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AN ESTIMATION OF INTERNATIONAL MARITIME CONTAINER VOLUME AMONG ASIAN COUNRTIES BY GTAP MODEL AND SIMULATION ON FTA AND TRANSPORT IMPROVEMENT SCENARIO

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Abstract: While regional economic integration has recently attracted much interest, its impact on the rapidly developing international maritime transport industry is a major concern. This paper proposes a method for estimating the international container cargo OD flows under various hypothetical FTA memberships and transport technical progress by incorporating the GTAP model. The effects under the FTA scenarios and transport technical progress scenarios on the selected countries' economy, social welfare, trade amounts and container OD flows are discussed. Since this method provides an approach for estimating the OD flows on a national wide level, it can be utilized for assessing the policy effects on international trade and transportation. In addition, it is also an important step for demand forecasting such as the volume of container handling and transshipment on the international container shipping transport networks.

Key Words: container cargo, OD flow, GTAP model, FTA, transport technical progress

1. INTRODUCTION

Globalization and regionalism are the major trends in today's global economy. As the world economy becomes more integrated, the development of international trade is greatly stimulated, and maritime transport, which is a primary mode in terms of international freight transport especially in Asia region, experiences a remarkable development. As for Japan, a bilateral FTA with Singapore and Mexico has already been established respectively. Also there are now under negotiations with Philippines, Thailand, Malaysia, and South Korea. In addition, an EPA negotiation with whole ASEAN countries will start soon. These policies would stimulate regional economies and increase trade amount in Asian region.

At the same time, the ratio of containers arriving in and leaving Asian ports has recently increased, keeping in pace with the economic development of these Asian countries. The amounts of international cargoes handled in such hub ports as Hong Kong and Singapore rank now among the tops of the world, to replace the major ports of Europe, the USA and Japan. At the same time, the containerships are becoming larger in pursuit of economies of scale. Now, a hierarchical transport system, or the hub and spoke system, has been established, in which cargoes tend to gather at hub ports with deeper berths and efficient material handling systems. Also, in the pursuit of economies of scale, carriers are going beyond the conventional shipping conference to sealing a more advanced "global alliance" to thoroughly integrate operations within the group across the borders of individual carriers. Intensive as well as strategic port improvement in port structures is urgently needed in Japan, to prevent Japanese port business from being not left far behind these rapidly growing Asian ports.

Against such a background, the author *et al*. have been developing models which produce container flows among ports on the sea, applying to traffic network assignment methodology, including use of different types of ships and transshipments. This model will be used in order to reproduce the actual, but also to estimate the effect of port investment policies (for example, new birth construction and reduction of handling cost) on container flows among ports and the amount of handling containers by each port (e.g. Shibasaki, *et al*. 2004). However, in our models, the amounts of Origin-Destination container cargoes are so exogenously given that we cannot predict the effect of policies which increase the demand of container volume itself, for example, international trade policy as FTA and EPA. At all, because transport demand is a derived demand by nature, the models which cannot consider that kind of effects would not say to be perfect.

On the other hand, numerous studies have been conducted on the impact of economic integration policies on many industries (for example, Nakajima 2002, , etc.) so far. There are many researches on world trade with general equilibrium analysis so that the effects of trade policies such as FTA or transport efficiency improvement policies can be predicted. However, there seems few researches focus on the impact of these policies to the physical volume of international transport (i.e. tonnage-base or TEU [Twenty-foot Equivalent Unit: the unit of maritime container cargo] base). In particular, although international maritime container transport should support the increase of international trade amount, almost no studies are there as far as authors know.

Therefore, this study proposed a transformation methodology for estimating the international container cargo OD flows and their changes, incorporating the simulation results of the GTAP model under several scenarios. Then, as applications of this proposed approach, the effects

under FTA and transport technical progress scenarios, with various hypothetical membership combinations among Asian countries, on these member countries' economy, social welfare, trade amounts and container OD flows were discussed.

Figure 1 shows a conceptual framework of an integrated trade-freight forecasting system. We have already developed the international container cargo flow model and now under improvement as mentioned above. This study covers in the red dash-dot line area, shown in the figure. This study is the first step of extending to the integrated trade-freight forecasting system from the international container cargo flow model.

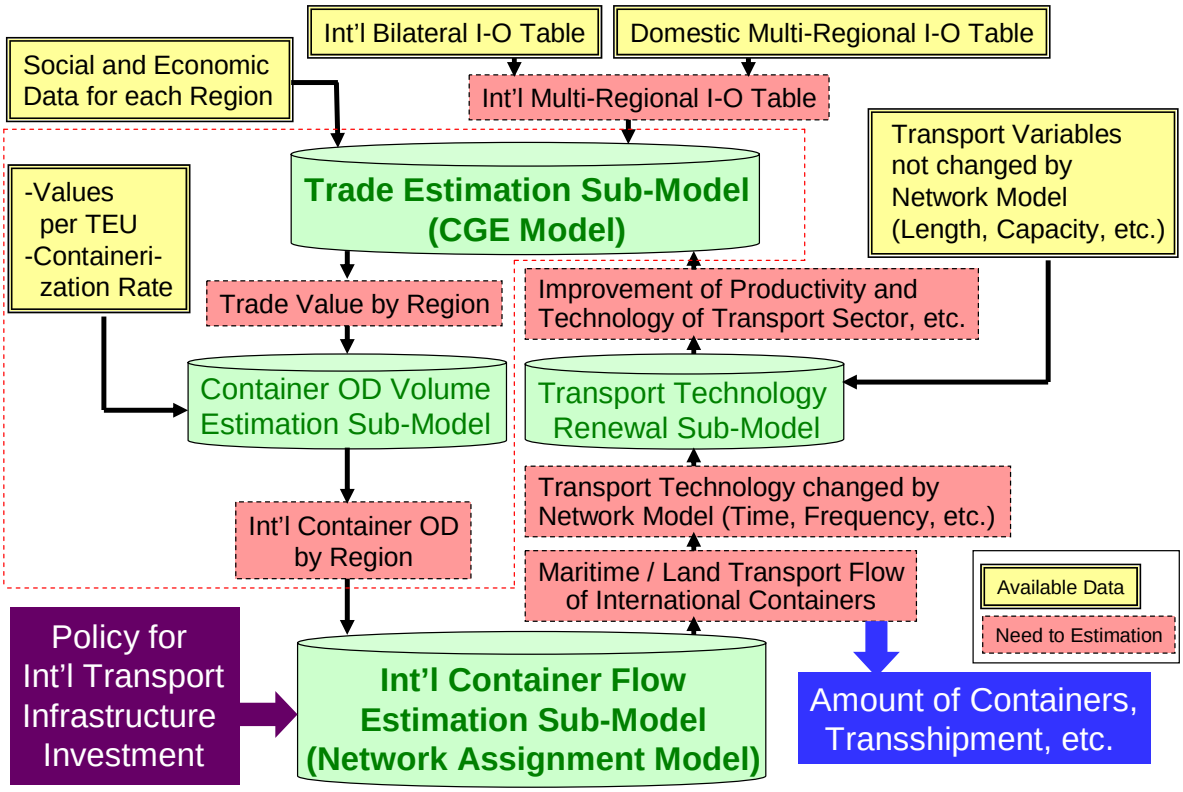


Figure 1. Integrated Trade-Freight Forecasting System (proposed by authors)

2. METHODOROGY AND DATASET PREPARATIONS

2.1 Transformation Methodology of OD Volume of International Maritime Container Cargo

Estimation of the international container shipping OD flows under regional economic integration has recently become a concern; however, the outputs of GTAP model are only of the matrix of commodity-based bilateral trade volume in monetary-base; therefore, it still needs an approach to transform into the container flows shown in Figure 2.

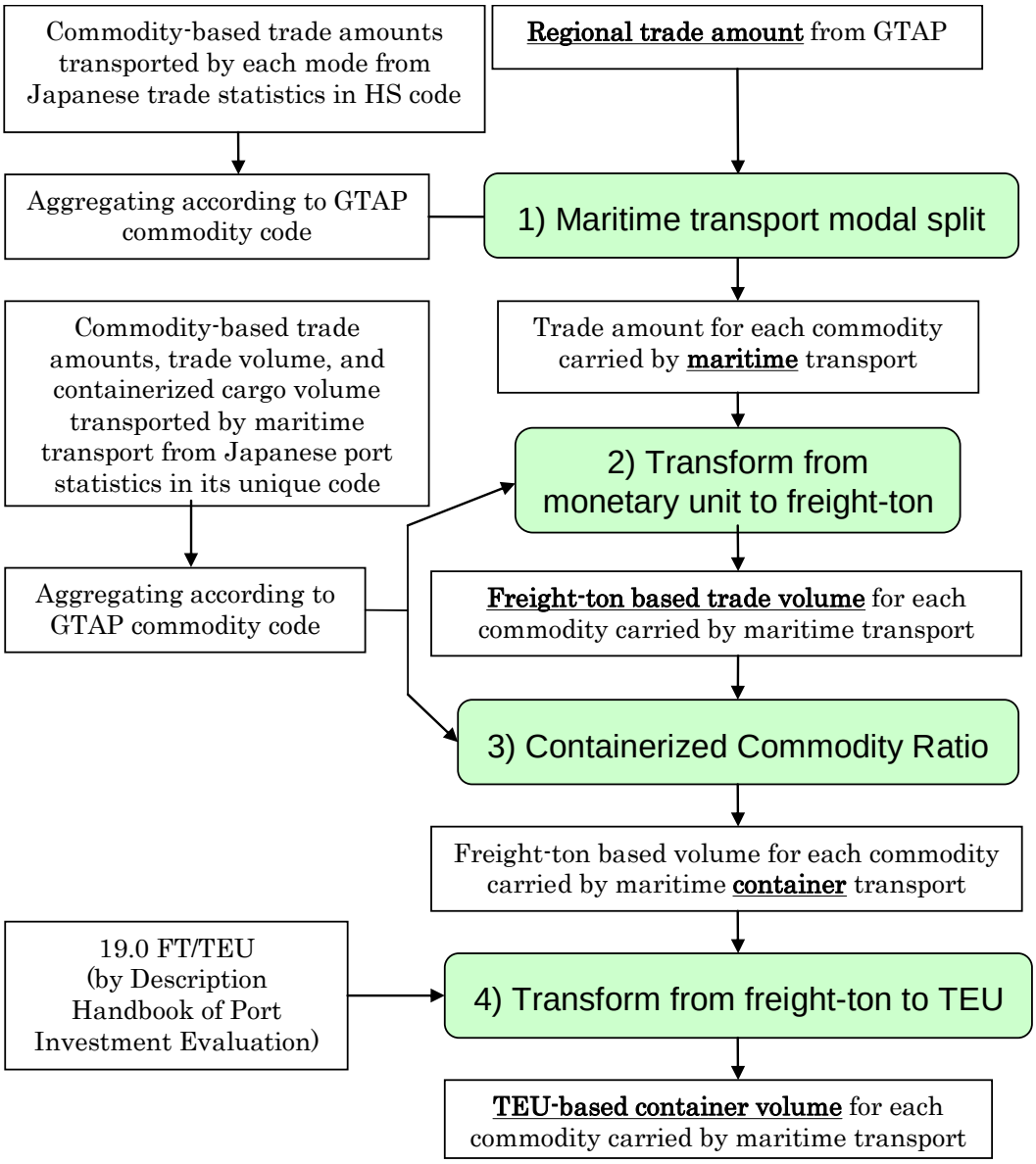


Figure 2. Transformation Flowchart from Regional Trade Amount in the GTAP Model to TEU-Based Container Volume Carried by Maritime Transport

Step 1. Modal Split

International trade commodities are carried by different transport modes. There is a unique international transport sector in the GTAP model, which provides the services that account for the difference between FOB and CIF values. This international transport sector consists of maritime, air and land transport. Therefore, the modal share of maritime transport must be determined. Because the figures on modal share in the GTAP is based on the United States' dataset, in this study, focusing in Asian region, modal share was approximately replaced by the share of trade amounts carried by each transport mode originating from or destined for Japan, using data obtained from the trade statistics of the Ministry of Finance, Japan. Here, because trade statistics has HS code (97 classification for major division), which is different from classification of the GTAP (42 for tradable), it is sort of tough work to re-aggregate according to the GTAP classification, once after breaking down trade statistics. As for the actual figures of each commodity, please refer to Table A1 in Appendices.

Step 2. Transforming Monetary Units to Freight-Ton

Freight Ton (FT) is unit for calculating freight amount according to weight and/or cubic measurement. By using each commodity's unit price (USD/FT) and its trade amount by maritime transport, the FT-based weight can be obtained. The commodity unit price (JPY/FT) is derived from Port Statistics Yearbook of Japan. Japanese port statistics also has different commodity code (54 classification for major division) from either HS code or the GTAP classification. Thus another re-aggregation is needed from port statistics code to the GTAP classification. We changed from USD to JPY at currency rate 1 USD = 120 JPY. As for the actual figures, also see refer to Table A1

Step 3. Containerized Commodity Ratio

Not all commodities for maritime transport can be carried packed by containers; therefore, the containerized ratios of the different commodities must be incorporated. Because we were unable to obtain all containerized ratios for each commodity on each route, Japanese commodity-based containerized ratios were used, which were also obtained from the data of Japanese Port Statistics Yearbook. Please refer to Table A1.

Step 4. TEU Transformation

TEU (Twenty-foot Equivalent Unit) is unit of maritime container cargo. It is very difficult to identify the number of tons of one TEU cargo for each commodity. In this study, the value of 19.0 FT/TEU was used, which was taken from the Description Handbook of Port Investment Evaluation, published by the Port Investment Evaluation Committee of Japan.

2.2 Data Aggregation from GTAP Database

In this study, GTAP version 5.4 and version 6.0 database were used, which is the 1997 and 2001 Datasets respectively for each country. Thirty countries and regions were selected in order to apply the calculation data for the international transport network model proposed by autohors (Shibasaki, Ieda, et al, 2004). First, the GTAP model was used to calculate the GDPs and trade amounts of all these countries, then the outputs were aggregated according the main seven regions shown in Table 1.

