalization more precisely, and we plan to refine and update the database.

In the manufacturing sector, trade and FDI are found to be complements in the APEC regions. Trade liberalization leads to an increase in the inward and outward FDI stocks, and FDI liberalization leads to an increase in imports and exports of manufactures. The only exception is that when Japan liberalizes FDI barriers, it leads to an increase in imports but not in exports. However, this may be treated as a special case because Japan's inward FDI stock is extremely small relative to its capital stock. The result on complementarity suggests that gains from trade liberalization would be amplified in the presence of FDI. At the same time, FDI liberalization would increase both FDI and trade flows, which brings additional gains in the worldwide production.

References

Asia-Pacific Economic Cooperation (APEC) (1997). *The Impact of Trade Liberalization in APEC*. Singapore: APEC Secretariat.

Brown, Drusilla K., Alan V. Deardorff, Alan K. Fox, and Robert M. Stern (1996). "The Liberalization of Services Trade: Potential Impacts in the Aftermath of the Uruguay Round," in W. Martin and L.A. Winters, eds., *The Uruguay Round and the Developing Countries*, Cambridge: Cambridge University Press.

Brown, Drusilla K. and Robert M. Stern (1999). "Measurement and Modeling of the Economic Effects of Trade and Investment Barriers in Services." Discussion Paper No. 453, Research Seminar in International Economics, University of Michigan. (http://www.spp.umich.edu/rsie/workingpapers/wp.html)

Dee, Philippa, Kevin Hanslow, Patrick Jomini, Susan Stone, and Andrew Welsh (1999), "Creating an FDI Database," Paper presented at the Second Annual Conference on Global Economic Analysis, Ebberuk, Denmark, June 20-22.

Fry, Maxwell J. (1993). *Foreign Direct Investment in Southeast Asia: Differential Impacts*. Singapore: Institute of Southeast Asian Studies.

Hanslow, Kevin, Tien Phamduc, and George Verikios (1999). *The Structure of the FTAP Model*. Research Memorandum MC-58, Productivity Commission, Canberra. (http://www.pc.gov.au/pcpubs/memoranda/ftap/index.html)

Hanslow, Kevin, Tien Phamduc, George Verikios, and Andrew Welsh (2000). *Incorporating Barriers to Services Trade into the FTAP Database*. Research Memorandum MC-59, Productivity Commission, Canberra.

Hardin, Alexis and Leanne Holmes (1997). *Services Trade and Foreign Direct Investment*. Staff Research Paper, Industry Commission, Canberra. (http://www.pc.gov.au/research/other/servtrad/index.html)

Hertel, Thomas W., ed. (1997). *Global Trade Analysis: Modeling and Applications*. Cambridge: Cambridge University Press.

Hoekman, Bernard (1995). "Assessing the General Agreement on Trade in Services," in W. Martin and L.A. Winters, eds., *The Uruguay Round and the Developing Countries*, World Bank Discussion Paper No. 307. Washington, DC: World Bank.

Kaleeswaran, K., G. McGuire, D. Nguyen-Hong, and M. Schuele (2000). "The Price Impact of Restrictions on Banking Services," in C. Findlay and T. Warren, eds.,

Impediments to Trade in Services: Measurement and Policy Implications. London: Routledge.

Kawai, Masahiro and Shujiro Urata (1998). "Are Trade and Direct Investment Substitutes or Complement? An Empirical Analysis of Japanese Manufacturing Industries," in H. Lee and D.W. Roland-Holst, eds., *Economic Development and Cooperation in the Pacific Basin: Trade, Investment, and Environmental Issues*. Cambridge: Cambridge University Press.

Kreinin, Mordechai E., Michael G. Plummer, and Shigeyuki Abe (1999), "Export and Direct Foreign Investment Links: A Three-Country Comparison," in M.E. Kreinin, M.G. Plummer, and S. Abe, eds., *Asia-Pacific Economic Linkages*. Amsterdam: Pergamon/Elsevier.

Lee, Hiro and David Roland-Holst (1998). "Cooperative Approaches to Shifting Comparative Advantage: The Case of Bilateral Trade between the United States and Japan," in H. Lee and D.W. Roland-Holst, eds., *Economic Development and Cooperation in the Pacific Basin: Trade, Investment, and Environmental Issues*. Cambridge: Cambridge University Press.

