Transportation Working Group Meeting

Asia-Pacific
Economic Cooperation

/TPTWG/MEG
Agenda Item:

Impacts of Trade and Transport Policy on International Cargo Shipping and Economic Activities

Purpose: Consideration

Submitted by: Japan

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1. INTRODUCTION

1.1 Background and Objective of the Study

Trade liberalization and efficient transport are the most important factors for the regional development of the APEC economies. This was also emphasized in the Joint Transport Ministerial Statement of the 6th APEC Transportation Ministerial Meeting in Manila, 2009, which stated, for example, "In an environment of continued economic challenges, we reaffirm our commitment to achieve greater liberalization of the transportation sector. In this regard, we support APEC's work to strengthen Regional Economic Integration (REI) in the APEC region through promoting free and open trade and investment" (A. Liberalization and Facilitation of Transport Services, paragraph 10), and "We support the Working Group's initiatives to enhance seamless interconnectivity among the various modes within the transportation system to ensure effective, safe, secure and efficient movement of people and goods while improving the conservation of natural resources and mitigating environmental impacts. This includes efforts to address congestion and intermodal issues" (B. Seamless Transportation Systems, paragraph 16).

When discussing a roadmap for realizing trade liberalization and efficient transport, a comprehension of the "quantitative effects" of the related policies could be highly supportive and suggestive for discussion of the issues mentioned above. For example, a knowledge of the economic growth that may be expected as a result of trade liberalization would motivate each economy to further facilitate related trade and international economic policies. Similarly, a knowledge of the amount of reduction in transport costs that may be realized by investing in transport infrastructure and removing cross-border barriers would motivate each economy to further implement related transport policies.

However, until now, virtually no studies have succeeded in providing a worldwide quantitative projection of transportation flow (namely, international cargo flow) or in connecting trade volume forecasts with projections of transportation flow.

Therefore, this study will develop a successive prediction system for trade value and international cargo flow ("Trade and Logistics Forecasting System for the APEC Region") in order to support discussions aimed at realizing trade liberalization and efficient transport among the APEC economies. This forecasting system also provides an effective tool for quantifying the impacts of trade and transport policy on international cargo shipping and the economic activities of individual economies, as well as the mutual development of the entire APEC region. By collaborating with a system development group and preparing additional data as necessary, it will be possible for each member economy to use the system, in whole or in part, for analyses of its own economic interests, as well as impacts on the entire APEC region.

This system can
- forecast the future trade values and international cargo flows of each economy, and
- simulate policy impacts by quantifying changes in model output corresponding to the implementation of a wide range of trade- and infrastructure-related policy decisions.

The details of the inputs and outputs for each model are explained in the next chapter and thereafter. Examples of the policies for which impacts can be measured by this system include:

1) Trade Policy
For example, the output of this system can answer questions regarding the impacts on international cargo volumes and the economic activities of the APEC region which can be expected by trade liberalization and facilitation toward the Bogor Goal, including bilateral and multilateral negotiations on Free Trade Agreements (FTA), Economic Partnership Agreements (EPA), and Trans-Pacific Partnership (TPP).

2) Transport Infrastructure Investment and Cost Reduction Policy
This system can also answer questions regarding the impacts on international cargo flow patterns, transport costs, and the economic activities of the APEC region which can be expected as a result of implementing transport policies such as

- construction of new terminals and berths in ports
- smoothing transactions and shortening lead-time at terminals
- discounting charges and fares, and
- removing cross-border barriers.

3) Risk Management of International Shipping
The system also makes it possible to analyze the potential impact of security threats on the international shipping market and economic activity in the APEC region, for example, the impacts that can be expected if a sea route such as the Straits of Malacca cannot be used for security-related reasons.

1.2 Methodology

The overall structure of the trade and logistics forecasting system is shown in Figure 1. The system consists mainly of three steps, a trade forecasting model, conversion of the estimated trade value obtained with the trade forecasting model into cargo shipping demand, and an international cargo flow model.

In the first step, that is, the trade forecasting model, the bilateral trade value for each member economy and its partner is estimated by inputting economic variables such as the target economic growth rate and trade-related policies. Next, the estimated bilateral trade value is converted into cargo shipping demand between regions, in which individual economies and other countries are subdivided into several smaller areas (“zones”) using various databases on the worldwide and local economics and transportation after processing. The third step is application of the international cargo flow model by inputting the cargo shipping demand on a regional basis, as estimated above, and various policies related to international cargo shipping. In this step, maritime and land cargo flows are estimated by route or for each port, and shipping costs are also estimated. The effects of proposed policies can be quantified by calculating the difference in the estimated cargo flow and shipping cost for cases with and without implementation of those policies.

Chapters 2-4 present a rough description of the model and its procedure, including a summary of the system inputs and outputs. Examples of policy simulation are also provided for each step. The details of each model and input variable are described in the Annexes at the end of this report. Finally, the conclusions of this study and a discussion of the future application of the system are presented in Chapter 5.

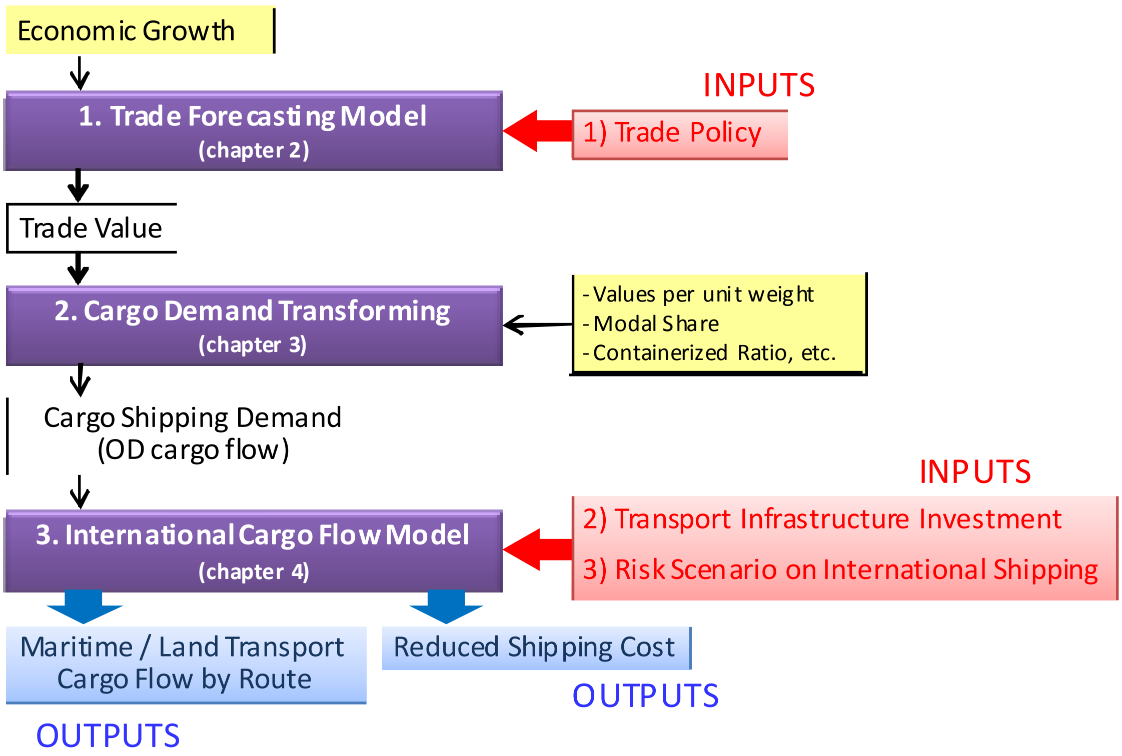

Figure 1 Overall structure of trade and logistics forecasting system

2. TRADE VALUE FORECASTING

2.1 Model

As the trade forecasting model, a GTAP (Global Trade Analysis Project) model is used with minor modifications by the authors. The GTAP model, which was developed by Hertel et al. at Purdue University in the United States, is a typical CGE (computable general equilibrium) model based on microeconomic theory, in which the behaviors of all economic bodies are simultaneously considered to reach equilibriums based on balances of supply and demand. The model has been used frequently in intergovernmental cooperation, as exemplified by the evaluation the effect of the Manila Action Plan by APEC (1994) and the evaluation of the effect of the Uruguay Round by GATT.

The details of the GTAP model can be found in Hertel (1997) and several supplements published by the development group, which can be downloaded from the official website (https://www.gtap.agecon.purdue.edu/). In the model, prices and quantities are simultaneously determined in factor markets and commodity markets by accounting relationships, the equilibrium conditions specified by the behavior of economic agents, and the structure of international trade. The model includes five factors of production: skilled labor, unskilled labor, capital, land, and natural resources. (For a more detail description of the model, see Annex A1.)

The RunGTAP software (ver.3.21) used to operate the actual GTAP model can also be downloaded from the above-mentioned website free of charge, although a charge is imposed when one would like to process databases. The user can input a change in an economic variable as a "shock" to the model by giving this change as a shock file or writing directly into a command space. For future forecasting using the GTAP model, the program provides a preset command for performing simulation calculations based on a new dataset ("Use updated database from last simulation"), instead of the use of the prepared database. Future forecasting can be performed by continuous use of this command to apply new shocks to changes for each coefficient.

2.2 Input, Output, and Policy Variables

The major input and output variables are summarized in Table 1. When forecasting future trade value, what data are input is significant because the results will be very different. In this study, in addition to a "baseline" scenario in which the input economic data are set based on past trends, three future scenarios (high, middle and low cases) of future economic development are defined, as defined in Table 2. These are based on the results of a questionnaire survey of experts in Japan. In these scenarios, several endogenous parameters are set for each economy, reflecting the results of the survey and considering acquisition of results with a wide range of variations among scenarios within the range of convergent solutions.