Table 1 Classification of Regions

No.	Code	Description	Region	No.	Code	Description	Region
1	jpn	Japan	Japan	16	nzl	New Zealand	ROW
2	kor	Korea	Korea	17	hkg	Hong Kong	
3	chn	China	China	18	twn	Taiwan	
4	idn	Indonesia	ASEAN	19	inbg	India, Bangladesh	
5	mys	Malaysia		20	lka	Sri Lanka	
6	phl	Philippines		21	xsa	Rest of South Asia	
7	sgp	Singapore		22	xcm	Central America, Caribbean	
8	tha	Thailand		23	per	Peru	
9	vnm	Vietnam		24	chl	Chile	
10	M	Mediterranean Countries	EU	25	xap	Rest of Eastern South America	
11	E	Europe except Mediterranean		26	wsa	Western South America	
12	can	Canada	NAFTA	27	rus	Russia	
13	usa	USA		28	xme	Rest of the Middle East	
14	mex	Mexico		29	ba	Black Africa	
15	aus	Australia	ROW	30	xrw	Rest of the World	

(Note: Among the ASEAN countries, the GTAP model only has the databases on Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam.)

Table 2 Basic Information of the Selected Countries in 1997

Country	Japan	China	Korea	Brunei	Cambodia	Indonesia	Lao,PDR
Trade Amount	739,880	325,066	280,780	4,670	NA	95,137	1,065
GDP	4,212,258	898,244	476,487	5,422	3,063	215,749	1,747
rate	0.18	0.36	0.59	0.86	NA	0.44	0.61
Country	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	ASEAN
Trade Amount	157,771	2,903	63,499	257,433	120,282	20,777	723,862
GDP	100,169	31,002	82,239	96,318	150,617	27,609	713,935
rate	1.58	0.09	0.77	2.67	0.80	0.75	1.01

(Note: Rate = Trade Amount/GDP; Source: United Nations Yearbook; Unit: Million USD)

The GTAP has 57 industry sectors; 19 non-tradable industries such as service industries were removed when aggregating the calculation results. The remaining 42 industries (refer to the Appendix) were examined in order to improve the calculation accuracy and identify the containerized volume in detail.

2.3 Scenario Settings

Based on the above method, the effects of FTA and transport technical progress scenarios on the selected countries' economies, bilateral trade amounts and container shipping transport flows were examined and discussed in next chapter. In order to easily reference the results of the two applications, the results were put together according to the corresponding problem categories. Six combinations of FTA memberships were considered, as shown in Table 3.

The FTA Scenarios were examined under the various tariffs shown in Table 4. The tariff reduction is from 20% Off to 100% Off. This can be set in the GTAP by changing the shock variable *tms* (change in tax on imports of i from region *r* into *s*)

In order to draw a comparison with the results of the FTA scenarios, the transport technical progress scenarios were set to the same country combinations according to the corresponding FTA countries' combinations. The transport technical progress of a country means the improvement ratio of its transport technology between the country and all its trade partner countries. For example, corresponding to FTA 1, for PRO 1 it was considered that the transport technology between Japan and all its trade partner countries was improved; meanwhile, the same change occurred between Korea and all its trade partner countries. Furthermore, the progress ratios were set from 50% down to 50% up as shown in Table 5. In the GTAP model, the shock variables were expressed as *atf* (tech change shipping from region *r*) and *ats* (tech change shipping to region *s*). For the transport technical progress scenarios, due to time constraints, only four scenarios have been calculated so far.

Table 3 FTA and Transport Technical Progress Scenario Settings

FTA1	FTA2	FTA3	FTA4	FTA5	FTA6
JPN-KOR	JPN-CHN	CHN-KOR	JPN-CHN-KOR	JPN-ASEAN	JPN-CHN-KOR-ASEAN
PRO1	PRO2	PRO3	PRO4	PRO5	PRO6
JPN, KOR	-	-	JPN,CHN,KOR	JPN, ASEAN	JPN,CHN,KOR, ASEAN

Table 4 Tariff Reduction Sets

TAX20%OFF	TAX40%OFF	TAX60%OFF	TAX80%OFF	TAX100%OFF

Table 5 Transport Technical Progress Sets

TECH -50%	TECH -25%	TECH + 25%	TECH + 50%

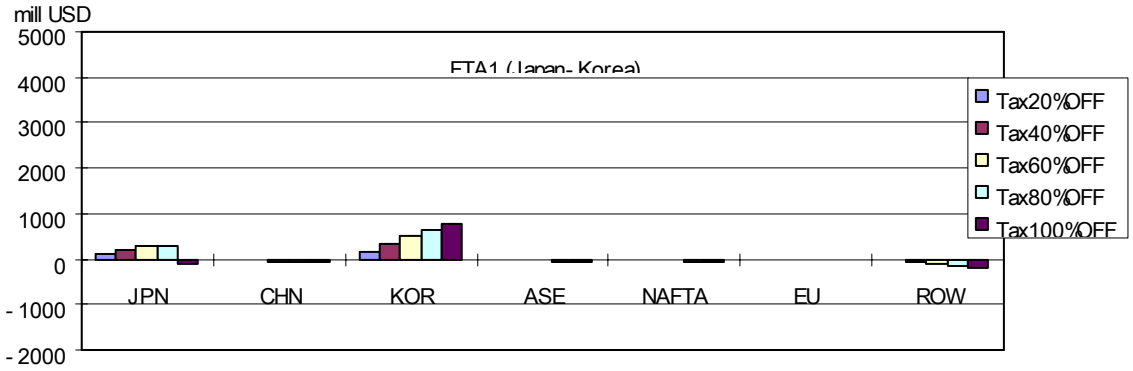
3. SIMURATION RESULTS & ANALYSES

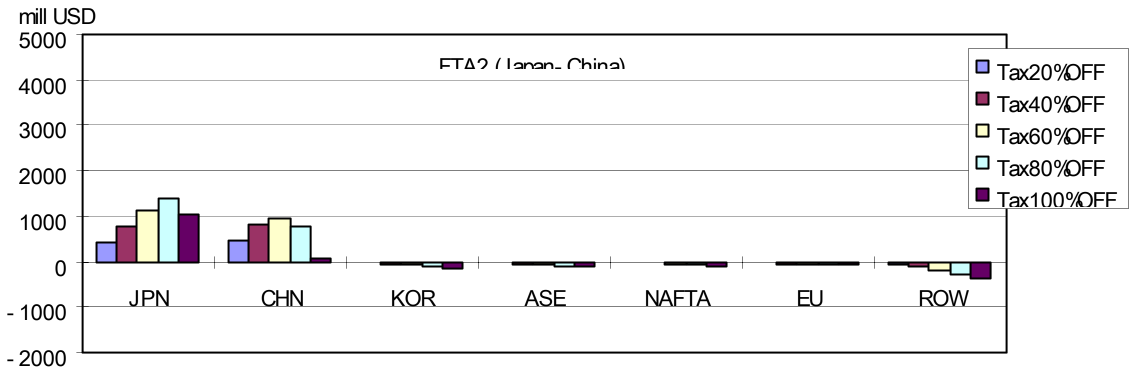
3.1 GDP Changes under FTA and Transport Technical Progress Scenarios

(1) GDP Changes under FTA Scenarios with Various Tariff Reductions

From the following figures (Figure 3 and 4), by comparing each FTA combination under various tariff reduction settings, it can be seen who gains the most and who gains the least in each of the combinations. In particular, the more countries joined FTA, the more benefits they will receive. The FTA among Japan, China, Korea and ASEAN gain the largest benefits. On the other hand, the countries that didn't join the FTA will lose the benefit in almost all cases. Also, whatever the bilateral or multilateral FTA, the larger the country's GDP is, the more increasing it is in the all FTA scenario. However, Japan at FTA 1 and China at FTA 3 in 1997 are exceptional. In both cases, Korea benefits much more than Japan and China.

We also find that GDP increases with the tariff reduction. However, when the tariff was cut 100%, the GDP decreased in most of FTA scenarios in 1997. This is because under these circumstances, some country's import increases much faster than its export. When examines the commodity-based import and export amount, it is seen that for each commodity, the import amount increases much faster than the export amount from 80% tax reduction case to 100% tax reduction case. For example, for Japan at the FTA 6 with 100% tax reduction, the imports amount of agriculture products, foods and wearing apparel increases significantly. It shows that 100% tax reduction is not always the most profitable case for some FTA country from the viewpoint of GDP, due to the different development level of some particular industries. As an extreme example, in FTA 1 in 1997, even the GDP change becomes a minus value for Japan due to the trade deficit.

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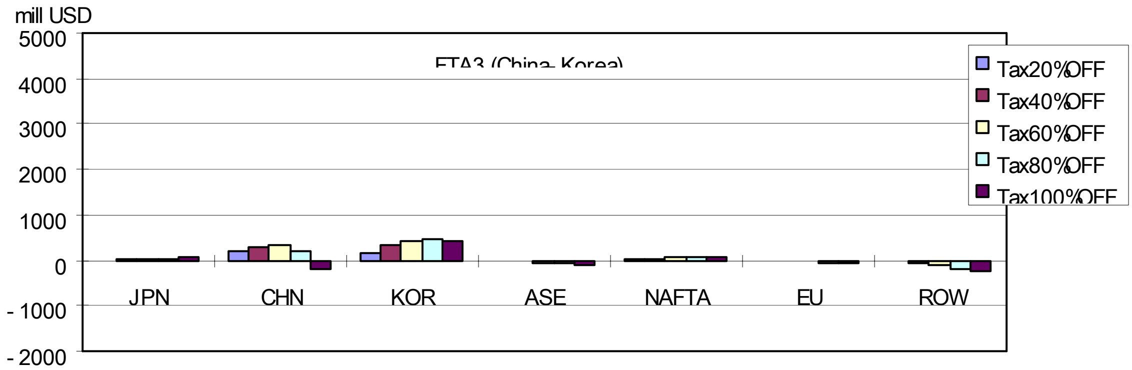
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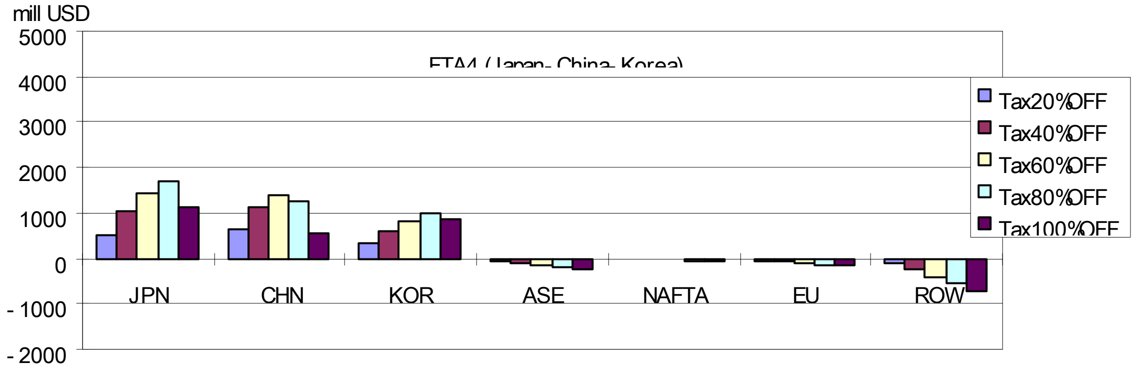
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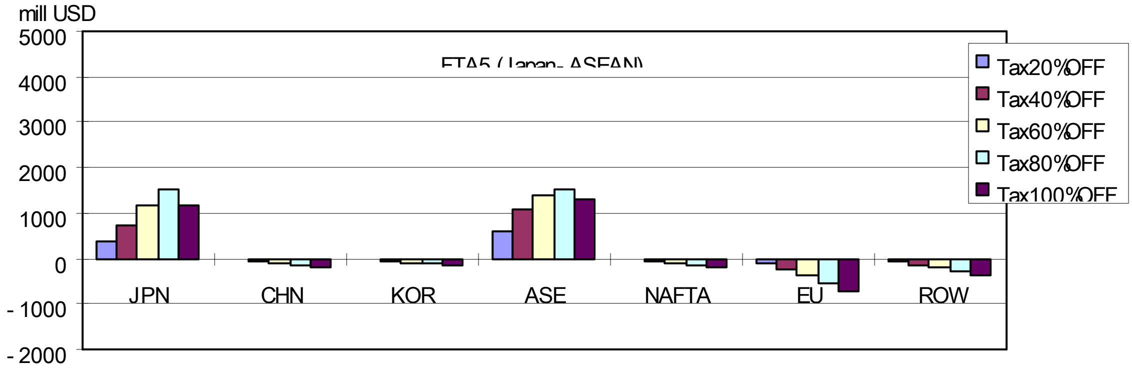
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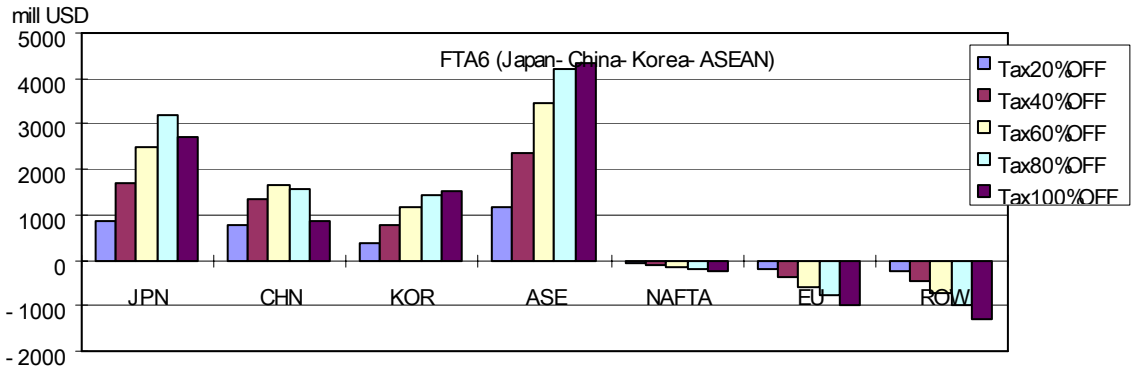

Figure 3. GDP Changes under FTA Scenarios with Various Tariff Reductions in 1997

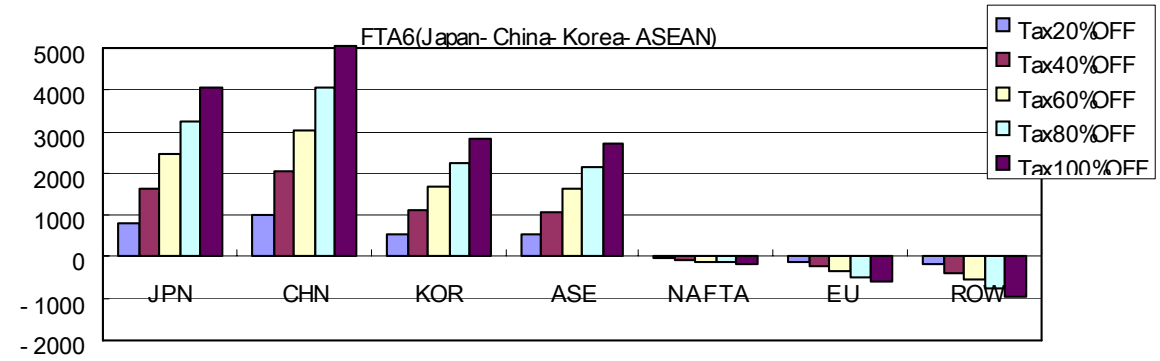

Figure 4. GDP Changes under FTA 6 with Various Tariff Reductions in 2001

(2) GDP Changes under Transport Technical Progress Scenarios

From Figure 5 and 6, we find that transport technical progress has a positive impact on the GDP growth. However, there is no significant difference among the four scenarios in terms of the effects of transport technical progress on a country's GDP. For individual counties, for example, when both China and Japan improve their transport technology, the impact on China's GDP is much higher than for Japan, because China has a higher ratio of transport cost over trade amount. (By GTAP calculation: China: 11.5%, Japan: 5%, Korea: 4.5%, ASEAN: 4.2%, NAFTA: 3.8%, EU: 3.6%, ROW: 5.2%). Therefore, if China can improve its transport technology, it can reduce much of its costs, which would stimulate GDP growth.