Lee, Hiro, David Roland-Holst, and Dominique van der Mensbrugghe (1999). "Quantitative Analysis of APEC Liberalization Using Calibrated General Equilibrium Modelling," in M.E. Kreinin, M.G. Plummer, and S. Abe, eds., *Asia-Pacific Economic Linkages*. Amsterdam: Pergamon/Elsevier.

Low, Linda, Eric D. Ramstetter, and Henry W. Yeung (1996). "Accounting for Outward Direct Investment from Hong Kong and Singapore: Who Controls What?" NBER Working Paper No. 5858. Cambridge, MA: National Bureau of Economic Research.

Markusen, James R. (1983). "Factor Movements and Commodity Trade as Complements," *Journal of International Economics*, 14: 341-356.

Markusen, James, Thomas F. Rutherford, and David Tarr (2000). "Foreign Direct Investment in Services and the Domestic Market for Expertise." NBER Working Paper 7700. Cambridge, MA: National Bureau of Economic Research.

McDougall, R., A. Elbehri, and T.P Truong, eds. (1998). *Global Trade, Assistance, and Protection: The GTAP 4 Data Base*. West Lafayette: Center for Global Trade Analysis, Purdue University.

Mundell, Robert A. (1957). "International Trade and Factor Mobility," *American Economic Review*, 47: 321-335.

Naya, Seiji (1990). “Direct Foreign Investment and Trade in East and Southeast Asia,” in R.W. Jones and A.O. Krueger, eds., *The Political Economy of International Trade: Essays in Honor of Robert Baldwin*. New York: Basil Blackwell.

Neary, J. Peter, and Frances Ruane (1988). “International Capital Mobility, Shadow Prices, and the Cost of Protection,” *International Economic Review*, 29: 571-585.

Pacific Economic Cooperation Council (PECC) (1995). *Surveys of Impediments to Trade and Investment in the APEC Region*. Singapore: PECC for APEC Secretariat.

Petri, Peter A. (1997). “Foreign Direct Investment in a Computable General Equilibrium Framework,” paper presented at the Brandeis-Keio Conference on “Making APEC Work: Economic Challenges and Policy Alternatives,” Keio University, Tokyo, March 13-14.

Petri, Peter A. and Michael G. Plummer (1998). “The Determinants of Foreign Direct Investment: A Survey with Application to the United States,” in H. Lee and D.W. Roland-Holst, eds., *Economic Development and Cooperation in the Pacific Basin: Trade, Investment, and Environmental Issues*. Cambridge: Cambridge University Press.

Ramstetter, Eric D. (1999). “Comparisons of Foreign Multinationals and Local Firms in Asian Manufacturing Over Time,” *Asian Economic Journal*, 13: 163-203.

Ramstetter, Eric D. (2000). “Recent Trends in Foreign Direct Investment in Asia: The Aftermath of the Crisis to Late 1999.” Working Paper Series 2000-02, The International Center for the Study of East Asian Development, Kitakyushu.

United Nations Conference on Trade and Development (UNCTAD) (1996). *World Investment Report, 1996: Investment, Trade and International Policy Arrangements*. Geneva and New York: United Nations.

United Nations Conference on Trade and Development (UNCTAD) (1999). *World Investment Report, 1999: Foreign Direct Investment and Challenges of Development*. Geneva and New York: United Nations.

United Nations Conference on Trade and Development (UNCTAD) (2000). *World Investment Report, 2000: Cross-border Mergers and Acquisitions and Development*. Geneva and New York: United Nations.

van der Mensbrugghe, Dominique (2000). “A Simple World CGE Model Using GTAP Version 4.0.” Mimeo, Development Prospects Group, The World Bank, September.

Verikos, George and Xiao-guang Zhang (2000). “Sectoral Impacts of Liberalising Trade in Services.” Paper presented at the Third Annual Conference on Global Economic Analysis, Melbourne, June 28-30.

Verikos, George and Xiao-guang Zhang (2001). “The Economic Effects of Removing Barriers to Trade in Telecommunications and Financial Services.” Paper presented at the Fourth Annual Conference on Global Economic Analysis, Purdue University, West Lafayette, Indiana, June 27-29.