Table 1 Major inputs and outputs of the trade model

Input (external variables)		Output (internal variables)
demography	population	GDP
	number of labors	trade amount (total, bilateral)
	share of skilled labor	commodity outputs
economic variables	capital accumulation	
	natural resource output	
	total factor productivity	
	GDP*	
trade policy	tariff rate (average, bilatelal)	
	export tax (export subsidies)	
	non-tariff barrier	
	international shipping cost	

*If GDP is exgeneously input, total factor productivity should be internally decided in the model.

Table 2 Four economic scenarios prepared as model input

Scenario	Description
High case	High growth rate of economic indices (population, capital stock, natural resource output, technological advancement) and large reduction rate of tariffs (both in average and bilateral), including elimination of tariffs within the APEC region.
Middle case	Moderate growth rate of economic indices and reduction of tariffs.
Low case	Low growth rate of economic indices and reduction of tariffs.
Baseline	Growth rate of economic indices is based on the past trend, and no additional tariff reduction is assumed.

2.3 Example of Simulation: Future Forecast until 2025 by Economic Scenario

In this study, as an example of a simulation of trade value forecasting, the basic GTAP model (ver.6.2) and the dataset for 2004 (ver.7) are used. With a view to future application to the estimated results of the international cargo flow model, the regional classification uses the 40 regions (including 21 APEC economies) listed in Table 3, and the classification of commodities (sectors) uses the 6 categories listed in Table 4.

As the periods of future forecasts used in this simulation, the actual and estimated trade value in 2008 are first compared, and the trade value is then forecast for 5 year intervals (2015, 2020, 2025). The detailed setting of the input variables for each economic scenario is described in Annex A2.

The estimated results of the future trade value worldwide and in the APEC region (total for 21 economies) are shown in Figure 2. In the figure for total world trade, the actual amounts are shown within the range of available years. The actual amount exceeds the estimated amount. The reason for this is partly because the years up to the financial crisis in 2008 can be interpreted as a time of imbalance as part of a global economic bubble.

As shown in the figure, estimated world trade (indexed to the estimated value for 2008 as 100) is 165 in 2025 for the baseline scenario, and 243, 203, and 148 for the high, middle, and low case scenarios, respectively. For the same scenarios, trade in the entire APEC region is 189, 287, 232, and 165. That is to say, the expected growth in trade in the APEC region is potentially higher than the world average under every economic scenario. If converted using the annual rate of growth in 2008 for the entire APEC region, these numbers represent growth of 3.8% for the baseline scenario, and 6.4%, 5.1%, and 3.0% for the high, middle, and low case scenarios. Looking at the growth rate by time period (annualized rate), from 2008 to 2015, the growth rate under the respective scenarios is 3.5%, 6.6%, 4.7%, and 2.6%, while that from 2020 to 2025 is 4.3%, 6.6%, 6.5%, and 3.7%. This indicates an overall rising trend in the rate of growth with each passing year.

Figure 3 shows the estimated trade value in the APEC region by import and export. The expected growth rate of exports surpasses that of imports in every scenario, particularly in the high case scenario. Figure 4 also shows the estimated results of future GDP (actual values in 2004 prices) worldwide and in the entire APEC region. The growth rate of GDP in the APEC region is also higher than the world average rate for each scenario, although the difference in APEC and world GDP growth is very small compared with the growth rate of trade.

This simulation model can also output the above variables for individual economies. The results and findings are shown in Annex A3.

Table 3 Regional classification used in the example simulation

No.	abb.	Economy / Region	No.	abb.	Economy / Region
1	jpn	Japan#	21	xsa	Rest of South Asia
2	kor	Republic of Korea#	22	rus	Russian Federation#
3	prc	China#	23	kaz	Kazakhstan
4	hkg	Hong Kong, China#	24	kgz	Kyrgyztan
5	tpe	Chinese Taipei#	25	xsu	Rest of Former Soviet Union
6	xea	Rest of East Asia	26	usa	United States#
7	phl	Philippines#	27	can	Canada#
8	vnm	Vietnam#	28	mex	Mexico#
9	lao	Lao PDR	29	xcm	Central America
10	khm	Cambodia	30	per	Peru#
11	tha	Thailand#	31	chl	Chile#
12	mys	Malaysia#	32	xap	South America West Coast
13	sgp	Singapore#	33	sae	South America East Coast
14	mmr	Myanmar	34	xme	Rest of Middle East
15	idn	Indonesia#	35	med	Mediterranean
16	xse	Rest of Southeast Asia (incl. Brunei Darussalam#)	36	eur	Europe
			37	afr	Africa
17	bgd	Bangladesh	38	aus	Australia#
18	ind	India	39	nzl	New Zealand#
19	lka	Sri Lanka	40	xoc	Rest of Oceania (incl. Papua New Guinea#)
20	pak	Pakistan			

APEC member economies

Table 4 Commodity classification used in the example simulation

No.	Commodities (Sectors)	Type
1	Agriculture	Traded goods
2	Mining	
3	Household Consumption Products	
4	Basic Industrial Materials	
5	Processing and Assembling	
6	Others (Services, Transport, etc.)	Non-traded goods

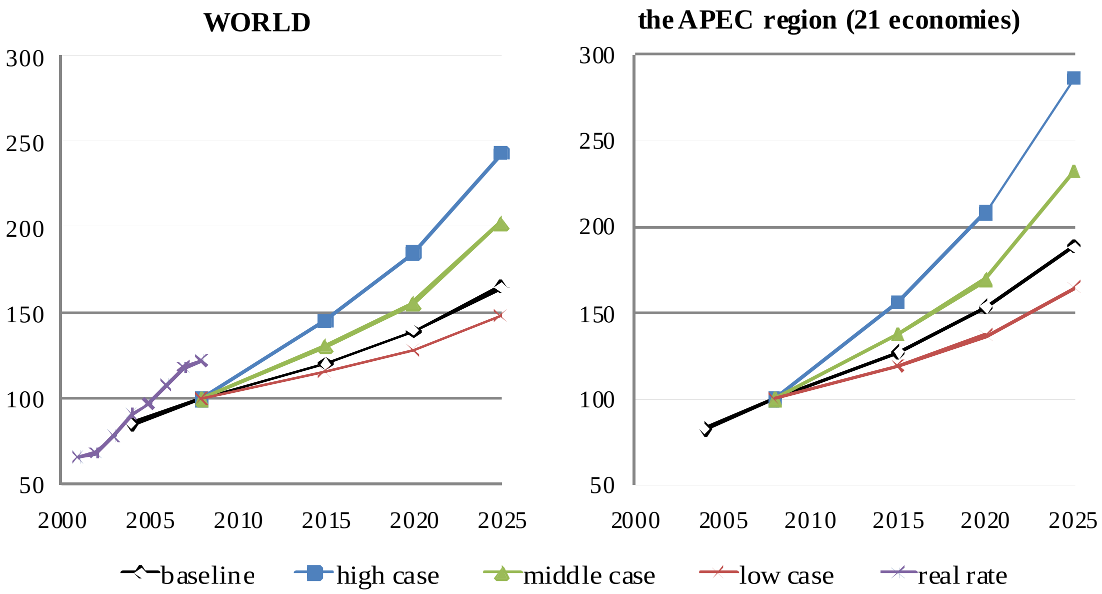

Figure 2. <u>Estimated trade value</u> worldwide and in the APEC region by economic scenario (indexed to 2008 estimated results as 100)

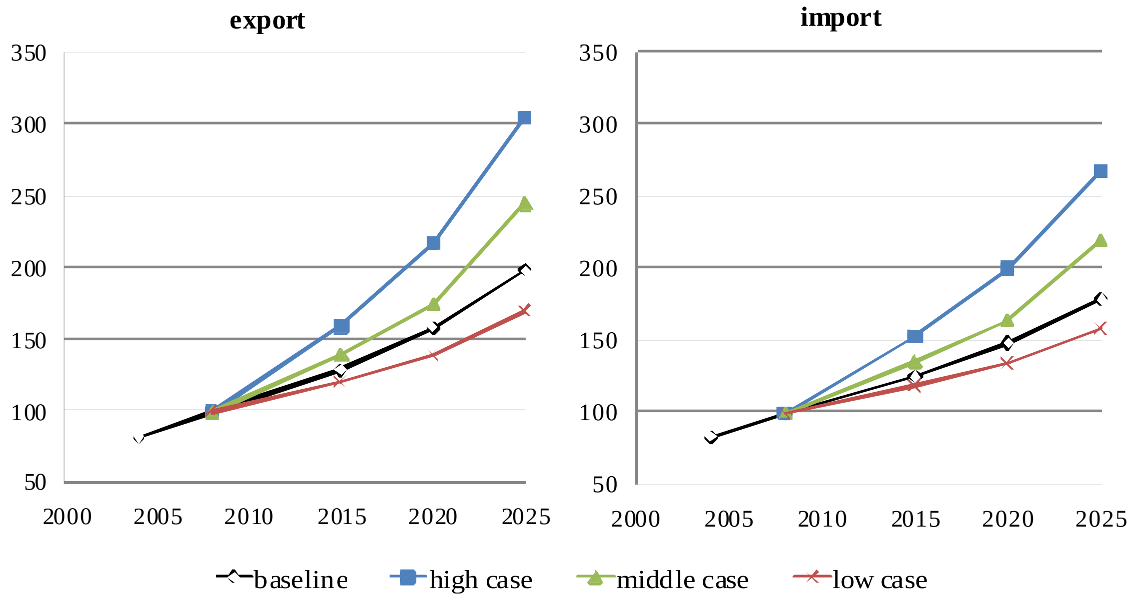

Figure 3. Estimated export and import trade value in the APEC region by economic scenario (2008 estimated results = 100)