Comparing with the results of FTA scenarios, for example, the impact of Japan and Korea's technical progress on their GDP is bigger than in the case of Japan-Korea FTA. It can be assumed that technical progress will affect the entire tradable commodity. This implies that the effect of "bilateral" FTA would be less than the effect of technical progress by the respective countries. On the other hand, the GDP changes under the transport technical progress of Japan, China, Korea and ASEAN scenarios in 2001 is some larger than the GDP changes under the same scenario in 1997 except for China. The reason why the GDP change is smaller in China may be due to decrease the share of transport cost over trade amount.

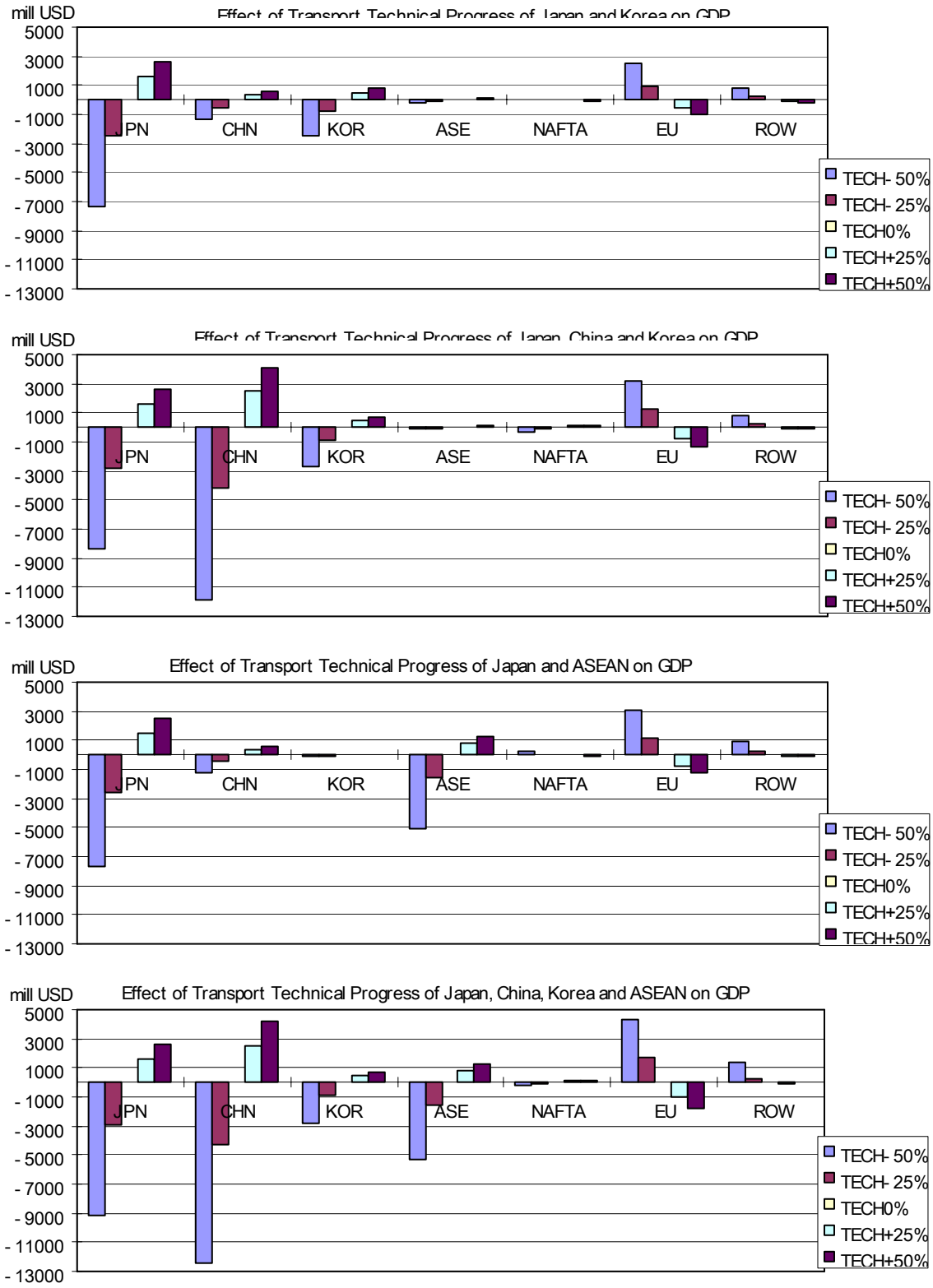

Figure 5. GDP Changes under Transport Technical Progress Scenarios in 1997

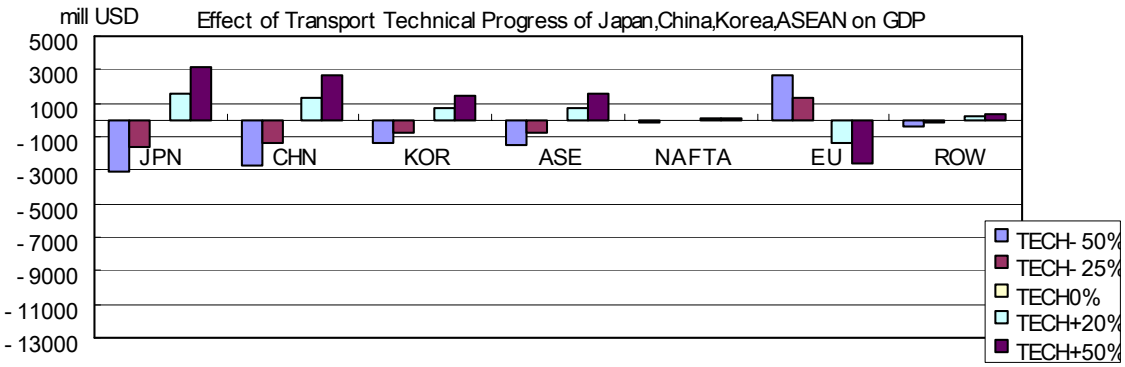

Figure 6. GDP Changes under Transport Technical Progress Scenario (PRO 6) in 2001

3.2 Comparisons of GDP Change and EV

In the GTAP model, economic welfare is represented as being derived from the allocation of national income between private consumption, government consumption and savings. Hertel (2001) defines welfare decomposition for the Equivalent Variation (EV) of Region *r* in the GTAP model as:

$$EVr = INCOME_r (u_r + pop_r) \quad (1)$$

where $INCOME_r$ is the income level of Region *r*; u_r is the percent change in per capita utility; pop_r is the population change rate of Region *r*.

Figure 7 and 8 illustrate that in most cases, FTA and transport technical progress will improve the GDP growth and social welfare EV simultaneously. Furthermore, in the two figures, China has the smallest slopes in the liner regressions. In order to understand it, in the GTAP model, *GDPr* is defined as

$$GDPr = INCOMEr * POPr \quad (2)$$

where *POPr* is the population of Region *r*. Therefore,

$$\Delta GDP \approx \Delta INCOMEr * POPr + INCOMEr * pop_r \quad (3)$$

When the change in GDP is equal, if the population and/or its change rate are larger, the income and/or its change rate will be smaller. Then, *EVr* will be smaller because the EV includes the term of product of income, *INCOMEr*, and utility change, u_r, in addition to the contribution of population change. Since Chinese population and its change rate are absolutely larger, thus, with the same change of GDP, China has the smallest EV.

In addition, when comparing with the changes of GDP and EV under FTA scenarios and transport technical progress scenarios, it is seen that transport technical progresses have much more effect on country's economic welfare than country's GDP, especially for ASEAN countries.

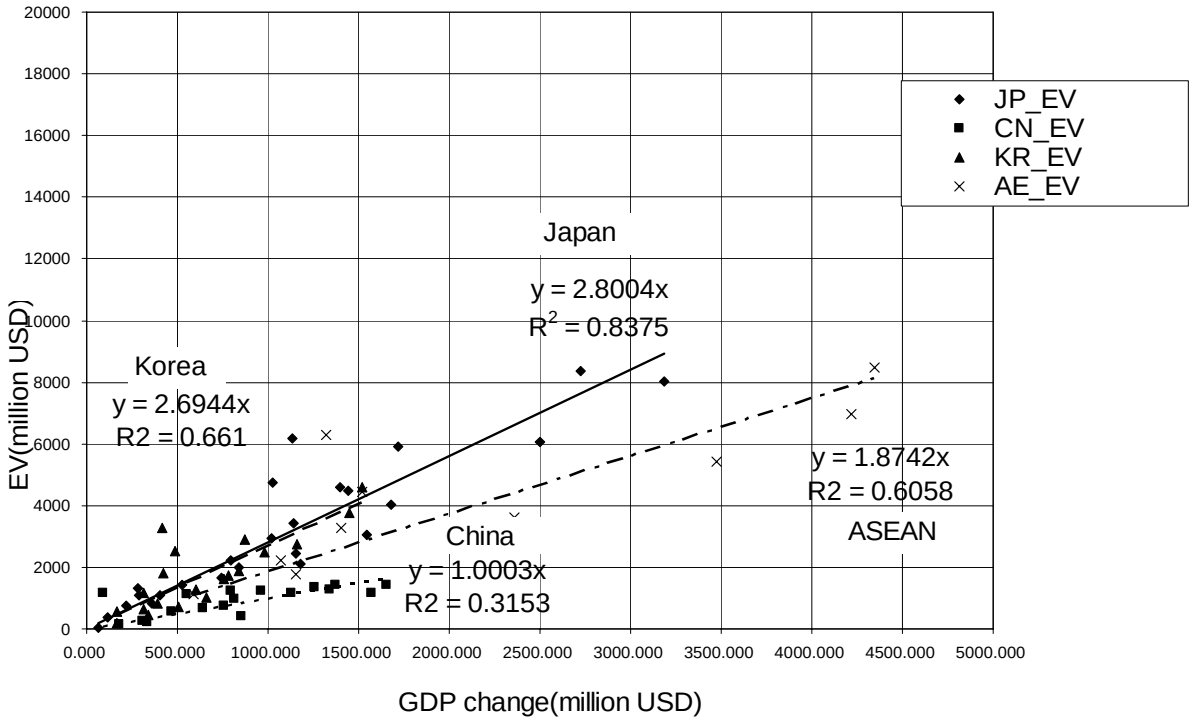

Figure 7. Change of GDP and EV under FTA Scenarios
(in 1997; figure in case of 2001 is omitted because of similar tendency)

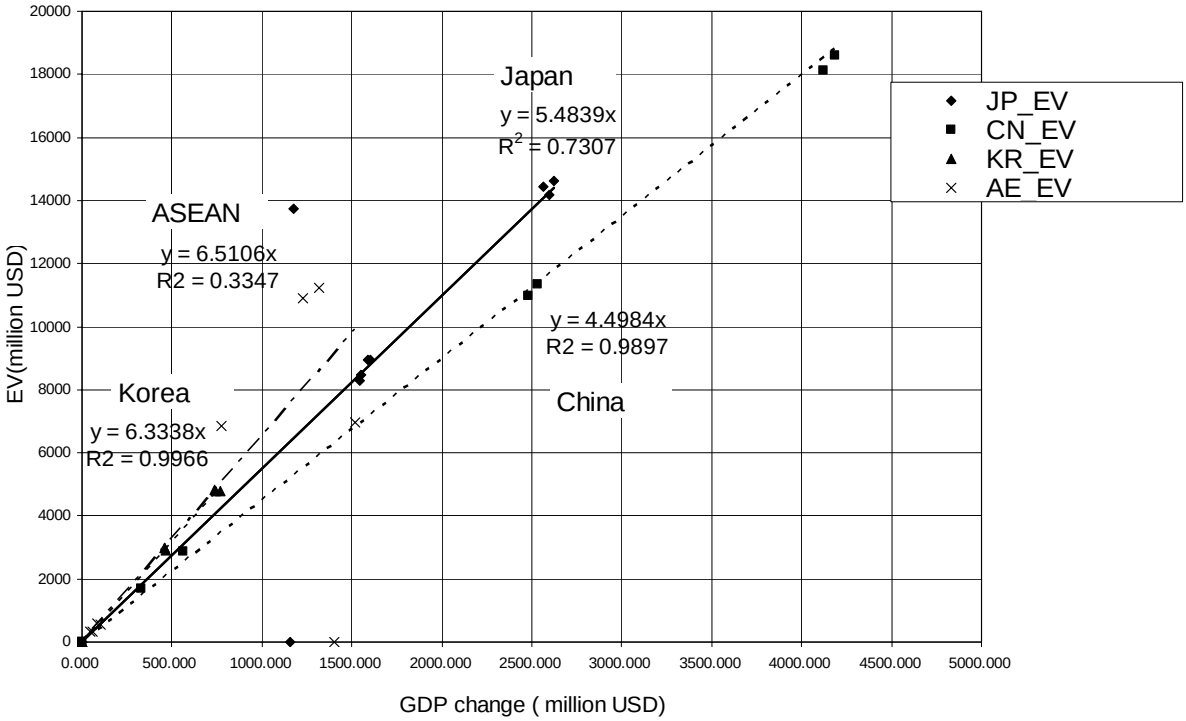

Figure 8. Change of GDP and EV under Transport Technical Progress
(in 1997; figure in case of 2001 is omitted because of similar tendency)

3.3 Trade Amount Change

As for the trade amounts under the various FTA scenarios in 1997 (GTAP ver. 5.4) and 2001 (ver. 6 beta), it was confirmed that the more countries that joined FTAs, the more benefit they would obtain as well as what is observed on the GDP change. On the other hand, the non-FTA countries would lose the benefit. Furthermore, the trade amount would increase more by reducing the tariff to zero even in 1997, which differs from the results for GDP change. The following Figure 9 are examples of the FTA situation among Japan, China, Korea and ASEAN under the various tariff reductions in 1997 and 2001, and also shows that the trade amount increases following the tariff reduction. Comparing with the results in 1997 and 2001, especially for Japan, Korea and ASEAN countries, trade amount changes in 2001 is much lower (nearly half) than those in 1997. One reason of such decreasing changes might be from lowering tariff and eliminating non-tariff barriers during these four years gradually.