Walmsley, Terrie L. (1999). “Incorporating International Capital Ownership into the GTAP Model: Results for Asia-Pacific Trade Liberalisation.” Working Paper No. IP-72, Centre of Policy Studies, Monash University, Clayton, Australia.

Warren, Tony (2000). “The Impact on Output of Impediments to Trade and Investment in Telecommunications Services,” in C. Findlay and T. Warren, eds., *Impediments to Trade in Services: Measurement and Policy Implications*. London: Routledge.

Wong, Kar-Yiu (1986). “Are International Trade and Factor Mobility Substitutes?” *Journal of International Economics*, 21: 25-43.

Wong, Kar-Yiu (1995). *International Trade in Goods and Factor Mobility*. Cambridge, MA: MIT Press.

Appendix: Model Specification

Indices

i, j Sector indices
r, s Regional indices
f, d, v Varieties – *f* represents foreign varieties only, whereas *d* represents the domestic variety, i.e. production from home owned and based plants. *v* represents both *f* and *d* (i.e. it is the union of *f* and *d*).

Equations

Production

$$ND^{d}_{r,j,v} = and^{d}_{r,j,v} XP_{r,j,v} \tag{A.1}$$

$$PND^{d}_{r,j,v} = \sum_{i} ad^{d}_{r,i,j,v} PA_{r,i} \tag{A.2}$$

$$WTF^{p}_{f,j,d,r} = and^{m}_{r,j,f} XP_{r,j,f} \tag{A.3}$$

$$PND^{m}_{r,j,f} = PM_{f,j,d,r} \tag{A.4}$$

$$VA_{r,j,v} = ava_{r,j,v} XP_{r,j,v} \tag{A.5}$$

$$L^{d}_{r,j,v} = \alpha^{l}_{r,j,v} \left(\frac{PVA_{r,j,v}}{W_r} \right)^{\sigma^{p}_{r,j,v}} VA_{r,j,v} \tag{A.6}$$

$$K^{d}_{r,j,v} = \alpha^{k}_{r,j,v} \left(\frac{PVA_{r,j,v}}{PK_{r,j,v}} \right)^{\sigma^{p}_{r,j,v}} VA_{r,j,v} \tag{A.7}$$

$$PVA_{r,j,v} = \left[\alpha^{l}_{r,j,v} W_r^{1-\sigma^{p}_{r,j,v}} + \alpha^{k}_{r,j,v} PK^{1-\sigma^{p}_{r,j,v}}_{r,j,v} \right]^{1/\left(1-\sigma^{p}_{r,j,v}\right)} \tag{A.8}$$

$$VC_{r,j,v} = ava_{r,j,v} PVA_{r,j,v} + and^{d}_{r,j,v} PND^{d}_{r,j,v} + and^{m}_{r,j,v} PND^{m}_{r,j,v} \tag{A.9}$$

$$PP_{r,j,v} = \left(1 + \tau^{p}_{r,j}\right) VC_{r,j,v} \tag{A.10}$$

Income Distribution

$$\begin{aligned} YH_r &= \sum_{i}\sum_{v} W_r L^{d}_{r,i,v} + \sum_{i}\sum_{v} \left(1 - \chi_{r,i,v}\right) PK^{n}_{r,i,v} K^{d}_{r,i,v} \\ &+ TY^{k}_{r} + TY^{m}_{r} + TY^{p}_{r} + TY^{x}_{r} \\ &+ InFlowY^{k}_{r} \end{aligned} \tag{A.11}$$

$$TY^{p}_{r} = \sum_{i}\sum_{v} \tau^{p}_{r,i} VC_{r,i,v} XP_{r,i,v} \tag{A.12}$$

$$TY_r^k = \sum_i \sum_v \tau_{r,i,v}^k PK_{r,i,v} K_{r,i,v}^d \tag{A.13}$$

$$InFlowY_r^k = \sum_i \sum_s \chi_{s,i,r} PK_{s,i,r}^n K_{s,i,r}^d \tag{A.14}$$

$$OutFlowY_r^k = \sum_i \sum_s \chi_{r,i,s} PK_{r,i,s}^n K_{r,i,s}^d \tag{A.15}$$