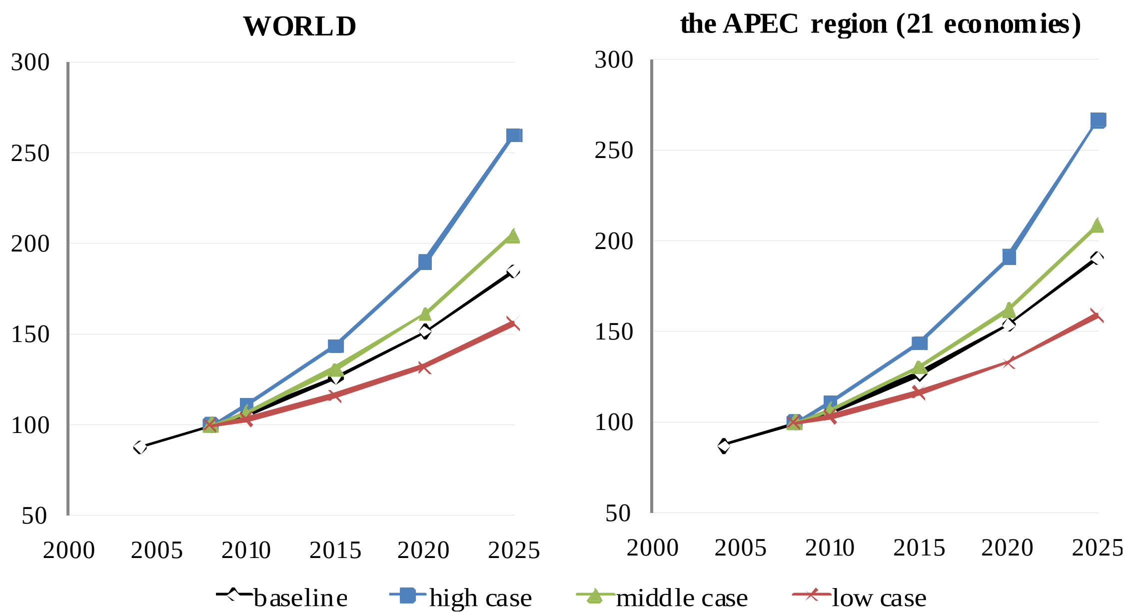

Figure 4. Estimated GDP worldwide and in the APEC region by economic scenario (2008 estimated results = 100)

3. CARGO SHIPPING DEMAND FORECASTING

3.1 Data Conversion Procedure

Based on the bilateral trade value estimated as described in the previous chapter, future volumes of international maritime container cargo are estimated on a zone basis (obtained by dividing an economy into multiple zones) by the conversion procedure shown in Figure 5 and Annex B1. Conversion is performed using various global databases such as Global Insight (GI) and Global Trade Atlas (GTA) and local databases. A summary of the mode share, unit price, containerized ratio, and TEU conversion ratio by type of commodity is shown in Annex B2 for each economy.

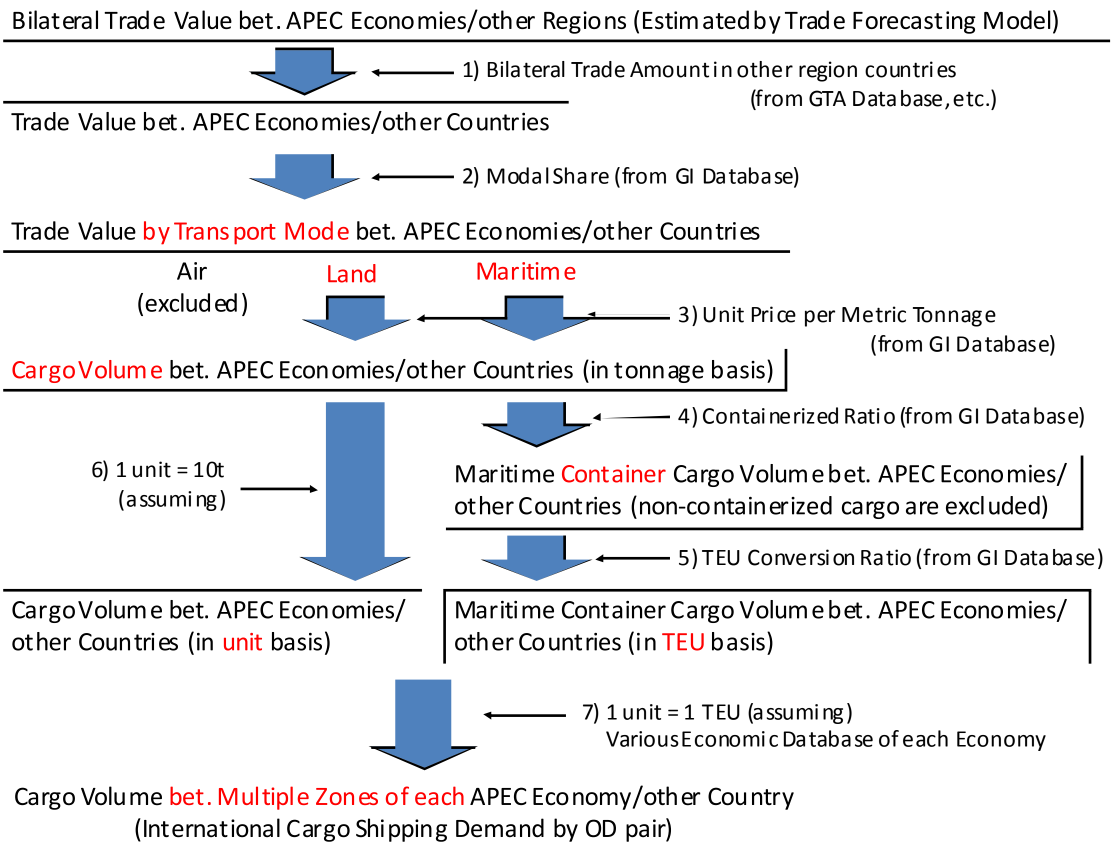

Figure 5 Flowchart of process of data conversion from bilateral trade into international cargo shipping demand by multiple zones

3.2 Input and Output Variables

The major input and output variables of the conversion process are summarized in Table 5.

Table 5 Major inputs and outputs of the international cargo shipping demand estimation

Input		Output
output of the trade model	bilateral trade amount (USD)	cargo shipping demand
indices for international cargo shipping	modal share (maritime, air, land)	
	unit price (USD/ton)	
	containerized ratio	
	conversion rate (TEU/ton)	
	regional economic indices of each economy (GRDP etc.)	

3.3 Example of Simulation: Future Cargo Shipping Demand for Estimated Future Trade Value by Scenario

Based on the forecasts of future trade value, cargo shipping demand between zones can be also estimated for each scenario and each projection year.

The estimated results of future shipping demand for international maritime container cargo worldwide and for the entire APEC region are shown in Figure 6. Compared with the estimated future trade value in Figure 2, the expected growth rates of shipping demand for international cargo (i.e., sum of maritime container cargo and land cargo) surpass the expected growth rates for trade value, both worldwide and in the entire APEC region. Furthermore, the growth rate in the APEC region is larger than the world growth rate.

Figure 7 shows the estimated shipping demand for international maritime container cargo in the APEC region by import and export. As in the estimation of trade value, the expected growth rate of exports surpasses the growth rate of imports in every scenario, especially in the high case scenario.

The estimated results of international cargo shipping demand for each economy by future economic scenario and those for each zone in the middle case scenario are shown in Annex B3.

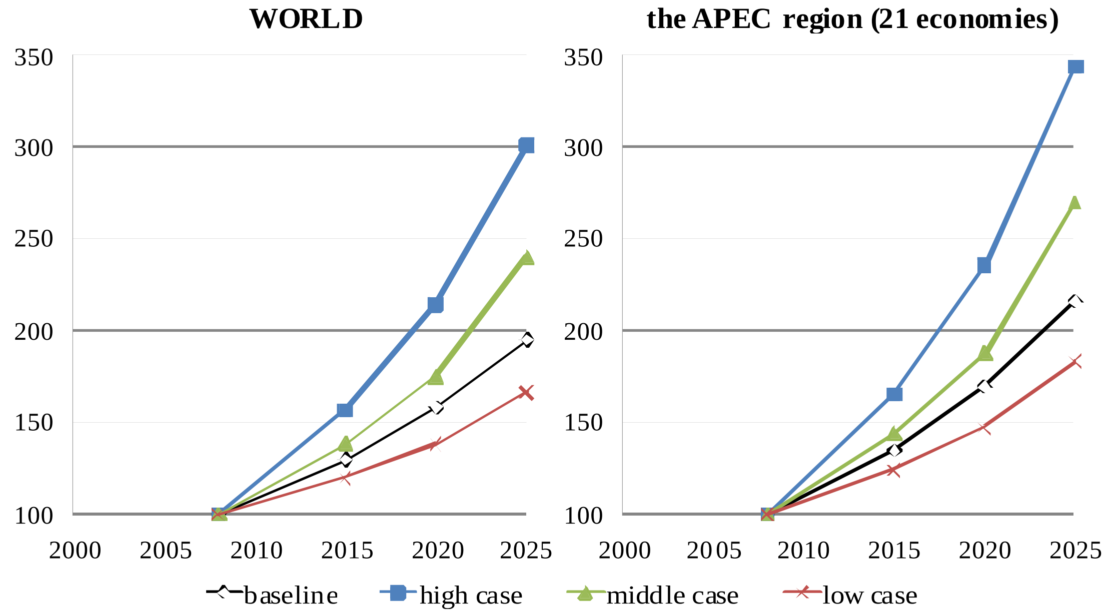

Figure 6 Estimated shipping demand for international maritime container cargo worldwide and in the APEC region by economic scenario (2008 estimated results =100)