Meanwhile, transport technical progresses stimulate all counties' trade amounts. In Figure 10, it can be seen that the technical progress improved China's trade amount much more than other countries due to China having a higher transport cost share compared to its trade amount. Comparing with the results in 1997 and 2001, to the contrary with FTA scenarios, trade amount changes in 2001 is much higher than those in 1997 except for China. It may indicate that a speed of technical progress is so slower than that of tariff reduction and non-tariff barrier elimination that transport technology become bottlenecks in expanding international trade.

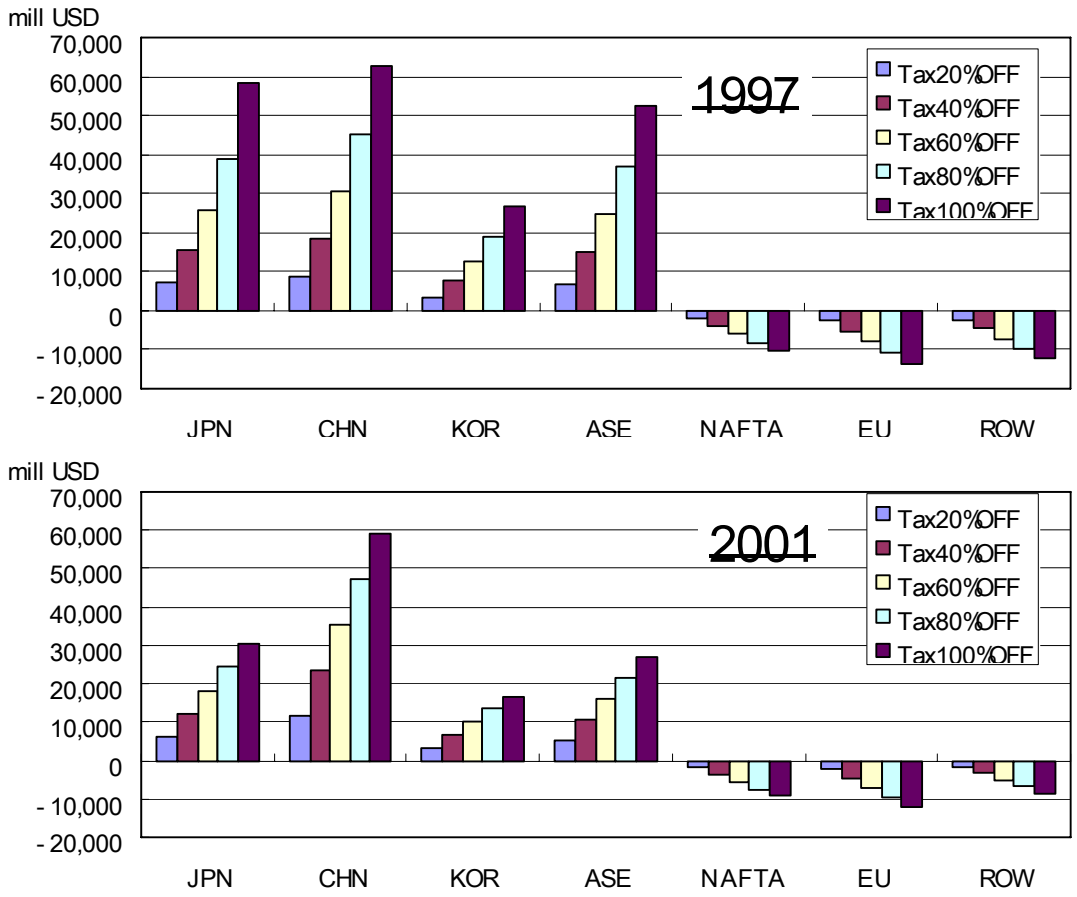

Figure 9. Trade Amount Changes under FTA6 Scenario in 1997 and 2001

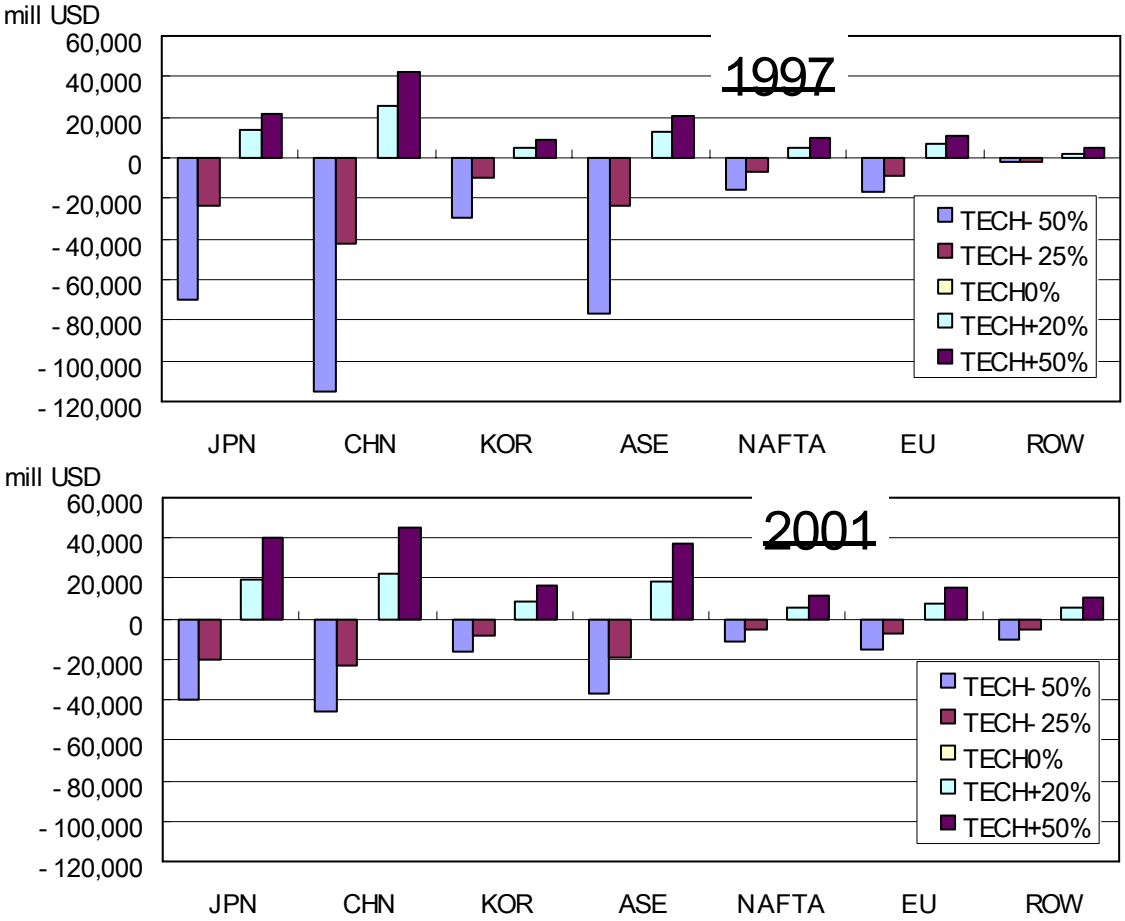

Figure 10. Trade Amount Changes under PRO6 Scenario in 1997 and 2001

3.4 Container Volume Change

The container shipping volume of each country can be derived from the GTAP model outputs under the various FTA and transport technical progress scenarios settings. It also confirms the above conclusions such as that Japan-China-Korea-ASEAN FTA or transport technical progress among these countries in 1997 and 2001 can greatly stimulate the container volumes. Comparing with the results in 1997, the container volume changes in 2001 is much smaller under FTA scenario and some larger under technical progress scenario, which are the same tendencies on trade amount change.

As for the change rate of container volume, figures are at most around 5 to 10 % of total handled container volume in each country. For example, Japanese container volume increases around 927 million TEU in case of 100 % tariff reduction under FTA scenario 6 (Japan, China, Korea and ASEAN) in 2001, which shares 7.1 % of the total handled container volume in Japan in same year (13,127 million TEU). The change rates are relatively higher in Japan and Korea (occasionally over 10 %), while in China and ASEAN countries they are relatively lower, mainly because the former countries depend much on maritime transport due to traditional and geographical reason.

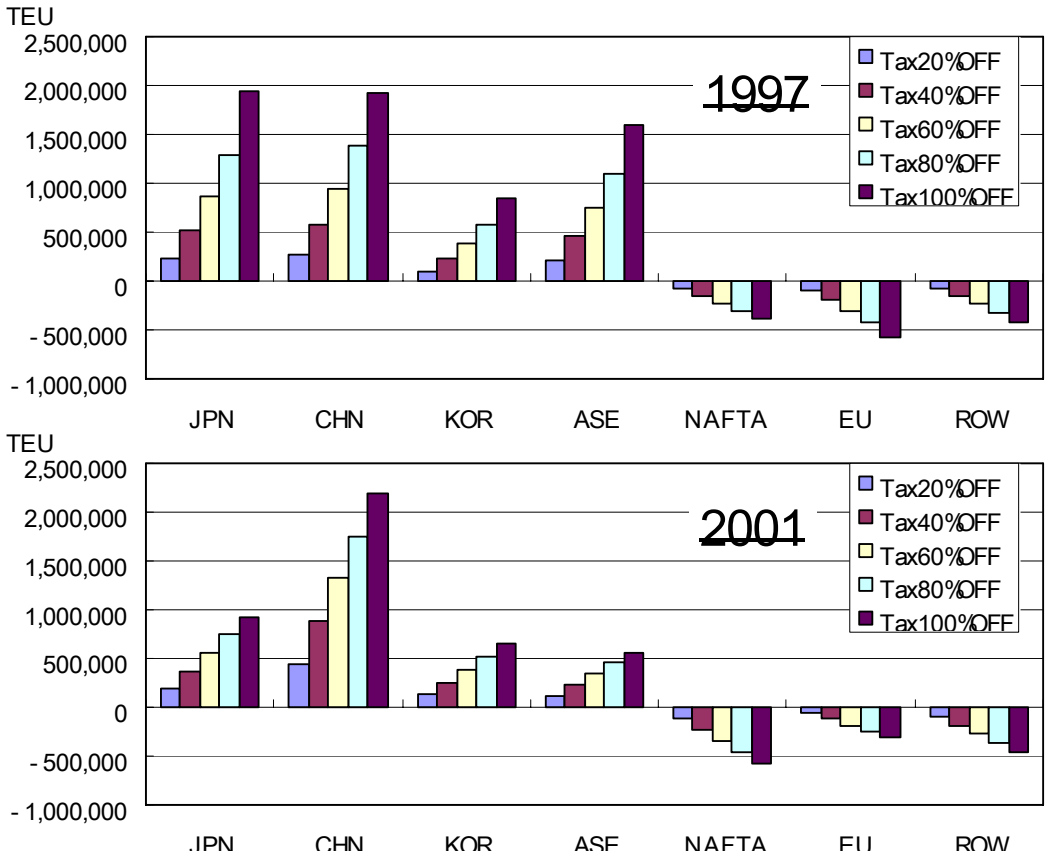

Figure 11. Container Volume Changes under FTA 6 Scenario in 1997 and 2001

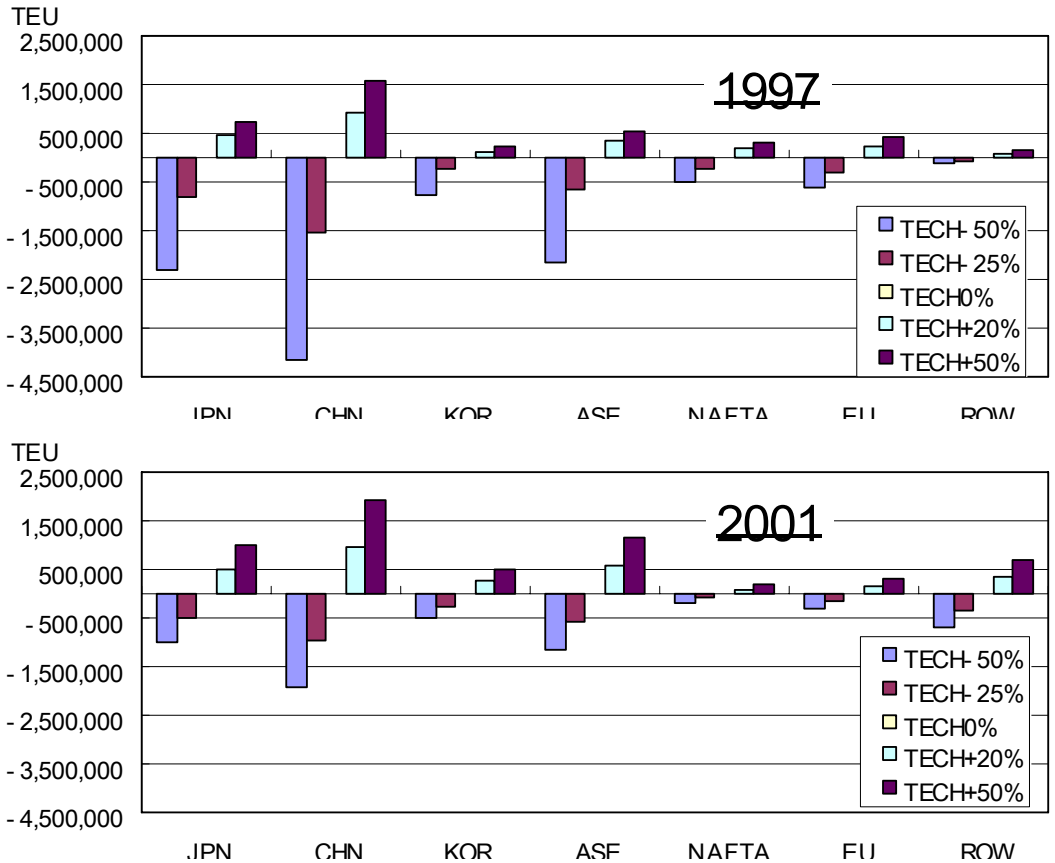

Figure 12. Container Volume Changes under PRO 6 Scenario in 1997 and 2001

3.5 Container OD Flow Change

For the international container shipping OD flow, the GTAP model can calculate bilateral trade amounts, and then by using the proposed method, it can obtain the container shipping OD flow. As space is limited, here, just discuss the aggregated results of Japan-China-Korea-ASEAN FTA with 50% tariff reduction and 50% transport technical progress in the corresponding countries. Base on the OD tables, as shown in Table 6, Japan's import and export container OD flows in 1997 can be compared in Figure 13. According to the upper of Figure 13 on change rates of container volume from Japan to other countries at FTA6 with 50% tariff reduction, the container cargo transported from Japan to China changes at the highest rate under both tariff reduction and transport technical progress. Meanwhile, the container cargo transported from Japan to EU and NAFTA decreases in both cases. On the other hand, as shown in the lower of Figure 13, the container cargo from NAFTA and EU to Japan decreases under the tax reduction case, but increases in the technical progress case.