$$PINV_r Inv_r = S_r^h + P^{MUV} \; S_r^f \tag{A.16}$$

Domestic demand

$$Y_r^* = YH_r - \sum_j \left(1 + \tau_{r,j}^c\right) PA_{r,j} \theta_{r,j} \tag{A.17}$$

$$XAc_{r,i} = \theta_{r,i} + \frac{\mu_{r,i} Y_r^*}{\left(1 + \tau_{r,i}^c\right) PA_{r,i}} \tag{A.18}$$

$$S_r^h = YH_r - \sum_j \left(1 + \tau_{r,j}^c\right) PA_{r,j} XAc_{r,j} \tag{A.19}$$

$$XAi_{r,i} = \alpha_{r,i}^i \left(\frac{PINV_r}{\left(1 + \tau_{r,i}^i\right) PA_{r,i}} \right)^{\sigma_r^i} Inv_r \tag{A.20}$$

$$PINV_r = \left[\sum_i \alpha_{r,i}^i \left(\left(1 + \tau_{r,i}^i\right) PA_{r,i} \right)^{1-\sigma_r^i} \right]^{1/\left(1-\sigma_r^i\right)} \tag{A.21}$$

$$XA_{r,i} = \sum_v \sum_j ad_{r,i,j,v}^d ND_{r,j,v}^d + XAc_{r,i} + XAi_{r,i} \tag{A.22}$$

$$TY_r^x = \sum_i \left[\tau_{r,i}^c PA_{r,i} XAc_{r,i} + \tau_{r,i}^i PA_{r,i} XAi_{r,i} \right] \tag{A.23}$$

Trade

$$XDT_{r,i} = \alpha_{r,i}^d \left(\frac{PA_{r,i}}{PDT_{r,i}} \right)^{\sigma_{r,i}^m} XA_{r,i} \tag{A.24}$$

$$XMT_{r,i} = \alpha_{r,i}^m \left(\frac{PA_{r,i}}{PMT_{r,i}} \right)^{\sigma_{r,i}^m} XA_{r,i} \tag{A.25}$$

$$PA_{r,i} = \left[\alpha_{r,i}^d PDT_{r,i}^{1-\sigma_{r,i}^m} + \alpha_{r,i}^m PMT_{r,i}^{1-\sigma_{r,i}^m} \right]^{1/\left(1-\sigma_{r,i}^m\right)} \tag{A.26}$$

$$XD_{r,i,v} = \alpha_{r,i,v}^{xd} \left(\frac{PDT_{r,i}}{PP_{r,i,v}} \right)^{\sigma_{r,i}^d} XDT_{r,i} \tag{A.27}$$

$$PDT_{r,i} = \left[\sum_{v} \alpha_{r,i,v}^{xd} PP_{r,i,v}^{1-\sigma_{r,i}^{d}} \right]^{1/\left(1-\sigma_{r,i}^{d}\right)} \tag{A.28}$$

$$XMT_{r,i}^{Own} = \alpha_{r,i}^{Own} \left(\frac{PMT_{r,i}}{PMT_{r,i}^{Own}} \right)^{\sigma_{r,i}^{v}} XMT_{r,i} \tag{A.29}$$

$$XMT_{r,i}^{For} = \alpha_{r,i}^{For} \left(\frac{PMT_{r,i}}{PMT_{r,i}^{For}} \right)^{\sigma_{r,i}^{v}} XMT_{r,i} \tag{A.30}$$

$$PMT_{r,i} = \left[\alpha_{r,i}^{Own} \left(PMT_{r,i}^{Own} \right)^{1-\sigma_{r,i}^{d}} + \alpha_{r,i}^{For} \left(PMT_{r,i}^{For} \right)^{1-\sigma_{r,i}^{d}} \right]^{1/\left(1-\sigma_{r,i}^{d}\right)} \tag{A.31}$$

$$WTF_{s,i,r,r}^{a} = \alpha_{r,i,s}^{Ownx} \left(\frac{PMT_{r,i}^{Own}}{PM_{s,i,r,r}} \right)^{\sigma_{r,i}^{o}} XMT_{r,i}^{Own} \tag{A.32}$$

$$WTF_{r,i,d,r}^{a} = \alpha_{r,i,d}^{Ownx} \left(\frac{PMT_{r,i}^{Own}}{PM_{r,i,d,r}} \right)^{\sigma_{r,i}^{o}} XMT_{r,i}^{Own} \tag{A.33}$$