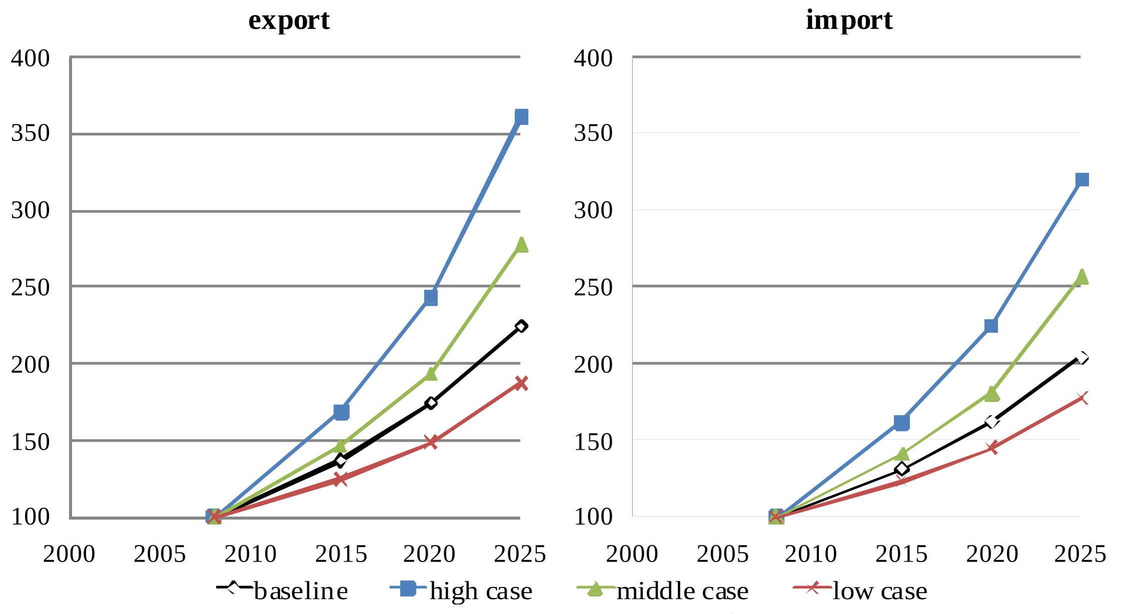

Figure 7 Estimated export and import shipping demand for international maritime cargo in the APEC region by economic scenario (2008 estimated results = 100)

4. INTERNATIONAL CARGO FLOW FORECASTING

4.1 Model

The international cargo flow model outputs transportation patterns of international cargo on maritime and land networks based on input of the cargo shipping demand (OD cargo volume) on a zone basis estimated as described in the previous chapter. In addition, the service level of each port (e.g., number of berths by water depth and port charges) and information related to the transportation network (transportation costs and time, etc.) are given in the model. The outputs are tabulated for each port to calculate the handling volume and transshipment cargo volume by port.

The model focuses on the behavior of "shippers" and "ocean-going container carrier groups," which are the important actors in the international cargo shipping market. Referring to the freight and shipping time by route indicated by each ocean-going container shipping group, a "shipper" selects a shipping group for maritime transport, the ports to be used for import/export, and the land transport route and mode for each cargo. Shippers can also choose an alternative shipping route consisting of only the land transport mode (i.e., truck and/or railway) if available. For shippers, the selection is assumed to be determined so as to minimize "recognized generalized costs," including not only observed shipping cost and time, but also factors which cannot be observed by the model developer, in other words, stochastic factors.

"Ocean-going carrier groups" are assumed to behave so as to maximize profit for each group under the condition that cargo shipping demand by port pair (combination of ports for export and import) is given as an input. Each group determines freight charges and vessel sizes by port pair, as well as shipping routes (ports of call and transshipment ports) so that the profit (= income – costs) of that group is maximized, considering the freight charge and shipping time of other groups. Although carrier groups consider the shipper's behavior as far as possible, here, the behavior of carrier groups is assumed to be shortsighted. Concretely, this means that a carrier group behaves to maximize its own income in the short term, considering the shipper's behavior in selecting a carrier group; however, the carrier group cannot predict the mid-term behavior of shippers, such as changes of ports used for export/import and transport mode. A detailed description of the model can be found in Annex C1.

4.2 Input, Output, and Policy Variables

The major input and output variables are summarized in Table 6. Significant features of the developed model include the fact that many policy variables are considered and a huge maritime shipping network is included, encompassing a large number of container ports as well as the land transport network worldwide.

Table 6 Major inputs and outputs of the international cargo flow model

Input (external variables)		Output (internal variables)
output of the trade model and conversion process	cargo shipping demand (regional basis, TEU/year)	container cargo flow (maritime, land)
shipping network	maritime shipping cost	container throughput by ports (local, transshipment)
	land drage cost	
	maritime shipping network	shipping cost and their change by policy implementation
	land transport network	
	vessel and truck speed	
other important data	value of time for shippers (USD/h/TEU)	
international logistics policy	lead time for import/export	
	port charge (entrance, handling and terminal)	
	number of container berth by depth	
	productivity of container handling	

4.3 Example of Simulation (1): Reproducing Actual Global International Cargo Flow and Future Forecast

In the simulation in this study, the world maritime shipping network includes approximately 150 container ports, as shown in Figure 8. The names of the ports and parameter settings for each port are shown in Table C1 of Annex C2. The land shipping network considers only all APEC economies and a few neighbor countries such as the ASEAN region. The land shipping networks included in the model in this study are also shown in Figure C5 of Annex C2.

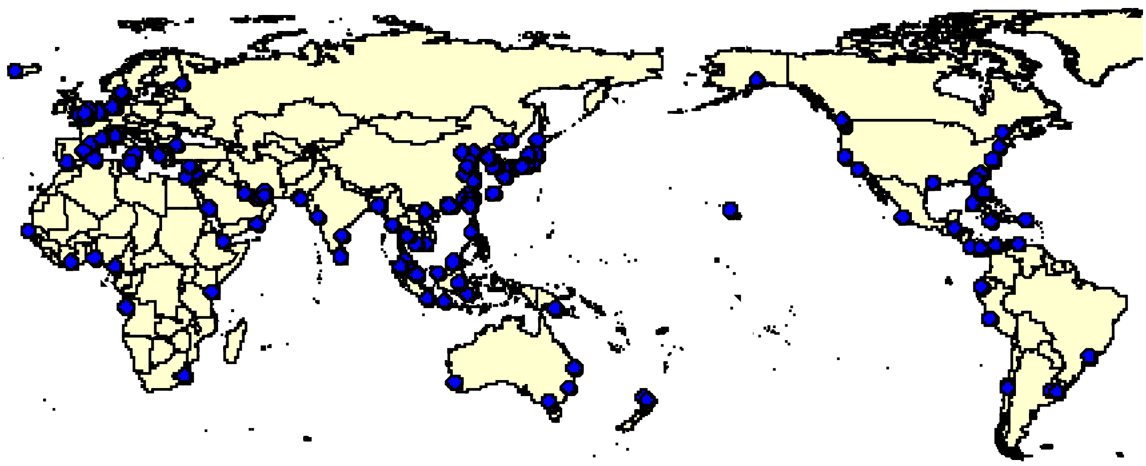

Figure 8 Container ports of the world included in the international cargo flow model

Figure 9 shows the reproducibility of the model developed in terms of container cargo throughput for each port in 2008 (empty containers are excluded). Since hinterland transport is considered in the APEC region and its adjacent region, the volumes handled for export and import container cargo (left side of figure) are compared for the ports within these regions. The volumes handled for transshipped container cargos (right side of figure) are compared for all the ports considered in the model. Judging from these figures, although there is a minor difference between the actual and estimated volume, the model is considered to reproduce the trend in global international maritime container cargo shipping as a whole.

Figure 10 shows the future forecasting results of international maritime container cargo throughput (total of export, import, and transshipment cargo, excluding empty containers) for major ports in the APEC region, inputting international cargo shipping demand in the middle case scenario for 2015 predicted in the previous chapter. Future plans for container berths (newly constructed or deepened existing berths) are assumed in many ports based on actual plans (no other parameters of the model input are changed). The present and future number of container berths assumed in the simulation is shown in Table C1 in Annex C2. A 58% increase is expected in total throughput worldwide, while a 54% increase is expected in total throughput in the ports of all APEC economies. Figure 10 also shows that 50% to 100% increases are expected for most major ports in the APEC region.

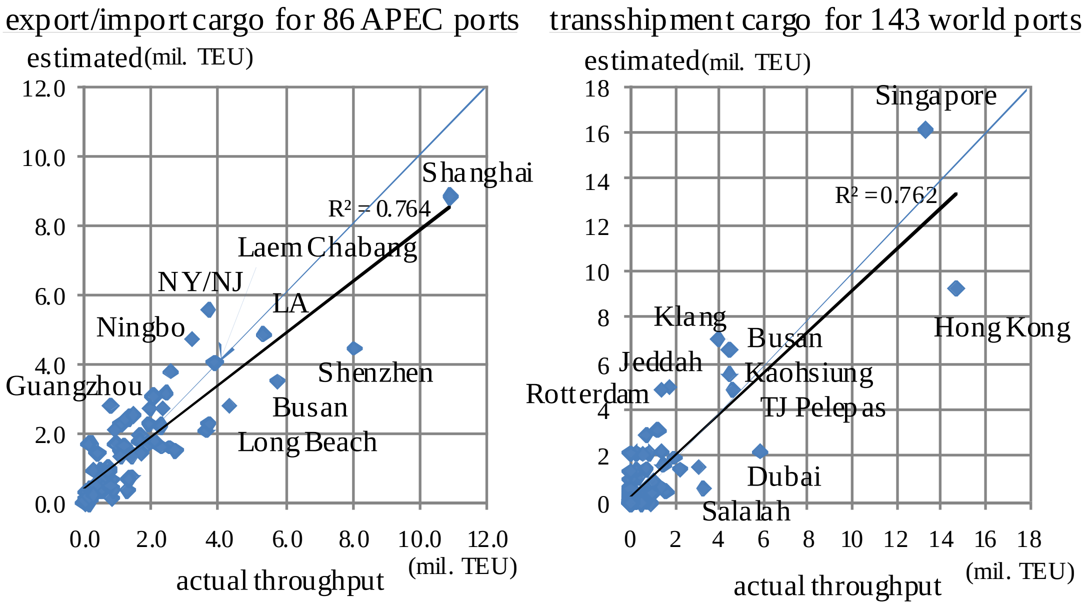

Figure 9 Verification of the model: Comparison of actual and estimated container throughput for each port in 2008 (excluding empty containers)