Why the effects on the container volume between Japan and NAFTA or EU countries in the technical progress case are so different? As already mentioned, transport technical progress of a country should have positive effects on traffic volume for all countries over the world. However, why the container volumes from Japan to NAFTA or EU countries in the technical progress case are decreasing? The reason for this was found from checking the OD flow in Table 6: Japan exports more to China instead of NAFTA and EU, then NAFTA and EU imports more from China and ASEAN instead of Japan. Furthermore, by examining the container shipping flow changes by each commodity in the following Figure 14 (due to the limited space, only the top 10 fast-changing commodities are shown) , it can be seen that the decreasing volumes of *ome* (machinery) and *mvh* (automobile) from Japan to NAFTA and EU are much larger than the increasing volumes of other exported commodities. In particular, as for commodity *ome*, export to China is increasing very much, converting products which used to be exported toward NAFTA and EU.

The above phenomenon is not observed in the same case of 2001, as shown in Table 7 and Figure 15. Under FTA scenario, export to China is dominant, while under technical progress scenario, the increasing rate on import from Korea is much larger. As for detail OD matrix change by each country, please refer to Table A2 to A5 in Appendices.

Table 6 OD Matrix of Container Cargo Change in 1997 (unit: TEU)

- FTA6 with TAX50% OFF

From/ To	JPN	CHN	KOR	ASE	NAFTA	EU	ROW	TOTAL
JPN	0	415,412	161,998	158,816	- 158,807	- 109,304	- 112,255	355,859
CHN	231,264	0	92,018	74,149	- 10,614	- 13,766	- 14,133	358,918
KOR	59,704	102,758	0	51,504	- 32,549	- 36,211	- 44,139	101,067
ASE	142,561	82,724	27,176	130,811	- 17,890	- 21,244	- 35,926	308,212
NAFTA	- 39,835	- 46,438	- 46,200	- 29,322	44,703	17,358	22,230	- 77,504
EU	- 37,217	- 100,202	- 28,101	- 83,456	28,904	11,196	24,591	- 184,285
ROW	- 40,021	- 89,224	- 11,563	- 26,837	43,492	34,680	24,314	- 65,159
TOTAL	316,456	365,031	195,328	275,665	- 102,762	- 117,292	- 135,318	797,108

- PRO6 with TECH+50%

From/ To	JPN	CHN	KOR	ASE	NAFTA	EU	ROW	TOTAL
JPN	0	356,685	22,802	18,995	- 71,775	- 61,120	- 31,009	234,579
CHN	132,259	0	15,419	77,630	201,442	163,303	6,154	596,207
KOR	16,114	51,078	0	5,563	- 6,102	- 10,825	- 5,568	50,259
ASE	31,871	67,231	7,486	59,150	25,520	9,589	26,275	227,123
NAFTA	132,833	97,249	48,061	43,712	- 29,727	- 64,248	- 19,843	208,037
EU	74,260	130,949	50,729	79,824	24,089	612	48,601	409,065
ROW	57,610	195,569	13,734	30,517	- 57,109	- 54,161	- 21,713	164,447
TOTAL	444,947	898,761	158,230	315,390	86,339	- 16,850	2,898	1,889,716

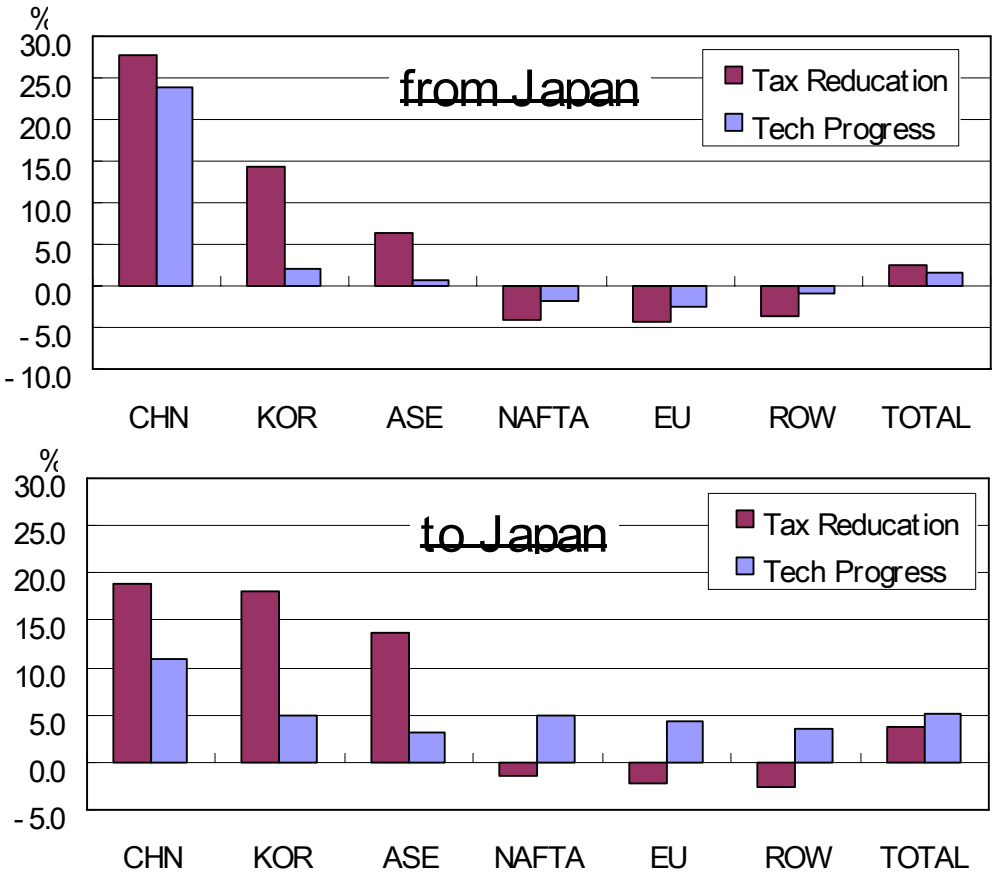

Figure13. Container Volume Change Rates from/to Japan at FTA6 with TAX 50% OFF and PRO6 with TECH +50% in 1997

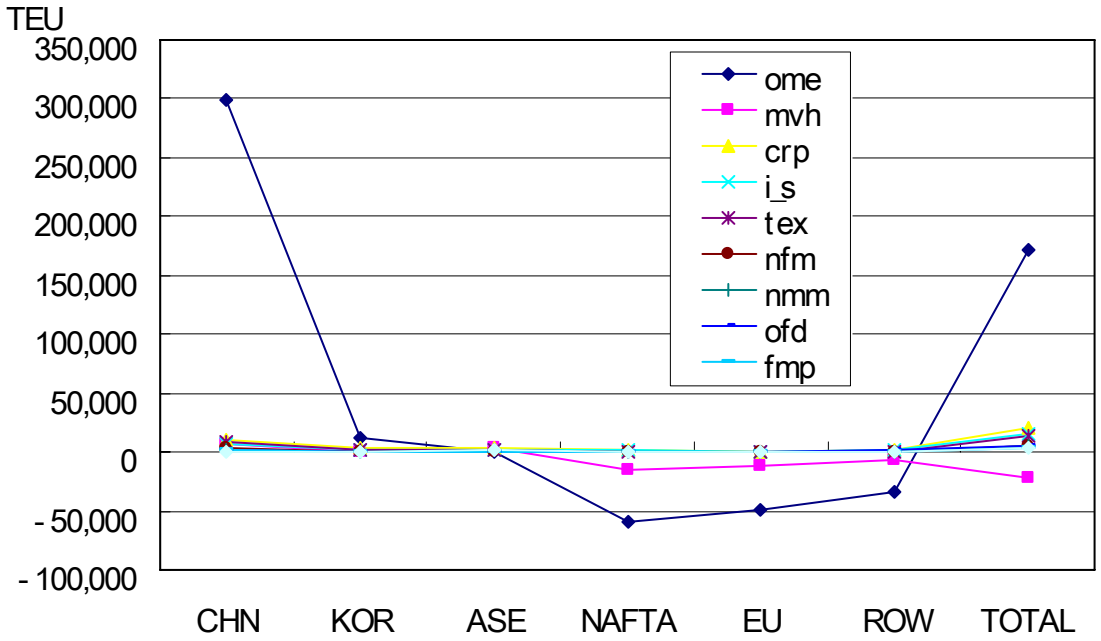

Figure 14. Commodity-based Container Cargo Volume Change from Japan under PRO6 with TECH + 50% in 1997

Table 7 OD Matrix of Container Cargo Change in 2001 (unit: TEU)

- FTA6 with TAX50% OFF

From/ To	JPN	CHN	KOR	ASE	NAFTA	EU	ROW	TOTAL
JPN	0	220,020	52,565	65,716	- 71,909	- 45,736	- 43,122	177,534
CHN	273,642	0	446,713	61,615	- 2,708	- 8,993	- 7,739	762,530
KOR	24,125	149,563	0	31,125	- 24,027	- 20,268	- 25,626	134,892
ASE	45,857	122,364	25,645	67,650	- 40,400	- 51,735	- 53,470	115,911
NAFTA	- 33,464	- 42,456	- 174,474	- 11,210	22,877	9,278	8,002	- 221,448
EU	- 33,930	- 69,294	- 20,815	- 34,836	22,648	9,506	12,410	- 114,311
ROW	- 8,454	- 59,601	- 152,518	- 24,277	32,247	29,915	30,482	- 152,205
TOTAL	267,777	320,597	177,116	155,782	- 61,272	- 78,033	- 79,063	702,904

- PRO6 with TECH+50%

From/ To	JPN	CHN	KOR	ASE	NAFTA	EU	ROW	TOTAL
JPN	0	102,965	54,961	77,887	12,280	15,054	45,279	308,426
CHN	308,751	0	61,496	69,022	130,497	43,784	66,987	680,536
KOR	55,202	92,308	0	31,724	13,530	3,854	24,620	221,238
ASE	177,578	123,841	57,289	162,092	- 12,131	- 2,673	4,226	510,222
NAFTA	- 563	89,949	46,772	65,174	- 43,607	- 51,998	- 31,033	74,693
EU	84,077	161,251	30,731	44,093	14,787	2,028	- 7,968	329,000
ROW	- 18,954	567,216	10,684	139,909	- 20,134	- 66,873	- 19,922	591,926
TOTAL	606,091	1,137,529	261,934	589,901	95,222	- 56,825	82,189	2,716,041

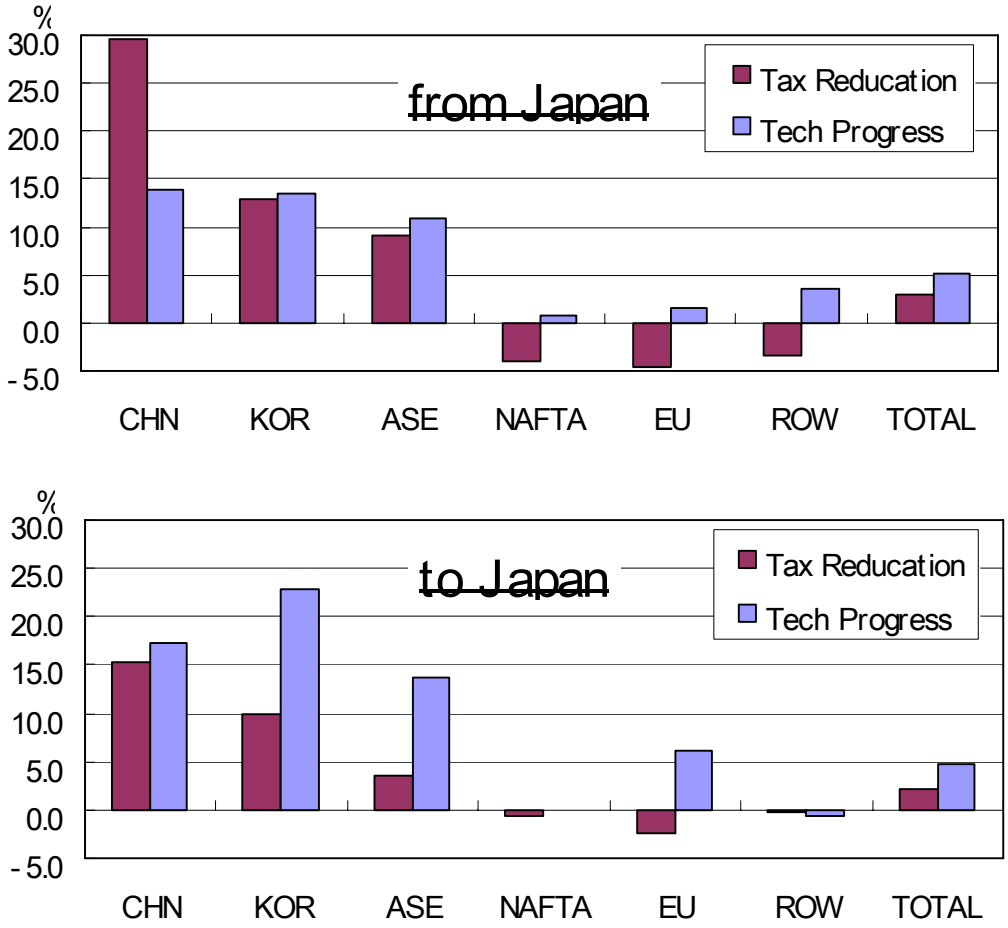

Figure15. Container Volume Change Rates from/to Japan at FTA6 with TAX 50% OFF and PRO6 with TECH +50% in 2001

4. CONCLUSION

This study proposed a method for estimating the trade volume and international container shipping transport OD flow under various changes in socioeconomic factors changes by using the GTAP model. In particular, as two applications in this study, the impacts of various regional economy integrations (FTA scenarios with different tariff reduction schemes) and transport technical progress on selected countries' economies especially in terms of international container shipping transport OD flows were examined and discussed.