$$PMT_{r,i}^{Own} = \left[\left(\sum_{s} \alpha_{r,i,s}^{Ownx} \left(PM_{s,i,r,r} \right)^{1-\sigma_{r,i}^{o}} \right) + \alpha_{r,i,d}^{Ownx} \left(PM_{r,i,d,r} \right)^{1-\sigma_{r,i}^{o}} \right]^{1/\left(1-\sigma_{r,i}^{o}\right)} \tag{A.34}$$

$$FV_{r,i,f} = \alpha_{r,i,f}^{xf} \left(\frac{PMT_{r,i}^{For}}{PFV_{r,i,f}} \right)^{\sigma_{r,i}^{fv}} XMT_{r,i}^{For} \quad \text{for} \quad \forall f \neq r \tag{A.35}$$

$$PMT_{r,i}^{For} = \left[\sum_{f \neq r} \alpha_{r,i,f}^{xf} PFV_{r,i,f}^{1-\sigma_{r,i}^{fv}} \right]^{1/\left(1-\sigma_{r,i}^{fv}\right)} \tag{A.36}$$

$$WTF_{s,i,f,r}^{a} = \alpha_{r,i,f,s}^{Forx} \left(\frac{PFV_{r,i,f}}{PM_{s,i,f,r}} \right)^{\sigma_{r,i,f}^{f}} FV_{r,i,f} \quad \text{for} \quad f \neq r \tag{A.37}$$

$$WTF_{s,i,d,r}^{a} = \alpha_{r,i,d,s}^{Forx} \left(\frac{PFV_{r,i,s}}{PM_{s,i,d,r}} \right)^{\sigma_{r,i,s}^{f}} FV_{r,i,s} \quad \text{for} \quad s \neq r \tag{A.38}$$

$$PFV_{r,i,f} = \left[\left(\sum_{s} \alpha_{r,i,f,s}^{Forx} PM_{s,j,f,r}^{1-\sigma_{r,i,f}^{f}} \right) + \alpha_{r,i,d,f}^{Forx} PM_{f,i,d,r}^{1-\sigma_{r,i,f}^{f}} \right] \quad \text{for} \quad f \neq r \tag{A.39}$$

$$PM_{r,i,v,s} = \left(1+\tau_{r,i,s}^{m}\right)\left(1+\xi_{r,i,s}\right) PP_{r,i,v} \tag{A.40}$$

$$TY_{r}^{m} = \sum_{s} \sum_{i} \sum_{v} \left[\frac{\tau_{s,i,r}^{m} PM_{s,i,v,r}}{\left(1+\tau_{s,i,r}^{m}\right)} \left(WTF_{s,i,v,r}^{p} + WTF_{s,i,v,r}^{a} \right) \right] \tag{A.41}$$

International Trade and Transport Services

$$XWM = \sum_r \sum_i \sum_v \sum_s PP_{r,i,v} \xi_{r,i,s} \left[WTF^p_{r,i,v,s} + WTF^a_{r,i,v,s} \right] / PWM \tag{A.42}$$

$$XMarg_r = \alpha^t_r \left(\frac{PWM}{PMarg_r} \right)^{\sigma^t} XWM \tag{A.43}$$

$$PWM = \left[\sum_r \alpha^t_r PMArg_r^{1-\sigma^t} \right]^{1/\left(1-\sigma^t\right)} \tag{A.44}$$

$$XMG_{r,i} = \alpha^{mg}_{r,i} XMArg_r \tag{A.45}$$

$$PMArg_r = \sum_i \alpha^{mg}_{r,i} PP_{r,i,d} \tag{A.46}$$

Goods market equilibrium

$$XP_{r,i,f} = XD_{r,i,f} + \sum_s \left[WTF^p_{r,i,f,s} + WTF^a_{r,i,f,s} \right] \tag{A.47}$$

$$XP_{r,i,d} = XD_{r,i,d} + \sum_s \left[WTF^p_{r,i,d,s} + WTF^a_{r,i,d,s} \right] + XMG_{r,i} \tag{A.48}$$