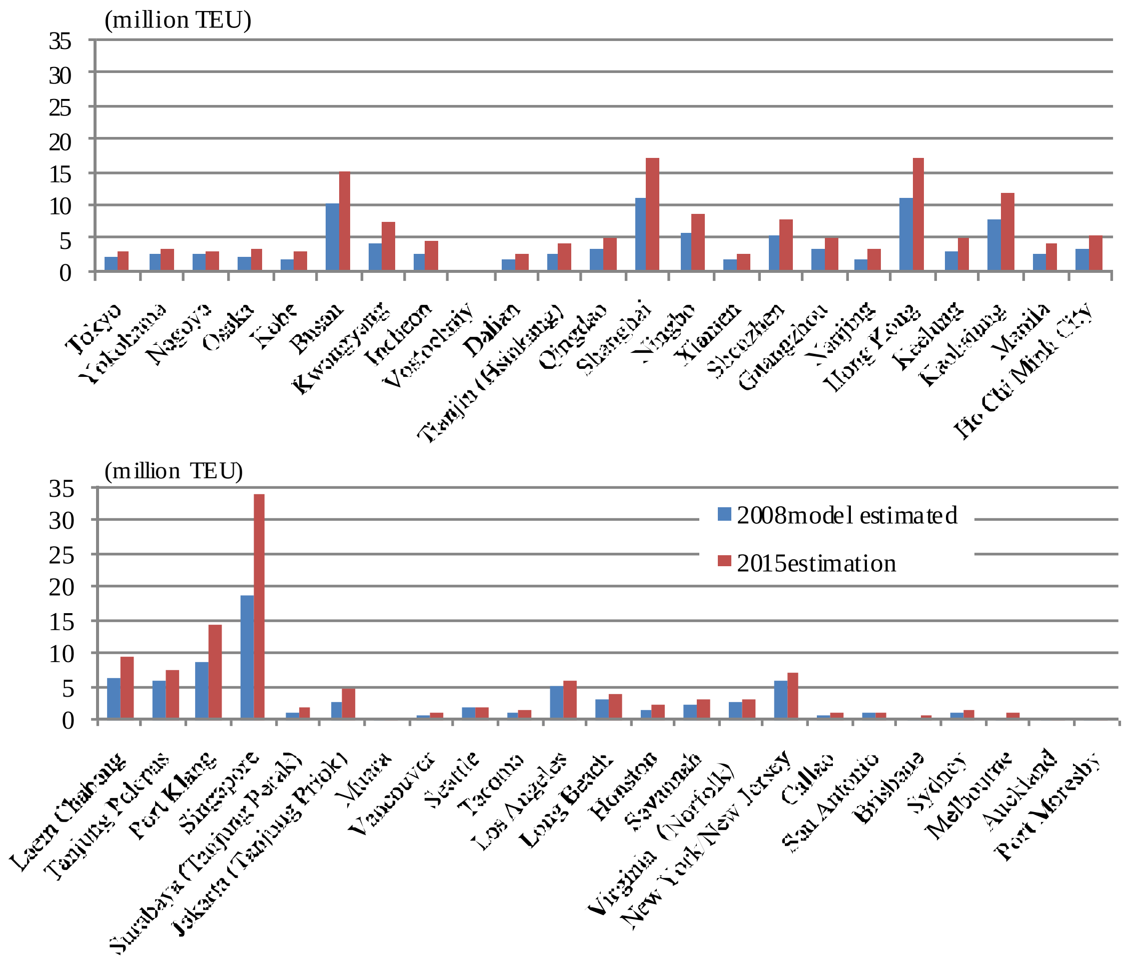

Figure 10 Forecasting results of container cargo throughput (total of export, import, and transshipment cargo, excluding empty containers) for major ports in the APEC region

4.4 Example of Simulation (2): Effect of Container Terminal Construction

In the above future simulation (Simulation (1)), all planned container berths are assumed to open as planned. In order to evaluate the effect of these investments, a hypothetical simulation is performed assuming that no investment is made from the present time in container berths worldwide. In other words, this simulation assumes 2015 cargo shipping demand and 2008 container berth data.

Figure 11 shows a comparison of the estimated results for container cargo throughput (total of export, import and transshipment, excluding empty containers) in 2015 with and without investment in container berths. The result with investment in Figure 11 is quite similar to the 2015 estimation in Figure 10. From Figure 11, the difference in the results in these two cases seems small. For example, total container cargo throughput worldwide increases only by 0.8% assuming implementation of container berth investment, while that in all APEC region ports decreases by 0.1%.

However, there are observed significant differences from the viewpoint of shipping cost and time. For example, port congestion causes waiting time (defined as *TWA* in

Equation C17 of Annex C1) when entering and departing ports. With investment, average waiting time worldwide is calculated to decrease from 1.65 hours to 0.92 hours, and average waiting time for all ports in the APEC region decreases from 1.79 hours to 1.27 hours. The changes in total shipping costs worldwide and in each region calculated by the model are summarized in Table 7. Port investment is estimated to have a positive impact in all the economies and regions, as well as in the entire world and the APEC region. Moreover, although the reduction rate is not high, the absolute amount of the reduction is large enough to be considered significant.

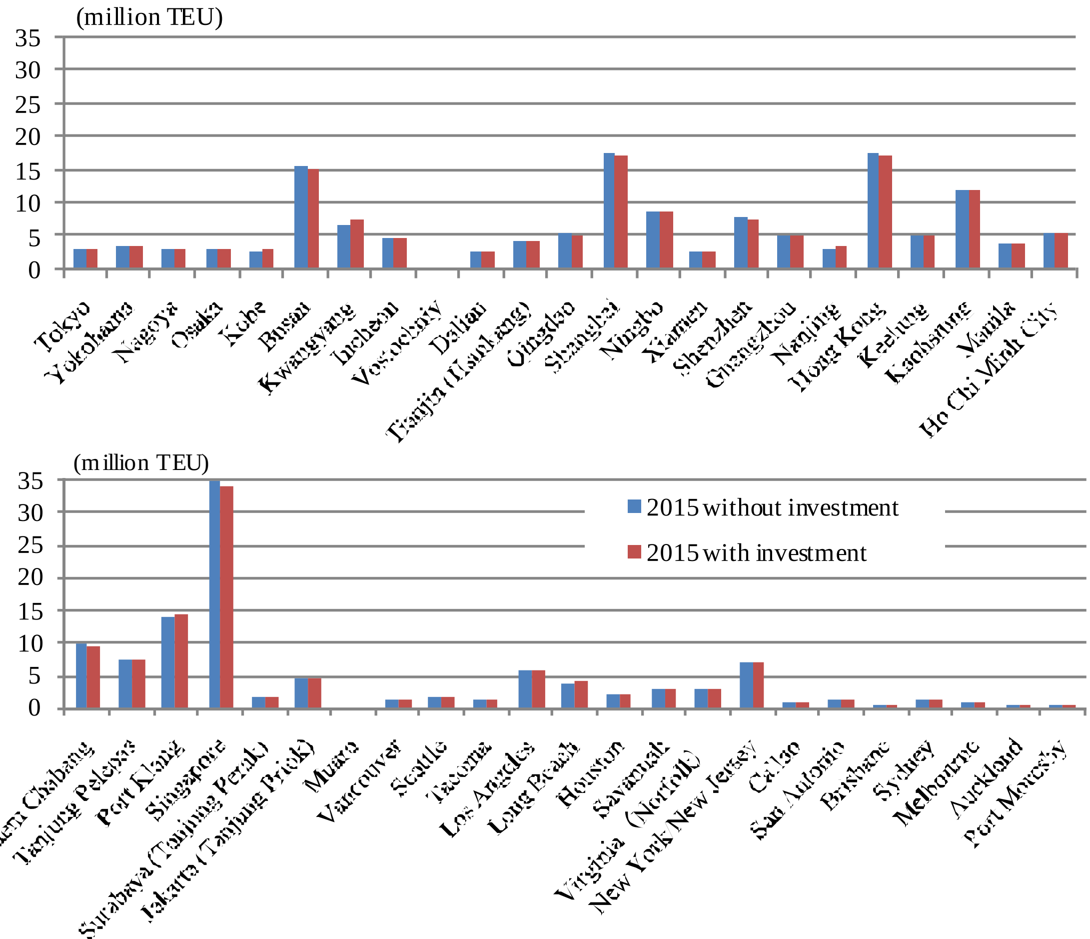

Figure 11 Comparison of estimated container cargo throughput for major ports in the APEC region with and without future container berth investment

Table 7 Calculated reduction in cost of international cargo shipping as a result of container berth investment

	Cost reduction rate	Amount of Cost reduction (trillion USD)		Cost reduction rate	Amount of Cost reduction (trillion USD)
world total	0.31%	9.19	South Asia	0.52%	0.61
APEC total	0.30%	10.77	Russian Federation#	0.10%	1.03
Japan#	0.41%	0.61	Central Asia	0.06%	0.80
Republic of Korea#	0.40%	0.49	United States#	0.39%	2.03
China#	0.61%	4.40	Canada#	0.10%	0.16
Hong Kong, China#	0.18%	0.06	Mexico#	0.08%	0.09
Chinese Taipei#	0.34%	0.32	Other Central America	1.29%	0.77
Rest of East Asia	0.13%	0.01	Peru#	0.38%	0.05
Philippines#	0.42%	0.18	Chile#	0.56%	0.14
Vietnam#	0.20%	0.22	Other South America	0.29%	0.34
Thailand#	0.12%	0.13	Middle East	0.64%	1.45
Malaysia#	0.28%	0.29	Europe	0.66%	2.67
Singapore#	0.21%	0.08	Africa	0.55%	0.94
Indonesia#	0.32%	0.39	Australia#	0.22%	0.08
Other Southeast Asia (incl. Brunei Darussalam#)	0.16%	0.02	New Zealand#	0.24%	0.03
			Rest of Oceania (incl. Papua New Guinea#)	0.15%	0.01

4.5 Example of Simulation (3): Detouring Malacca Strait

The Malacca Strait is geopolitically very significant for international maritime shipping, not only for the East Asian region, but also for the world as a whole. If navigation of the Malacca Strait were to become impossible for some reason, such as terrorism, a catastrophic accident, or a natural disaster, the effects would not be limited to the international transport sector, but would impact the entire Asian and global economies.