This method has the following features.

1) This methodology can provide the commodity-based OD flow information among the studied countries from the viewpoints of international trade and container flows, by processing the outputs from the GTAP model, which is also one of few applications of the GTAP model at the field of international maritime container transport network.
2) This methodology can also estimate the maritime cargo and container OD flow changes under various FTA scenarios and transport technology improvement scenarios among several combinations of Asian countries incorporated in the outputs from the GTAP model, which will be a useful tool to do the economic policy evaluations on the international maritime container transport network.

3) The result of the research will be also an important step for the demand forecasting such as the volume of container handling and transshipment on the international container shipping transport network.

From the applications in this study, it was demonstrated that both FTA and transport technical progress have almost all positive effects on the GDP, trade amount and container OD flows. These effects are increased by the growth in the number of FTA membership countries. Due to the difference in each country's industry development level and structure, the GDP of some countries will decrease when it join the non-tariff FTA in some cases. This is because the import volume is higher than export volume. However, in term of the trade amount, it will increase. Consequently, containerized goods will always increase. The change in the trade pattern generates new container shipping transport OD flows. Additionally, since the calculation of the GTAP model is based on each commodity, the proposed method can show not only the change in total container cargo volume on each OD pair, but also indicate the change in commodity–based container goods composition on each route under these scenarios.

As future studies, the above results should be further examined and explained theoretically based on the model structure, and the accuracy of the method should be improved. Furthermore, since this OD estimation is on a national level, consideration should be given to a method for assigning the OD flow into each port at the selected countries in case one country has more than one port. This will be the next step in our study on the international shipping transport network.

REFERENCES

Berrittela, M. (2004) Methods for Decomposing Welfare Changes in the GTAP Models, Technical notes

Cabinnet Office, Government of Japan (2001) Toward Trade and Investment Liberalization Among China, Japan and Korea

Filippini, C., Molini, V., (2003) The determinants of East Asian trade flows: a gravity equation approach, **Journal of Asian Economics, 14 (2003)** , 695-711.

Francois, J. and Wooton, I. (2000) Trade In International Transport Services: The Role Of Competition, discussion paper

Handbook of Port Investment Evaluation, published by Port Investment Evaluation committee of Japan

Hanslow, K. (2001) A General Welfare Decomposition for CGE Models, **GTAP Technical Paper**, No. 19.

Hertel, T. W. (1997) **Global Trade Analysis Project**. Cambridge University Press.

Huff, K., Hertel T. W. (1996) Decomposing Welfare Changes in the GTAP Model, **GTAP Technical Paper,** No. 5, part 2.

Ministry of Transport, Japan, Port Statistics Yearbook of Japan in 1996.

Nakajima, T.(2002)**,** An analysis of the Economic Effects of Japan-Korea FTA**, ERINA Discussion Paper**, No. 0202e

Ports and Harbors Bureau, Ministry of Transport, Japan, Survey Report of International Container Cargo Flow

Shibasaki, R., Kizushi, R., Ieda, H. Kadaono, T, (2004) An improved model of international maritime container cargo flow in eastern Asian considering both shippers' and carriers' behavior, International Association for Maritime Economists

Shoven, J.B., Whalley, J.(1992) **Applying General Equilibrium**. Cambridge University Press.

Trade Statistics of Ministry of Finance, Japan in 1997

Van M, H. and Frank, V. T. (1998) Endogenous International Technology Spillovers and Biased Technical Change in the GTAP Mode , **GTAP Technical Paper**, No.15.

Appendices

Table A1. Estimated Modal Share of Maritime Transport, Unit Price and Containerized Ratio by GTAP Commodity Classification in 1997 and 2001

No.	Code	Description	Maritime Transport Share		Unit Price (USD/FT)		Containerized Ratio	
			1997	2001	1997	2001	1997	2001
1	pdr	Paddy rice	1.000	1.000	0.1510	0.1500	0.027	0.165
2	wht	Wheat	1.000	1.000	0.1557	0.1274	0.056	0.045
3	gro	Cereal grains nec	1.000	0.999	0.1195	0.0078	0.124	0.203
4	v_f	Vegetables, fruit, nuts	0.836	0.826	0.4033	0.4718	0.496	0.596
5	osd	Oil seeds	1.000	1.000	0.9088	0.6292	0.498	0.554
6	c_b	Sugar cane, sugar beet	1.000	1.000	0.4381	1.7313	0.498	0.550
7	pfb	Plant-based fibers	1.000	1.000	0.4174	0.3419	0.897	0.993
8	ocr	Crops nec	0.964	0.943	1.1301	1.7751	0.434	0.486
9	ctl	Cattle,sheep,goats,horses	0.074	0.078	2.0091	2.0041	0.902	0.980
10	oap	Animal products nec	0.842	0.858	1.2890	0.9945	0.933	0.982
11	rmk	Raw milk	0.959	0.945	1.2890	0.9945	0.933	0.974
12	wol	Wool, silk-worm cocoons	0.995	0.994	1.1590	0.8119	0.957	0.980
13	for	Forestry	0.941	0.899	0.0275	0.0053	0.089	0.182
14	fsh	Fishing	0.380	0.423	0.9899	0.5100	0.623	0.732
15	col	Coal	1.000	1.000	0.2596	0.0424	0.004	0.005
16	oil	Oil	1.000	1.000	0.0406	0.1748	0.000	0.001
17	gas	Gas	1.000	1.000	0.1008	0.1131	0.002	0.002
18	omn	Minerals nec	0.927	0.837	0.0219	0.0489	0.013	0.018
19	cmt	Meat: cattle,sheep,goats,horse	0.965	0.978	2.7466	4.7160	0.904	0.979
20	omt	Meat products nec	0.989	0.992	0.4420	0.3441	0.903	0.974
21	vol	Vegetable oils and fats	0.991	0.992	1.2784	0.8846	0.608	0.708
22	mil	Dairy products	0.959	0.945	0.5642	1.5456	0.959	0.974
23	pcr	Processed rice	1.000	1.000	0.2533	0.4949	0.050	0.075
24	sgr	Sugar	0.999	0.997	0.0966	0.2588	0.111	0.234
25	ofd	Food products nec	0.985	0.978	1.9081	1.6742	0.796	0.851
26	b_t	Beverages and tobacco products	0.986	0.976	3.8694	1.4560	0.961	0.974
27	tex	Textiles	0.874	0.878	2.4008	2.0430	0.984	0.978
28	wap	Wearing apparel	0.713	0.765	1.4987	1.2078	1.000	0.991
29	lea	Leather products	0.679	0.641	4.4845	0.5711	1.000	0.991
30	lum	Wood products	0.982	0.976	0.1828	0.2745	0.121	0.170
31	ppp	Paper products, publishing	0.868	0.883	1.8505	0.7221	0.479	0.621
32	p_c	Petroleum, coal products	0.999	0.999	1.0357	0.2703	0.011	0.010
33	crp	Chemical,rubber,plastic prods	0.772	0.714	1.8731	0.8967	0.498	0.526
34	nmm	Mineral products nec	0.578	0.590	0.7125	0.2321	0.174	0.272
35	i_s	Ferrous metals	0.990	0.988	0.3928	0.5352	0.049	0.080
36	nfm	Metals nec	0.827	0.822	1.1775	1.6362	0.436	0.484
37	fmp	Metal products	0.826	0.795	2.4976	2.6615	0.835	0.847
38	mvh	Motor vehicles and parts	0.991	0.990	1.3196	1.3995	0.290	0.290
39	otn	Transport equipment nec	0.821	0.891	4.6186	0.8090	0.289	0.284
40	ele	Electronic equipment	0.374	0.325	8.9882	6.0094	0.810	0.862
41	ome	Machinery and equipment nec	0.647	0.605	0.3714	2.2178	0.829	0.856
42	omf	Manufactures nec	0.607	0.625	1.1592	2.8058	0.821	0.810

Table A2. OD Matrix of Container Cargo Change among All Calculated Countries under FTA6 with TAX 50% OFF in 1997(unit: TEU)

From \ To			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
						ASE						NAFTA			EU		ROW																
			jpn	chn	kor	idn	mys	phl	sgp	tha	vnm	can	usa	mex	M	E	aus	nzl	hkg	twn	inbg	lka	xsa	xcm	per	chl	xap	wsa	rus	xme	ba	xrw	
1		jpn		415,412	161,998	10,098	39,105	17,306	-10,421	95,934	6,793	-10,237	-142,911	-5,659	-23,451	-85,854	-11,592	-1,970	-14,814	-35,048	-4,172	-588	-1,550	-3,085	-653	-2,075	-730	-10,017	-1,717	-15,838	-5,988	-2,420	355,859
2		chn	231,264		92,018	9,986	13,831	15,552	3,782	19,982	11,016	-966	-9,512	-137	-2,811	-10,955	-753	-141	-4,990	-1,055	-195	71	-305	-272	-55	-161	-35	-1,154	-2,103	-1,066	-795	-1,124	358,918
3		kor	59,704	102,758		28,925	2,650	4,745	-2,361	9,198	8,346	-2,758	-27,813	-1,977	-13,096	-23,115	-3,007	-313	-5,289	-6,003	-2,575	-608	-567	-1,981	-495	-1,865	-194	-6,573	-2,235	-7,512	-3,953	-968	101,067
4	ASE	idn	29,779	12,001	4,971		5,490	2,258	544	6,140	822	-337	-5,692	-105	-2,544	-6,573	-561	-64	-515	-479	-531	-15	-290	-117	-12	-19	-10	-288	-165	-969	-191	-38	42,491
5		mys	6,456	25,510	4,453	4,812		3,590	6,190	11,856	3,612	-185	-1,998	-86	-716	-1,268	-303	-50	-851	-394	-1,878	-9	-329	-56	-9	23	-0	-165	-42	-754	-270	-155	56,984
6		phl	19,551	2,804	4,433	468	2,098		593	2,301	28	93	4,343	28	27	695	57	-34	78	32	14	3	12	62	0	29	1	-2	-14	-34	-6	6	37,666
7		sgp	4,445	24,614	6,609	3,502	25,006	5,591		21,836	7,226	-263	-6,129	-371	-1,095	-6,318	-954	-208	-5,780	-2,189	-1,862	-257	-524	-204	-9	-43	-8	-549	-263	-2,098	-846	-2,922	65,938
8		tha	69,222	17,267	5,226	2,566	8,194	-405	4,679		3,041	-832	-5,435	-27	-568	-6,321	-400	-7	-2,402	174	-248	13	-380	-66	-19	-20	-4	-80	-655	-348	-310	-16	91,838
9		vnm	13,107	529	1,485	-23	330	313	-617	-1,227		83	-883	-95	20	3,418	-244	0	-1,362	-862	-192	-0	-7	-9	-47	-8	0	-103	-243	-2	-49	-16	13,295
10	NAFTA	can	-12,793	-2,579	-907	-189	-605	-271	362	-825	-51		13,302	-20	-61	-295	20	-17	322	148	-5	1	-6	-85	-35	-7	-9	-129	-6	78	6	9	-4,649
11		usa	-22,394	-43,432	-44,844	-3,345	-10,528	-6,142	13,598	-20,330	-666	16,495		9,779	4,022	13,828	2,319	148	3,691	4,316	732	50	173	163	114	918	164	1,940	619	5,382	1,157	415	-71,658
12		mex	-4,649	-427	-449	-32	-71	-34	40	-226	-9	6	5,141		-35	-99	-2	-2	13	-39	3	-5	0	-202	-11	65	-7	-220	-6	62	-2	0	-1,197
13	EU	M	-13,831	-19,681	-3,821	-2,881	-5,343	-1,397	2,318	-6,414	-627	31	3,247	242		2,564	229	-7	62	318	247	64	92	-49	-9	235	9	-206	-522	2,698	490	521	-41,422
14		E	-23,386	-80,521	-24,280	-12,938	-21,467	-7,369	13,376	-37,447	-3,266	525	24,319	539	8,632		1,712	114	3,339	3,386	1,152	310	312	-110	-18	434	21	-208	-1,249	8,002	1,808	1,413	-142,864
15	ROW	aus	-5,526	-1,901	321	-300	-2,070	-315	1,024	-2,531	-210	165	1,221	52	442	1,139		684	1,066	-330	150	26	-39	14	4	36	1	65	52	433	267	497	-5,564
16		nzl	-2,653	-294	-480	56	-264	73	44	-382	-226	54	460	91	209	750	933		225	145	84	-2	10	54	18	12	3	82	111	147	43	147	-549
17		xoc	-427	-21,311	-179	-220	-328	-265	798	-882	-344	337	5,335	60	410	3,764	146	11		525	74	53	21	100	2	22	2	166	20	195	103	135	-11,677
18		hkg	-2,414	-52,195	-735	-1,473	-3,739	-1,768	4,926	-8,159	-2,418	1,532	21,153	753	2,424	9,525	1,254	195	2,675		425	7	82	163	114	194	48	1,354	75	394	684	146	-24,778
19		twn	-3,556	-1,649	-656	139	-1,183	-162	1,162	-1,051	-248	93	2,056	34	488	1,858	74	2	136	-139		143	160	13	3	13	1	58	135	976	344	32	-722
20		xea	-251	-13	-93	-7	-37	-2	38	-60	0	10	215	3	55	339	11	0	19	0	17		29	1	0	2	0	14	13	11	3	2	320
21		xse	-757	-1,487	-50	18	-80	-21	45	-97	-20	58	687	11	291	954	27	5	26	-121	129	26		10	4	2	1	38	16	348	92	14	170
22		inbg	-3,634	-916	-246	-43	-21	-11	64	-59	-1	98	2,707	38	265	1,182	10	1	22	2	10	-1	1		2	-25	26	100	205	21	22	13	-170
23		lka	-883	-693	-146	-5	37	-38	4	-60	-2	22	432	25	99	348	8	0	11	7	3	0	1	16		17	35	79	3	16	18	6	-637
24		xsa	-2,267	-250	-669	-60	-75	-10	33	-363	-4	38	671	92	212	613	16	3	284	214	19	4	0	31	50		55	432	8	71	14	7	-834
25		CA	-889	-107	-83	-9	-1	-1	1	-33	-1	9	339	4	102	243	6	-0	2	-4	14	0	0	6	-26	-34		72	57	37	3	2	-290
26		per	-9,577	-5,039	-5,512	170	71	-299	154	-354	-96	167	3,173	234	1,430	2,566	83	5	811	34	255	-11	108	174	59	445	261		175	981	403	54	-9,074
27		chl	-1,901	-3,023	-1,294	-110	-125	-128	79	-501	-194	48	638	19	1,879	2,328	5	2	78	35	86	3	-0	42	2	4	2	36		227	26	88	-1,648
28		WSA	-616	-915	-503	-240	-254	-190	478	-1,375	-5	-37	-41	-9	-593	-1,174	-6	-7	19	33	-95	3	-51	-10	-2	-1	-2	-84	-48		-34	0	-5,759
29		ESA	-3,066	894	-916	-161	-411	-17	303	-1,392	-20	17	457	-0	546	1,804	83	5	434	-123	311	8	25	5	1	25	1	-41	23	120		21	-1,064
30		rus	-1,602	-325	-322	-27	-232	23	303	-1,089	-5	-2	-80	50	74	105	10	-5	47	-16	164	0	10	10	0	0	0	3	4	12	7		-2,882
TOTAL			316,456	365,031	195,328	38,678	49,980	30,607	41,539	82,390	32,472	4,266	-110,600	3,573	-23,339	-93,952	-10,820	-1,650	-22,644	-37,433	-7,862	-711	-3,012	-5,382	-1,027	-1,779	-368	-15,382	-7,753	-8,410	-6,954	-4,131	797,108