Factor market equilibrium

$$L^s_r = \sum_j \sum_v L^d_{r,j,v} \tag{A.49}$$

$$W_r = PW_r W_{r,0} \tag{A.50}$$

$$K^{Sec}_{r,i} = \gamma^{Sec}_{r,i} \left(\frac{PK^{Sec}_{r,i}}{PW_r} \right)^{\omega^{Sec}_r} \frac{W_r}{PW_r} \tag{A.51}$$

$$PW_r = \left[\sum_i \gamma^{Sec}_{r,i} \left(PK^{Sec}_{r,i} \right)^{1+\omega^{Sec}_{r,i}} \right]^{1/\left(1+\omega^{Sec}_{r,i}\right)} \tag{A.52}$$

$$K^s_{r,i,d} = \gamma^{Dom}_{r,i} \left(\frac{PK^n_{r,i,d}}{PK^{Sec}_{r,i}} \right)^{\omega^{kx}_{r,i}} K^{Sec}_{r,i} \tag{A.53}$$

$$K^{For}_{r,i} = \gamma^{For}_{r,i} \left(\frac{PK^{For}_{r,i}}{PK^{Sec}_{r,i}} \right)^{\omega^{kx}_{r,i}} K^{Sec}_{r,i} \tag{A.54}$$

$$PK^{Sec}_{r,i} = \left[\gamma^{Sec}_{r,i} \left(PK^n_{r,i,d} \right)^{1+\omega^{kx}_{r,i}} + \gamma^{For}_{r,i} \left(PK^{For}_{r,i} \right)^{1+\omega^{kx}_{r,i}} \right]^{1/\left(1+\omega^{kx}_{r,i}\right)} \tag{A.55}$$

$$\chi_{f,i,r} K^s_{f,i,r} = \gamma^{kf}_{r,i,f} \left(\frac{PK^n_{f,i,r}}{PK^{For}_{r,i}} \right)^{\omega^{kf}_{r,i}} K^{For}_{r,i} \tag{A.56}$$

$$PK_{r,i}^{For} = \left[\sum_{f} \gamma_{r,i,f}^{kf} \left(PK_{f,i,r}^{n} \right)^{1+\omega_{r,i}^{kf}} \right]^{1/\left(1+\omega_{r,i}^{kf}\right)} \tag{A.57}$$

$$K_{r,i,v}^{s} = K_{r,i,v}^{d} \tag{A.58}$$

$$PK_{r,i,v}^{n} = \left(1-\tau_{r,i,v}^{k}\right) PK_{r,i,v} \tag{A.59}$$

Numéraire and closure

$$P^{MUV} = \frac{\sum_{r\in OECD} \sum_{i\in Manu} \sum_{v} \sum_{s} PP_{r,i,v} \left(WTF_{r,i,v,s,0}^{p} + WTF_{r,i,v,s,0}^{a} \right)}{\sum_{r\in OECD} \sum_{i\in Manu} \sum_{v} \sum_{s} PP_{r,i,v,0} \left(WTF_{r,i,v,s,0}^{p} + WTF_{r,i,v,s,0}^{a} \right)} \tag{A.60}$$

Dropped balance of payments equation

The following equation is deduced as a linear combination of the regional equations:

$$\begin{aligned} P^{MUV} S_{r}^{f} \;=\; & \sum_{s}\sum_{i}\sum_{v} \left[\frac{PM_{s,i,v,r}}{\left(1+\tau_{s,i,r}^{m}\right)} \left(WTF_{s,i,v,r}^{p} + WTF_{s,i,v,r}^{a} \right) \right] \\ & - \sum_{s}\sum_{i}\sum_{v} \left[PP_{r,i,v} \left(WTF_{r,i,v,s}^{p} + WTF_{r,i,v,s}^{a} \right) \right] \\ & - \sum_{i} PP_{r,i,d} XMG_{r,i} - InFlowY_{r}^{k} + OutFlowY_{r}^{k} \end{aligned} \tag{A.61}$$

Definition of Variables and Parameters

Endogenous Variables

Production

ND^{d}	Aggregate intermediate demand
PND^{d}	Price of aggregate intermediate demand
WTF^{p}	'Home' imports for production by foreign-based investment
PND^{m}	Price of 'home' imports
VA	Aggregate value added
L^{d}	Labor demand
K^{d}	Capital demand
PVA	Price of value added bundle
VC	Unit cost of production
PP	Producer price