This simulation assumes a shutdown of the Malacca Strait occurring on a straight line between the Ports of TJ Pelepas (Malaysia) and Dumai (Indonesia). Any container ships and ferries passing through the line would be obliged to detour, as shown in Figure 12. In this simulation, a tentative detour network for maritime shipping is prepared by replacing the physical distances between the related port pairs, i.e., connecting the two sides of the Malacca Strait (west side, including South Asia, the Middle East, Europe and Africa and east side, eastern Southeast Asia, East Asia, North and South America). To simplify the calculation, the simulation assumes that a shutdown of the Malacca Strait will not affect shipping demand for international cargo between any areas of the world, and negative impacts on the world economy will be limited to increased shipping costs. Therefore, this cost increase should be regarded as the minimum economic impact of the shutdown.

Figure 13 shows the change in container cargo throughput after the shutdown of the Malacca Strait using cargo shipping demand for 2008. It should be noted that the estimated result is for annual cargo volume. Thus, in a 6 month shutdown, the estimated cargo volume affected will be half that shown in each scenario. In other words, in discussions based on these results, what is important is the rate of difference in the scenarios. From the figure, in ports in the vicinity of the Malacca Strait, such as Singapore, Klang, and TJ Pelepas, cargo throughputs are estimated to decrease due to the shutdown. In particular, significant decreases are observed in huge regional ports such as Singapore and Klang, while certain other Asian ports, such as Busan and Hong Kong, show a slight increase in cargo volume, as part of the hub function of the Ports of Singapore and Klang would shift to these ports.

Table 8 shows the increased shipping cost due to detouring the Malacca Strait worldwide and by economy. Cargo shipping costs increase in every region of the world, and the effect of the increased rate of shipping costs is not limited to directly-related economies, such as Malaysia, Singapore, Indonesia, and Brunei Darussalam, but also impacts economies in South Asia, the Middle East, Europe, Eastern Asia, and Oceania.

Figure 9 shows the difference in the two cases in terms of the land cargo flow in the neighboring area of Southeast Asia. Land link flows on both sides of the shutdown point are estimated to increase. In the Malay Peninsula, the container cargo handled in the Port of Klang shifts to the Ports of Kuantan, Pasir Gudang, and TJ Pelepas. (Note: Export and import cargos handled in the Port of TJ Pelepas, as well as those in the Ports of Kuantan and Pasir Gudang, are estimated to increase, although the total container cargo throughput including transshipped containers in the Port of TJ Pelepas is estimated to decrease, as shown in Figure 13.) Also, shifts from sea to land transport are observed on Sumatra Island in Indonesia, in that Sumatran cargos shift from the Port of Belawan to land transport to Java via Sumatra.

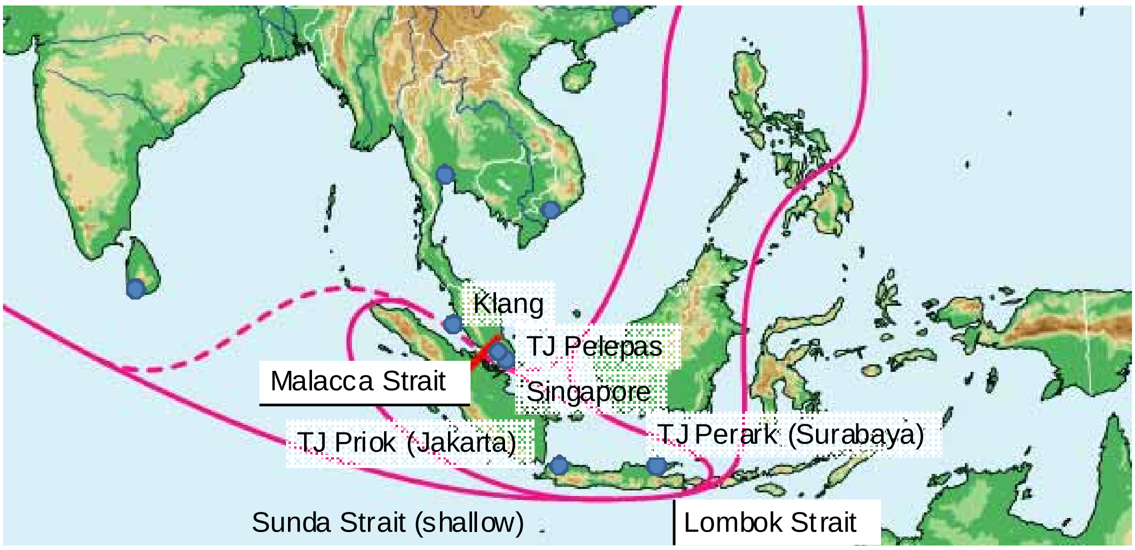

Figure 12 Detour route after shutdown of the Malacca Strait

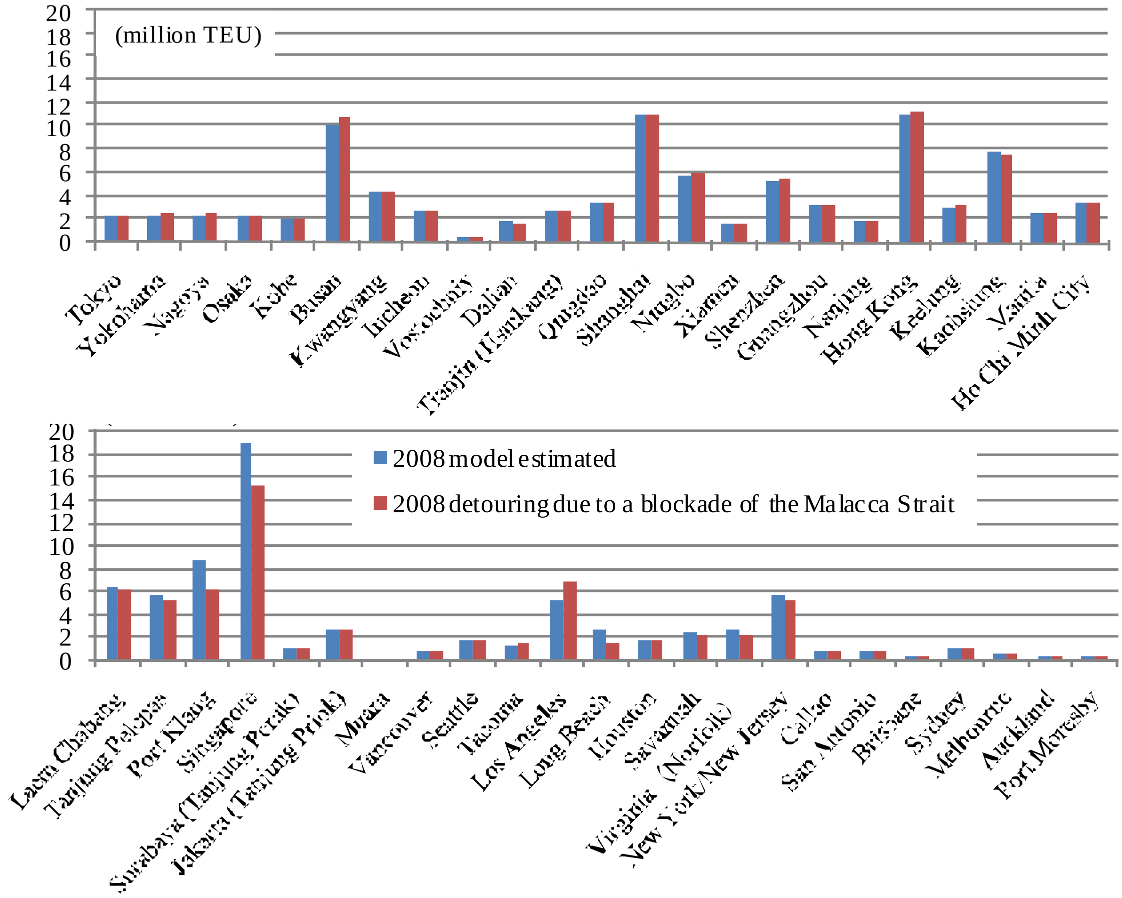

Figure 13 Effect of shutdown of the Malacca Strait on international maritime container cargo throughput for major ports in the APEC region

Table 8 Calculated increased cost of international cargo shipping due to shutdown of the Malacca Strait (annual conversion)

	Cost reduction rate	Amount of Cost reduction (trillion USD)
world total	0.87%	20.86
APEC total	0.88%	25.62
Japan #	1.30%	1.75
Republic of Korea #	1.51%	1.36
China #	1.56%	8.25
Hong Kong, China #	1.38%	0.36
Chinese Taipei #	1.26%	0.93
Rest of East Asia	0.79%	0.03
Philippines #	0.76%	0.25
Vietnam #	0.77%	0.56
Thailand #	1.33%	1.09
Malaysia #	2.54%	1.83
Singapore #	2.16%	0.64
Indonesia #	2.47%	2.12
Other Southeast Asia (incl. Brunei Darussalam #)	2.02%	0.16