Table A3. OD Matrix of Container Cargo Change among All Calculated Countries under PRO6 with TECH+50% in 1997 (unit: TEU)

		To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
						ASE						NAFTA			EU		ROW																
From			jpn	chn	kor	idn	mys	phl	sgp	tha	vnm	can	usa	mex	M	E	aus	nzl	hkg	twn	inbg	lka	xsa	xcm	per	chl	xap	wsa	rus	xme	ba	xrw	
1		jpn		356,685	22,802	2,705	2,304	3,260	938	6,170	3,618	-3,122	-67,233	-1,420	-11,431	-49,688	-1,441	-64	-6,956	-4,769	-47	-263	916	-1,541	-53	-549	-151	-3,621	-841	-12,470	-1,155	1,995	234,579
2		chn	132,259		15,419	5,066	14,710	15,945	32,566	10,226	-884	13,243	185,575	2,623	22,541	140,762	12,549	1,797	-23,618	6,584	1,029	522	-2,555	-2,852	199	3,419	223	11,020	-5,428	6,118	1,399	-4,251	596,207
3		kor	16,114	51,078		1,400	613	1,244	615	1,028	664	-382	-5,438	-282	-4,021	-6,804	55	95	861	-644	-167	-392	173	-727	-14	-227	-15	-1,187	335	-3,453	-582	320	50,259
4		idn	4,534	10,904	1,130		1,945	14	-130	780	138	36	1,961	188	-368	1,143	490	19	402	185	242	-37	-53	-61	11	-12	6	-24	-33	-821	546	126	23,260
5		mys	-1,113	21,011	596	1,846		898	13,111	2,218	546	288	4,203	192	1,457	2,216	1,033	102	874	1,807	1,643	10	687	56	19	13	1	129	40	431	254	915	55,483
6	ASE	phl	12,182	2,668	831	603	514		1,107	350	163	538	14,803	114	429	3,281	1,007	90	622	454	36	5	64	91	3	68	3	182	27	334	4	71	40,645
7	ASE	sgp	6,490	19,515	3,161	2,993	11,140	3,155		6,013	2,514	257	3,988	403	710	4,799	1,059	207	4,456	2,954	1,699	262	629	-40	5	45	22	519	287	1,216	978	2,321	81,754
8	ASE	tha	10,017	12,025	1,756	2,937	3,238	1,478	3,220		458	-15	-747	18	104	-2,149	499	49	-17	314	241	-46	39	-67	3	21	-4	-43	-121	-1,099	-259	127	31,974
9	ASE	vnm	-239	1,108	11	54	-212	186	-609	-1,517		-86	-563	-55	-359	-1,674	-203	-16	-744	-731	-114	-0	1	-3	-5	-15	0	-82	-110	-9	-13	5	-5,993
10	NAFTA	can	8,971	5,816	2,164	668	402	474	321	363	60		-9,771	7	-696	-1,818	82	41	342	324	-58	-5	1	-149	15	-39	-5	-196	-69	-303	-68	-12	6,863
11	NAFTA	usa	120,421	91,012	45,746	9,139	5,196	8,273	10,425	6,882	1,166	-10,328		-5,715	-12,913	-48,306	-1,731	-70	1,815	8,448	-1,519	-26	-145	-3,649	-205	-1,440	-493	-9,190	-1,563	-7,103	-2,180	-437	201,511
12	NAFTA	mex	3,441	421	150	65	97	48	66	64	2	401	-4,321		-162	-352	2	2	39	69	-16	1	-0	-137	12	-48	-9	-157	-9	13	-10	-7	-336
13	EU	M	9,965	26,950	10,207	3,591	3,095	1,346	3,219	3,129	1,038	996	3,392	1,315		17,561	907	221	2,907	2,073	269	73	297	522	205	266	99	2,925	3,766	1,846	1,212	913	104,306
14	EU	E	64,295	103,999	40,522	10,556	11,095	6,245	19,283	13,515	3,711	3,837	12,409	2,140	-16,948		3,163	802	8,795	11,243	-758	246	382	555	337	123	59	2,165	965	39	1,450	534	304,759
15	ROW	aus	18,113	14,639	1,145	1,223	915	621	162	318	264	-569	-3,053	-162	-2,331	-5,042		-1,480	-1,009	-112	-871	-92	-177	-64	-16	-76	-8	-248	-156	-783	-801	-959	19,390
16	ROW	nzl	3,464	2,573	1,439	195	-151	605	86	426	143	-99	-845	-169	-523	-1,694	-1,387		-193	-397	-378	-7	-27	-229	-48	-36	-8	-241	-381	-278	-89	-288	1,462
17	ROW	xoc	968	5,483	264	-30	31	9	88	55	132	-401	-6,440	-12	-308	-4,469	-66	-3		290	-64	-58	-3	-35	-1	-14	-1	-61	-6	-73	-56	-44	-4,824
18	ROW	hkg	3,152	109,363	977	-779	-981	103	-528	566	909	-2,496	-33,544	-1,087	-4,662	-17,837	-1,940	-318	-2,569		-752	-14	-126	-281	-190	-350	-85	-2,611	-138	-609	-1,199	-265	41,709
19	ROW	twn	4,488	5,891	1,197	1,841	1,665	607	1,692	1,574	246	-86	-3,227	31	-448	-2,636	-98	-16	195	268		-12	78	19	6	-38	1	-12	97	-217	-134	-3	12,968
20	ROW	xea	316	65	221	3	20	2	17	8	0	-9	-252	0	-54	-450	-8	-1	16	0	-14		-11	-0	0	-2	-0	-8	-14	-10	-2	1	-166
21	ROW	xse	263	1,900	230	89	26	52	-6	26	18	-66	-831	-1	-278	-1,211	-51	-6	21	150	-64	-33		-3	-0	-4	-1	-25	6	-150	-90	-0	-40
22	ROW	inbg	507	308	344	43	-3	0	95	27	0	354	667	83	76	763	17	4	42	4	7	18	1		34	82	32	116	134	10	43	10	3,818
23	ROW	lka	-481	1,700	43	81	451	125	4	136	8	-17	-502	-15	-111	-356	-1	-0	4	43	-0	-1	-1	-20		-40	-43	-77	-4	-15	-16	-3	894
24	ROW	xsa	2,214	467	2,110	186	164	89	160	124	6	13	-410	65	11	-40	15	4	-3	150	-23	-4	-0	-43	4		-62	-163	-12	-13	24	-3	5,028
25	ROW	CA	1,155	1,223	64	13	25	11	-3	13	1	5	-46	5	-143	-333	21	16	3	20	3	-0	-0	-2	63	23		-12	-185	-31	0	-3	1,905
26	ROW	per	12,009	8,403	2,927	1,845	1,509	795	405	1,339	85	30	-481	100	-1,589	-1,712	12	7	1,279	172	-340	11	-203	-50	167	-108	-56		-146	-401	-224	-31	25,754
27	ROW	chl	10,338	7,876	2,073	114	76	104	78	287	359	42	177	9	-468	-1,390	4	1	40	30	7	2	7	16	1	1	1	21		-22	4	-3	19,786
28	ROW	WSA	1,066	1,632	1,190	375	393	403	1,146	512	12	38	-2,535	34	61	-404	34	13	547	220	87	5	84	9	5	3	4	76	20		48	2	5,081
29	ROW	ESA	2,914	12,305	773	645	1,255	622	202	808	39	49	-597	24	-1,238	-3,110	74	11	35	302	-62	-3	10	1	1	-9	-0	62	-10	-52		5	15,057
30	ROW	rus	-2,877	21,739	-1,263	120	479	647	269	1,570	4	-30	-927	75	-489	-1,744	-80	-22	42	13	-758	-0	-83	6	0	-2	0	-11	-36	-8	-8		16,626
TOTAL			444,947	898,761	158,230	47,588	60,014	47,362	87,998	57,010	15,419	2,419	85,414	-1,495	-34,153	17,303	14,019	1,482	-11,771	29,464	-743	162	-17	-8,678	560	1,056	-490	-755	-3,582	-17,916	-924	1,033	1,889,716

Table A4. OD Matrix of Container Cargo Change among All Calculated Countries under FTA6 with TAX50% OFF in 2001 (unit: TEU)