Income

YH	Household income
TY^{p}	Production tax revenues
TY^{k}	Capital tax revenues
TY^{m}	Tariff revenues

TY^x	Indirect tax revenues
$InFlowY^k$	Capital income from abroad
$OutFlowY^k$	Capital income flowing abroad
Inv	Investment volume

Domestic demand

Y^*	Supernumerary income
XAc	Armington demand by households
S^h	Household savings
XAi	Armington demand for investment expenditures
PINV	Investment price deflator
XA	Aggregate Armington demand

Trade

XDT	Aggregate demand for goods produced domestically
XMT	Aggregate demand for imports
PA	Armington price
XD	Demand for goods produced domestically
PDT	Price of aggregate demand for domestic goods
XMT^{Own}	Aggregate import demand for 'own' imports
XMT^{For}	Aggregate import demand for 'foreign' varieties
PMT	Aggregate import price
WTF^a	World trade flow for imports (excluding 'home' imports)
PMT^{Own}	Price of aggregate import demand for 'own' imports
FV	Import demand for aggregate foreign varieties
PMT^{For}	Price of aggregate import demand for 'foreign' varieties
PFV	Price of import demand for aggregate foreign varieties
PM	Tariff inclusive bilateral import price

International Services

XWM	Aggregate demand for international trade services
XMarg	Regional supply of international trade services
PWM	Aggregate price index of international trade services
XMG	Sectoral supply of international trade services
PMarg	Regional supply price of international trade services

Goods

XP	Output

Factors

Wage	Wage rate
W	Value of wealth
K^{Sec}	Aggregate sectoral capital supply
PW	Price index of wealth
K^s	Sectoral capital supply by region and variety
K^{For}	Aggregate foreign capital allocation
PK^{Sec}	Price of aggregate sectoral capital supply
PK^{For}	Price of aggregate foreign capital allocation
PK	Price of capital
PK^n	Price of capital net of taxes

Exogenous Variables

τ^p	Output tax
τ^k	Capital tax
τ^m	Tariff rate
τ^c	Indirect tax on consumption
τ^i	Indirect tax on investment expenditures
ξ	International trade and transport margin
L^s	Aggregate labor supply
W_0	Initial (volume of) wealth
S^f	Foreign saving
P^{MUV}	World price index (of industrial countries' manufacturing exports)

Parameters

ad^d	Share parameter for Armington intermediate demand by sector of input
and^d	Share parameter for aggregate intermediate Armington demand
and^m	Share parameter for aggregate intermediate home demand
ava	Value added share in production
α^l	Labor share parameter in value added
α^k	Capital share parameter in value added
α^j	Investment expenditure share parameter
α^{xd}	Share parameter for domestic demand of domestically produced goods
α^{Own}	Aggregate share of own variety in aggregate imports
α^{For}	Aggregate share of foreign varieties in aggregate imports
α^{Ownx}	CES share parameters for importing own varieties
α^{xf}	Share parameter for aggregate demand of foreign variety *f*
α^{Forx}	Share parameters for allocating demand for foreign varieties across regions
α^t	CES share parameter for demand of international trade services
α^{mg}	Technical coefficient for supply of international trade and transport services
σ^p	Capital-labor substitution elasticity across varieties
σ^j	Investment expenditure substitution elasticity
σ^m	Substitution elasticity between domestic goods and imports
σ^d	Substitution elasticity of demand across domestic goods by variety
σ^v	Substitution elasticity of imports for own versus foreign firms
σ^o	Substitution elasticity of imports across regions of origin for own products
σ^{fv}	Substitution elasticity of imports across varieties for foreign firms
σ^f	Substitution elasticity of imports across regions of origin for firms of type *f*
σ^t	Substitution of demand for international trade and transport services
χ	Share of installed FDI owned by foreigners
θ	Household subsistence minima
μ	Household marginal propensity to consume
γ^{Sec}	CET share parameters for top-level CET capital nest
γ^{Dom}	Domestic capital share by sector
γ^{For}	Foreign capital share by sector
γ^{kf}	CET share parameter for allocation of FDI across regions by sector
ϖ^{Sec}	CET transformation elasticity for top-level CET capital nest
ϖ^{kx}	Transformation elasticity between domestic and foreign capital
ϖ^{kf}	Transformation elasticity of FDI across regions of destination