	Cost reduction rate	Amount of Cost reduction (trillion USD)
South Asia	2.14%	1.54
Russian Federation #	0.26%	2.17
Central Asia	0.19%	1.96
United States #	0.66%	3.41
Canada #	0.11%	0.18
Mexico #	0.05%	0.05
Other Central America	0.08%	0.04
Peru #	0.16%	0.02
Chile #	0.01%	0.00
Other South America	0.35%	0.33
Middle East	1.58%	2.82
Europe	2.66%	8.20
Africa	0.76%	1.03
Australia #	1.62%	0.45
New Zealand #	1.06%	0.12
Rest of Oceania (incl. Papua New Guinea #)	1.79%	0.08

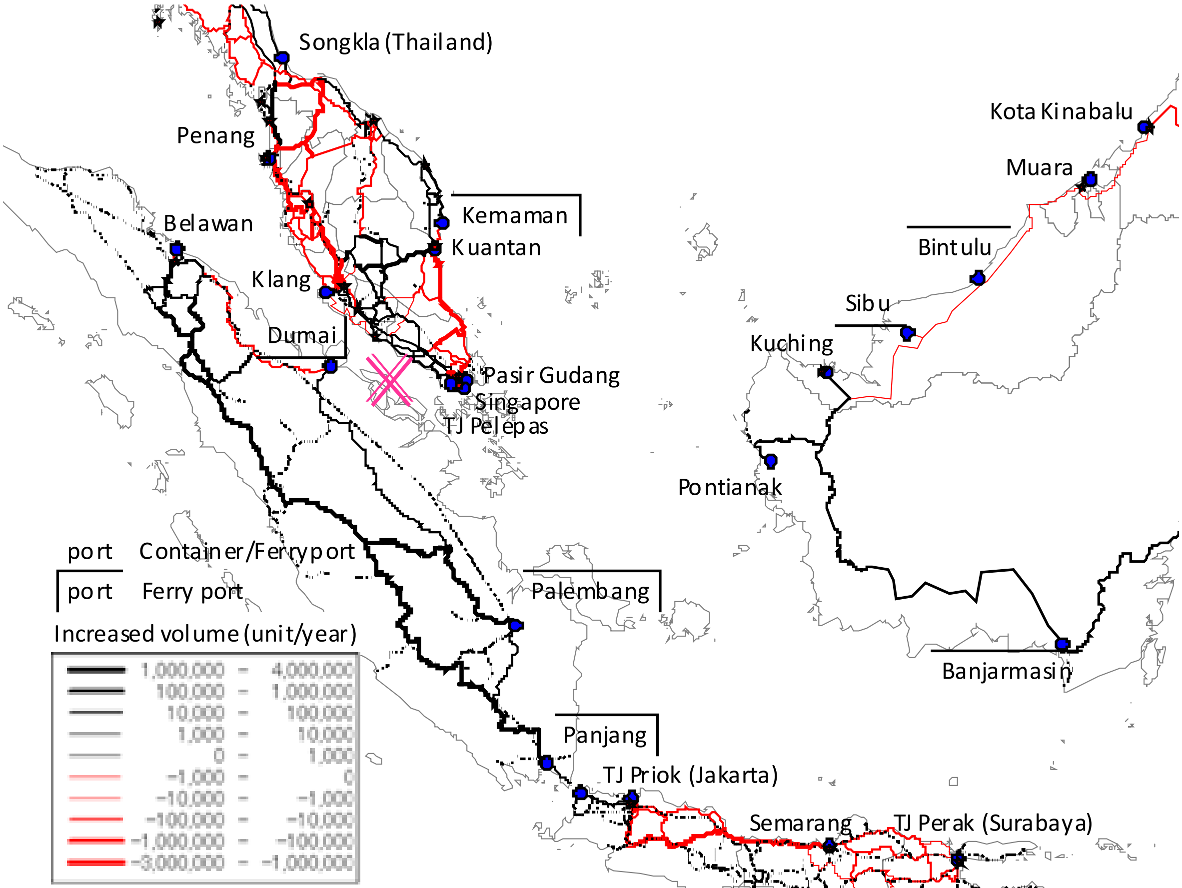

Figure 14 Difference in land cargo flow in Southeast Asia due to shutdown of the Malacca Strait

5. CONCLUSION

A successive prediction system for trade value and international cargo flow, called "Trade and Logistics Forecasting System for the APEC Region," was developed in order to support discussions aimed at realizing trade liberalization and efficient transport among the APEC economies. This system makes it possible to forecast future trade values and international cargo flows for individual economies, as well as for the region as a whole. It is also possible to simulate policy impacts by quantifying changes resulting from policy measures such as trade liberalization and infrastructure improvement, and to simulate conditions related to risk management.

This forecasting system will contribute to quantification of the impacts of trade and transport policy on international cargo shipping and the economic activities of individual economies, as well as the mutual development of the entire APEC region.

By collaborating with a system development group and preparing additional data as necessary, each member economy can use the system, in whole or in part, in analyses related to its own economic interests, as well as impacts on the entire APEC region. For further information regarding this forecasting system, please contact:

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ANNEX A. DETAILS OF TRADE FORECASTIING MODEL AND RESULTS

A1. Brief Summary of Trade Forecasting Model

The details of the GTAP model can be found in Hertel (1997) and several supplements published by the GTAP development group, which can be downloaded from the official GTAP website (https://www.gtap.agecon.purdue.edu/). In the model, prices and quantities are simultaneously determined in factor markets and commodity markets by accounting relationships, the equilibrium conditions specified by the behavior of economic agents, and the structure of international trade. The model includes five factors of production: skilled labor, unskilled labor, capital, land, and natural resources.

Figure A1 shows an overview of economic activity in the GTAP model (Hertel, 1997). In the model, the concept of a "regional household" is introduced, and expenditures by this household are divided into private, government, and saving expenditures. On the other hand, the regional household gains income by providing the factors of production to producers and by imposing tax on each economic activity (although this tax is omitted in Figure A1). The total amounts of income and expenditure for the regional household are assumed to be always strictly coincident. Likewise, the total amounts of income and expenditure are always coincident for each sector, including the private household, government, global bank, producer, and any sectors in other regions, under assumptions of perfect competition and equilibrium of the market.

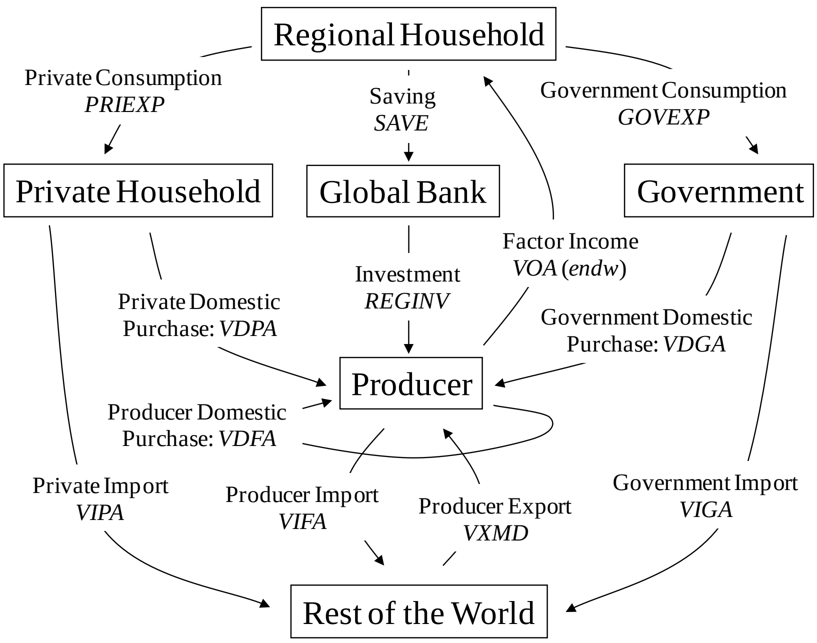

Figure A1 Overview of economic activity in the GTAP model (source: Hertel, 1997)

The regional household decides the shares of its expenditures for the private, government, and saving sectors so as to maximize its utility, which is defined as the Stone-Geary utility function

$$U(r) = C \cdot UP(r)^{DPPRIV(r)} \cdot UG(r)^{DPGOV(r)} \cdot \left\{ \frac{QSAVE(r)}{POP(r)} \right\}^{DPSAVE(r)} \qquad \text{(A1)}$$

where, *U*(*r*): utility (per capita) of regional household of region *r*, *UP*(*r*): utility (per capita) of private household of region *r*, *UG*(*r*): utility (per capita) of government of region *r*, *QSAVE*(*r*): total amount of saving of region *r*, *POP*(*r*): population of region *r*, *C*: scale parameter, *DPPRIV*(*r*), *DPGOV*(*r*), *DPSAVE*(*r*): coefficient of utility of private, government, and saving expenditures.

The private household also decide the shares of its expenditures for each commodity so as to maximize its utility by solving a duality problem (i.e., expenditure minimization problem) with a Constant Difference of Elasticity (CDE) type expenditure function. In addition, the shares of expenditures for each commodity for domestic and import products and the shares of expenditures for each import commodity by economy/country are decided according to the same principle as the producer's behavior mentioned below. On the other hand, the shares of government expenditures for each commodity are decided under the Cobb-Douglas assumption of constant budget share. The shares for domestic and import products and for regions when importing are decided according to the same principle as in the private household. The global bank invests the savings gathered from each region in the producer of each region to be capital stock in the next period.