From \ To			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	TOTAL
						ASE						NAFTA			EU		ROW																		
			jpn	chn	kor	idn	mys	phl	sgp	tha	vnm	can	usa	mex	M	E	aus	nzl	xoc	hkg	twn	xea	xse	inbg	lka	xsa	CA	per	chl	WSA	ESA	rus	ME	BA	
1		jpn		220,020	52,565	7,257	16,945	4,430	-3,499	34,682	5,900	-4,726	-64,694	-2,489	-9,450	-36,286	-4,078	-666	-279	-4,923	-14,771	-502	376	-1,759	-178	-414	-3,131	-177	-346	-180	-3,146	-543	-6,108	-2,297	177,534
2		chn	273,642		446,713	9,228	13,494	9,169	2,075	17,257	10,391	-494	-2,245	31	-3,126	-5,867	-288	-72	1	-3,750	-154	-2,142	2,480	-1,028	-124	-38	136	-21	-49	-29	-390	-1,271	-928	-70	762,530
3		kor	24,125	149,563		5,965	3,572	4,035	-1,139	7,115	11,576	-1,892	-20,572	-1,562	-8,031	-12,237	-1,401	-145	-643	-2,420	-2,960	-189	940	-2,069	-393	-447	-3,637	-173	-412	-160	-2,225	-606	-5,211	-3,472	134,892
4	ASE	idn	7,270	31,314	4,546		3,161	536	-132	6,558	2,731	-575	-11,361	-360	-3,702	-11,941	-957	-170	-186	-756	-1,262	-25	191	-8,668	-99	-234	-393	-30	-95	-27	-399	-117	-2,032	-1,032	11,754
5	ASE	mys	-6,526	24,358	6,923	1,542		1,259	1,956	9,778	3,407	-125	-2,598	-134	-1,339	-3,765	-408	-66	-14	-708	-1,908	-25	664	-10,882	4	-681	-67	0	-26	-5	-141	-70	-1,536	-892	17,978
6	ASE	phl	3,095	5,088	1,272	340	1,219		37	2,197	486	-81	-692	-29	-167	-1,122	-47	-13	-14	-186	-158	-1	29	-11	1	-2	-2	-2	-6	-1	-27	-36	-115	-16	11,038
7	ASE	sgp	3,773	23,135	3,051	763	5,336	999		8,064	6,656	-287	-4,698	-338	-1,144	-6,533	-1,059	-186	-161	-1,420	-1,302	-175	557	-2,049	-283	-417	-168	-11	-34	-9	-345	-101	-1,410	-818	29,388
8	ASE	tha	30,349	32,338	8,192	598	3,710	1,167	-844		3,163	-1,108	-15,623	-235	-2,491	-20,035	-797	-156	-100	-2,761	-2,058	-277	4,657	-956	-250	-403	-349	-17	-61	-9	-427	-369	-2,294	-1,370	31,184
9	ASE	vnm	7,896	6,132	1,661	11	214	376	-74	2,433		-45	-2,106	-7	-8	513	-186	-52	-3	-895	-220	-24	-1	-66	18	-14	-93	-3	11	-1	-65	-673	-53	-107	14,569
10	NAFTA	can	-4,019	-6,440	-2,535	25	-237	-425	200	-752	-143		6,372	-140	-89	-293	-7	-11	1	289	201	2	-10	12	1	10	-14	-66	-26	-8	-203	-32	-114	-9	-8,460
11	NAFTA	usa	-26,384	-35,103	-171,578	2,910	-4,534	-2,991	6,686	-10,345	-1,375	7,605		6,494	4,507	5,354	823	60	65	2,548	473	12	-378	372	32	-36	1,148	-108	67	51	168	-177	1,961	1,228	-210,445
12	NAFTA	mex	-3,061	-913	-361	-30	-93	-35	71	-201	59	28	2,520		-50	-151	2	0	0	13	-13	-2	-6	5	0	0	-146	-11	-29	-11	-121	-8	4	-2	-2,543
13	EU	M	-19,658	-14,771	-6,047	-939	-1,682	-537	1,163	-3,564	-1,628	343	5,136	277		9,138	266	25	53	821	-169	4	-188	161	36	-7	938	6	34	7	232	-634	1,096	570	-29,517
14	EU	E	-14,272	-54,524	-14,768	-2,758	-8,093	-2,186	5,487	-15,331	-4,768	716	15,686	490	368		922	109	362	1,907	1,298	58	-792	819	139	83	1,656	-89	53	21	227	-1,343	1,782	1,946	-84,794
15	ROW	aus	-5,591	948	-5,248	-630	-141	-364	1,832	-3,479	-292	156	936	66	498	875		444	96	388	-213	1	-77	316	69	-46	28	-4	5	1	17	30	940	205	-8,231
16	ROW	nzl	645	-10	1,084	10	40	352	214	-1,025	-145	28	296	35	119	452	369		23	103	265	0	-66	291	-2	-1	23	1	1	0	14	1	66	14	3,199
17	ROW	xoc	492	1,566	131	85	-55	161	27	-749	-2	9	67	11	27	114	99	6		20	241	0	-0	53	0	0	3	0	0	0	2	1	3	3	2,317
18	ROW	hkg	-387	-15,916	-261	-115	-270	-149	113	-348	-695	32	677	16	9	163	6	0	3		-125	-2	-147	9	8	1	8	0	-0	0	4	0	13	3	-17,347
19	ROW	twn	3,103	-38,341	-952	-1,376	-1,934	-1,071	1,645	-4,877	-8,457	827	11,083	461	1,218	4,448	580	82	79	1,941		173	-1,259	567	257	103	562	42	91	43	469	72	957	466	-28,997
20	ROW	xea	-610	-1,035	-27	-3	-7	-3	9	-92	-129	25	489	28	44	291	3	1	0	24	-1		-2	16	0	1	18	0	1	1	19	7	17	5	-908
21	ROW	xse	-60	4,670	240	211	1,080	25	1,482	-2,313	7	116	3,376	13	241	1,908	18	4	2	80	787	0		3,282	1	3	28	0	1	0	11	4	28	10	15,256
22	ROW	inbg	-2,326	-3,571	-1,690	-335	-1,056	-405	513	-1,806	-539	144	2,281	54	543	1,967	65	6	11	354	7	5	-188		226	25	53	4	7	2	82	82	856	401	-4,226
23	ROW	lka	-145	-52	-65	-13	-26	-3	17	-28	-19	8	408	5	22	112	-0	0	0	4	1	0	-2	20		14	5	-0	0	-0	2	5	29	2	300
24	ROW	xsa	-644	-2,612	-680	-5	-108	-27	49	-297	-148	83	1,087	27	329	911	25	5	3	91	-89	2	-31	809	43		33	2	11	1	35	13	797	128	-155
25	ROW	CA	-838	-802	-1,312	-112	-103	-50	82	-212	-80	77	1,027	-36	51	136	8	-1	2	37	-8	5	-20	65	1	1		-1	-0	4	-6	26	21	23	-2,014
26	ROW	per	-188	-319	-86	4	-5	-2	7	-157	-14	10	181	14	34	109	2	-0	-0	7	2	0	-1	2	0	0	14		10	19	41	0	7	2	-307
27	ROW	chl	-611	-1,613	-504	-1	-43	-13	172	-210	-37	22	632	219	176	491	8	1	1	105	118	0	-4	53	6	0	41	21		39	204	2	60	8	-655
28	ROW	WSA	-264	-57	-17	-3	-0	-1	7	-12	-1	3	109	4	39	75	1	1	-1	2	0	0	-0	47	0	-0	2	-17	-3		-51	11	8	2	-117
29	ROW	ESA	-3,844	-3,866	-138,571	-10	9,237	-288	768	-1,873	-258	163	3,897	297	3,914	2,856	64	5	3	1,080	-13	1,112	-19	1,209	76	2	364	-165	-70	140		217	3,247	511	-119,814
30	ROW	rus	5,940	1,891	-376	-47	-142	-24	179	-471	-430	34	1,024	17	2,062	2,756	6	2	3	30	104	25	-26	161	5	22	173	6	2	5	87		422	42	13,485
31	ROW	ME	137	-6,900	-813	-393	-381	-224	586	-1,957	-120	12	978	9	-198	179	39	9	1	122	137	-13	-31	119	31	-46	9	-0	1	-0	4	-7		72	-8,640
32	ROW	BA	-3,262	6,419	-3,372	-79	185	-121	447	-2,464	48	34	639	35	851	2,091	62	6	5	467	198	3	-7	2,223	12	-26	13	-2	4	-0	-10	18	233		4,648
TOTAL			267,777	320,597	177,116	22,101	39,286	13,592	20,137	35,523	25,144	1,144	-65,688	3,272	-14,743	-63,290	-5,860	-770	-686	-7,384	-21,592	-1,969	6,638	-16,878	-361	-2,545	-2,744	-816	-857	-104	-5,937	-5,498	-7,254	-4,446	702,904

Table A5. OD Matrix of Container Cargo Change among All Calculated Countries under PRO6 with TECH+50% in 2001 (unit: TEU)

		To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	TOTAL
						ASE						NAFTA			EU		ROW																			
From			jpn	chn	kor	idn	mys	phl	sgp	tha	vnm	can	usa	mex	M	E	aus	nzl	xoc	hkg	twn	xea	xse	inbg	lka	xsa	CA	per	chl	WSA	ESA	rus	ME	BA	
1		jpn		102,965	54,961	11,483	14,107	8,858	17,327	22,562	3,550	1,646	7,302	3,333	3,686	11,368	2,944	716	622	7,375	16,221	2,252	470	1,901	227	452	1,216	201	556	143	1,235	296	5,691	2,760	308,426
2		chn	308,751		61,496	14,145	27,575	6,563	8,605	6,691	5,443	8,817	119,972	1,707	12,854	30,929	4,514	592	73	37,443	4,138	351	1,851	1,323	106	607	1,016	273	494	259	1,046	3,030	6,785	3,085	680,536
3		kor	55,202	92,308		9,036	4,067	4,545	2,983	4,597	6,496	1,173	10,003	2,354	599	3,254	2,011	606	-53	3,420	3,702	116	1,360	2,098	544	798	36	343	510	221	1,617	1,447	5,832	13	221,238
4	ASE	idn	37,163	26,761	26,640		15,554	4,063	8,153	409	1,789	-175	-8,987	192	242	1,477	-208	254	-256	-986	1,538	-26	595	-9,023	-12	-135	-535	23	-39	56	316	-114	1,704	1,613	108,047
5	ASE	mys	104,194	61,055	21,055	7,988		5,061	30,716	9,237	8,741	651	11,037	242	8,453	16,815	2,388	506	153	1,820	-10,144	173	3,123	-19,900	524	1,988	285	66	112	32	611	200	3,925	3,430	274,538
6	ASE	phl	8,923	-206	1,173	671	1,008		325	374	163	-81	166	-58	-683	-3,381	38	-13	5	-414	347	-6	44	271	-2	-20	-94	-13	-10	-3	-150	-215	-614	-6	7,539
7	ASE	sgp	8,567	19,280	3,978	10,170	19,857	5,078		5,501	6,870	125	549	204	312	1,090	1,595	379	587	1,867	3,460	187	4,368	2,634	715	802	-81	30	100	10	341	326	3,548	3,205	105,653
8	ASE	tha	16,319	13,714	4,357	3,635	7,067	1,958	4,308		3,232	-645	-7,983	-108	-1,098	-15,717	494	119	-44	-2,522	760	-176	5,575	1,242	-4	-233	-127	-3	70	5	-187	-481	-1,440	472	32,557
9	ASE	vnm	2,412	3,237	87	218	68	421	34	-578		-689	-6,382	-188	-1,509	-8,674	-701	-112	-12	-2,496	-560	-66	-3	-90	-18	-33	-98	-15	-46	-9	-235	-1,609	-296	-173	-18,112
10	NAFTA	can	4,030	20,416	3,735	1,615	940	579	260	449	184		-15,144	80	-817	-1,724	84	48	2	-283	-14	4	5	-313	-4	-22	-189	169	-4	-24	-293	-57	-525	-176	13,011
11	NAFTA	usa	-9,320	68,779	42,613	28,691	4,762	9,024	8,927	5,742	3,078	-13,143		-8,140	-17,154	-31,246	-1,732	-131	247	-1,975	1,939	-0	260	-1,729	-104	-404	-5,149	137	-579	-453	-6,947	-1,585	-7,641	-2,147	64,620
12	NAFTA	mex	4,726	754	425	40	67	63	86	42	626	56	-7,316		-261	-796	-16	4	-5	-50	17	10	3	-20	-1	-9	-529	-61	-96	-64	-528	-13	-68	-21	-2,938
13	EU	M	18,214	24,831	8,741	1,884	1,414	1,752	1,441	1,957	851	128	-3,384	604		5,714	96	87	25	-2,787	19	35	107	-254	-71	1	818	15	77	-32	382	-208	-3,761	-985	57,708
14	EU	E	65,863	136,420	21,990	6,443	6,311	3,034	9,479	7,997	1,530	2,808	13,015	1,617	-3,685		1,263	339	375	-2,120	426	211	161	-1,173	-196	-298	1,883	261	7	-41	964	281	-2,144	-1,728	271,292
15	ROW	aus	6,770	25,564	709	789	2,498	1,793	267	-1,338	704	-552	-3,029	-219	-4,186	-4,888		-1,182	-581	-1,488	-1,824	-23	21	-2,335	-117	-437	-115	-49	-50	-9	-435	-168	-6,018	-1,287	8,785
16	ROW	nzl	-15,067	16,215	-16,345	1,052	1,057	8,543	-50	391	1,353	-204	-1,774	-235	-982	-3,135	-1,402		-309	-502	-356	-4	-47	-194	-6	-78	-253	-28	-18	-7	-237	-29	-689	-115	-13,455
17	ROW	xoc	-3,430	28,300	527	598	175	3,231	10	-3	0	-35	39	-12	-128	-366	226	-58		-116	-594	-0	-0	-635	-0	-1	-5	-0	-0	-0	-7	-4	-9	-7	27,694
18	ROW	hkg	770	27,324	261	194	78	340	99	226	271	-239	-3,187	-66	-244	-2,491	-36	-5	-23		-206	-41	170	-116	-55	-10	-36	-1	-2	-1	-42	-15	-77	-61	22,781
19	ROW	twn	13,768	34,266	2,327	2,043	1,745	2,007	1,672	2,839	1,570	-955	-13,160	-530	-1,945	-6,827	-715	-99	-79	-5,005		-339	1,120	-1,004	-444	-186	-566	-61	-138	-70	-697	-130	-1,661	-735	28,012
20	ROW	xea	915	2,617	24	1	4	19	8	32	49	-13	170	-48	-95	-385	-3	-2	-0	-88	-21		-1	-32	-0	-1	-17	-1	-3	-3	-31	-12	-29	-15	3,039
21	ROW	xse	2,345	32,049	394	1,570	7,915	56	7,424	38,620	-2	115	3,418	4	1,249	4,295	16	6	1	130	2,144	-0		17,650	3	133	30	-0	-1	-0	-7	-12	-199	18	119,364
22	ROW	inbg	2,286	4,270	2,557	2,721	2,092	1,187	922	921	566	78	362	41	-879	-1,504	53	26	-6	-884	-17	1	91		-353	-90	46	-2	19	-2	-49	-57	-974	-579	12,844
23	ROW	lka	983	189	681	21	55	5	38	18	14	-46	-1,419	-11	-217	-1,259	-9	-3	-1	-9	-3	-0	2	-53		-105	-18	-1	-0	-2	-13	-19	-146	-32	-1,361
24	ROW	xsa	406	2,352	1,205	530	209	158	46	97	77	-11	-129	-9	-345	-569	22	3	-3	-207	1	1	32	-913	-35		-18	-2	-12	-1	-36	-5	231	-141	2,933
25	ROW	CA	573	1,184	365	643	84	87	-35	32	29	141	1,716	57	-415	-900	14	7	2	-41	62	5	-1	140	-1	-5		3	-2	-34	-207	-18	-66	-53	3,367
26	ROW	per	624	1,417	16	208	27	162	-1	238	59	-23	-428	-28	-183	-417	-0	1	-1	-32	-26	-1	1	-8	-0	-1	-31		-48	-109	-156	-5	-24	-7	1,222
27	ROW	chl	5,684	5,408	1,354	205	305	19	114	329	25	81	-310	-283	-1,278	-1,033	4	4	-1	-277	-136	-1	3	-45	-10	-1	-120	16		-108	-263	-10	-205	-20	9,450
28	ROW	WSA	175	110	5	24	3	11	7	9	2	11	568	13	81	208	5	30	2	0	2	1	1	91	0	0	20	105	63		367	-27	-4	1	1,886
29	ROW	ESA	7,536	14,392	12,260	1,346	19,060	2,318	740	1,834	542	33	-3,172	381	-2,634	-1,056	-36	13	-1	206	67	1,158	14	-3,157	55	-107	135	1,770	1,638	-174		372	-1,121	-797	53,616
30	ROW	rus	-49,849	127,350	-692	268	-0	59	178	350	153	16	47	7	-2,513	-11,166	55	3	3	-66	-192	39	1	-96	-7	-32	29	-8	0	-3	-34		-328	-47	63,525
31	ROW	ME	2,093	9,147	2,027	765	955	587	1,350	1,089	373	142	2,681	80	550	1,779	60	12	3	-458	-206	47	46	-924	-52	28	70	4	11	2	81	33		-258	22,116
32	ROW	BA	4,465	235,062	3,009	2,205	2,992	488	-298	13	428	-86	-72	-52	-11,018	-11,975	140	33	13	-743	523	20	16	1,973	-18	29	-44	10	9	10	-7	-48	-969		226,107
TOTAL			606,091	1,137,529	261,934	111,204	142,051	72,069	105,134	110,676	48,767	-875	95,169	928	-24,244	-32,581	11,167	2,184	735	28,713	21,068	3,926	19,390	-12,688	665	2,630	-2,439	3,181	2,614	-412	-3,600	1,145	-1,294	5,206	2,716,041