The producer outputs each commodity by inputting the factors of production provided by the regional household and intermediate goods (commodities) purchased from producers (including domestic and international) belonging to its own commodity category and others. Because perfect competition is assumed to exist in the market, the profit of every producer in each region becomes zero; i.e., the total amount of expenditures by each producer to purchase inputs should always strictly coincide with the total amount of its income, respectively. The producer also decides the share of factors of production and intermediate goods, the share of each commodity as intermediate goods, the share of domestic and import product for each commodity, and the share of regions for each import commodity so as to minimize its production cost under the given amount of outputs. The assumed "technology tree" of producers is shown in Figure A2. As shown at the top of the figure, for outputting a final product, the model assumes non-substitution (i.e., a Leontief-type production function) between all inputs, including composite production factors (value added), and every commodity as intermediate. For compositing production factors as well as compositing domestic and import goods for each intermediate, constant elasticity of substitution (CES) is assumed. CES is also assumed for compositing import goods from each region. The behavior of the private household and government in choosing the region for each import commodity is similarity defined. This assumption of structure when importing goods is called the "Armington approach," as it was first proposed by Paul Armington. Hereinafter, the elasticity parameters for choosing import goods and regions are given by commodities, respectively.

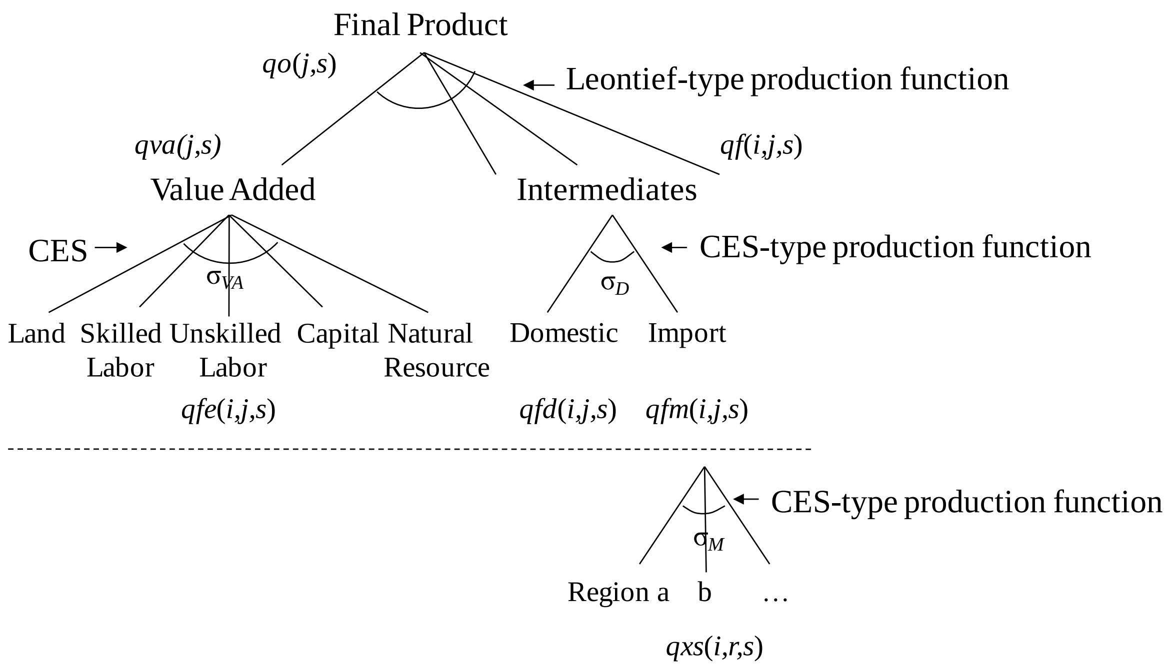

Figure A2 Production structure of the GTAP model (source: Hertel, 1997, as revised by the authors)

A2. Future Scenarios for Example Simulation

In general, the Delphi method is one of the forecasting methods in which respondents answer the same questionnaire several times in order to clarify respondent forecasts. The distinctive feature of the Delphi method is that the results of the previous survey are provided as feedback to the respondents to questionnaires in the next questionnaire survey. In the survey conducted by the authors' group, the questionnaire survey was carried out twice, in February and March 2008. Questionnaires were distributed to almost 100 Japanese experts in international economics (81 questions) and international transportation (103 questions). For the most standard questions, respondents were asked to choose from among 5 stages (e.g., ranging from "there will be significant progress" to "there will be significant setbacks") that which they think best answers the question being asked for each of four time periods (short-term (around 2010), mid-term (to around 2015), long-term (to around 2020), and very long-term (after 2020). For detail of the survey and its results, please see Shibasaki at al. (2008a), also available on a website http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0495.htm.

The several endogenous parameters in the GTAP model are set for each economy as follows, reflecting the results of the questionnaire survey and, at the same time, getting varied results with keeping convergence in the calculation. Parameters other than those shown below remain unchanged from the initial values of the GTAP model.

A2.1 Population

The rate of population change is represented by the parameter *pop* in the GTAP model. Table A1 (at the end of this Annex) shows the set values for *pop* (%) for each scenario and period.

(1) Baseline scenario

The medium variant of population forecasted by the United Nations (for Chinese Taipei provided by its Council for Economic Planning and Development) is applied as population in the basic scenario.

(2) High, middle, and low cases
Similarly, population for each scenario (high, middle, and low cases) is obtained from the statistics of the United Nations and the other government.

A2.2 Factors of Production I: Land

The rate of change for land, which is represented by the parameter *qo*(*Land*), is one of the factors of production in the GTAP model. Even if the change in national land area can be regarded as negligible, changes in productivity resulting from changes in land use remain as a possibility. However, for simplicity, this study assumes that land is unchangeable in each scenario after the starting year (2004).

A2.3 Factors of Production II, III: Unskilled and Skilled Labor Force

The rate of change in the unskilled and skilled labor force is represented by the parameters *qo*(*UnSkLab*) and *qo*(*SkLab*) in the GTAP model. The rate of change for skilled labor *qo*(*SkLab*) (%) is represented by approximately the sum of the growth rate of the labor population *lab*(%) and the growth rate of the share of the skilled labor force in the total labor force (combined unskilled and skilled labor force) *dSHR_SkLab* (%). Based on this definition, the rate of change in the unskilled labor force is represented by (*lab* - *dSHR_SkLab*). Table A2 shows the set values for *lab* and *dSHR_SkLab* for each scenario and period.

A2.3.1 Growth Rate of Labor Force, *lab*

(1) Baseline scenario
As the value *lab* for the rate of growth of the labor force cannot be obtained directly, this is replaced by using the growth rate of the productive age population (15 to 64) provided by the United Nations and the other government.

(2) High, middle, and low cases
The rate of growth of the productive age population used in the baseline is not available for the high, middle, or low variants. Therefore, while the obtained rate of growth of the productive age population is used for the baseline and middle case, the rate of change of the productive age population for the high and low cases is obtained by multiplying the rate of change of the estimated total population (high and low variants) in A2.1 and the rate of change of the productive age population as the middle case in the same year.

A2.3.2 Rate of Change in Skilled Labor Force Share, *dSHR_SkLab*

(1) Baseline scenario
The share of the skilled labor force will naturally increase due to the age composition of the current skilled labor force (the share is smaller for older age group to be soon retirees and higher for younger age group just entering the labor force), even without considering increases in the rate of advancement to higher education as shown in (2). However, as actual data for age composition cannot be obtained, the rate of change in the skilled labor force in the baseline scenario *dSHR_SkLab* is assumed to be zero.

(2) High, middle, and low cases

Changes in the ratio of the skilled labor force can be envisioned due to changes in the ratio of students who go on to the next stage of education at each educational level. Based on information such as that contained in the GTAP database manual, skilled labors are defined as having graduated from a post-secondary educational institution. The questionnaire survey conducted by Shibasaki et al. (2009) posed the following questions (A58, A59), the answers to which are given in Figure A3. In this study, as shown in Figure A3, the maximum and minimum levels for increases and decreases in this five year period are set at ±10% based on the actual growth rate in advancement to post-secondary education in recent years in each region.

(A58) The percentage of students in China continuing on to senior high school (post-secondary education) was about 48% in 2004. What do you foresee for trends in the future?
(A59) The percentage of students attaining post-secondary level education in other developing countries in Asia was about 40-60% in 2006. What do you foresee for trends in the future?

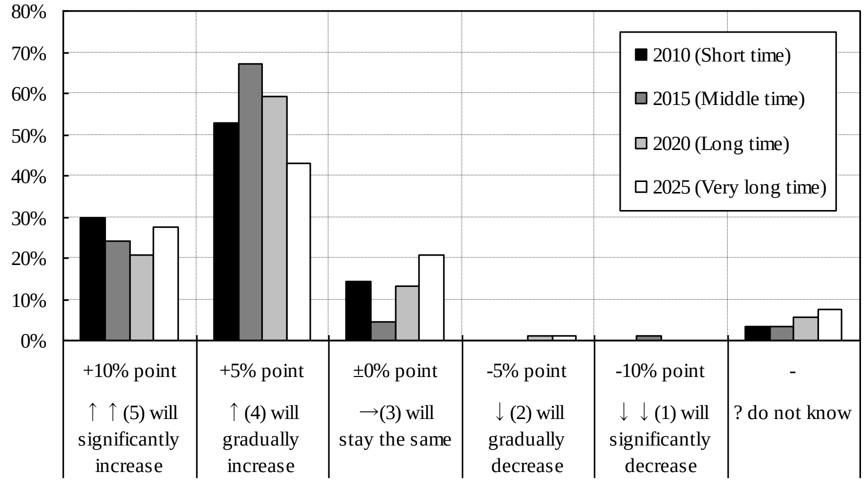

Figure A3 Range of answers (Shibasaki et al., 2009) and values (growth rate) set for each selection in this study (example of Question A58)

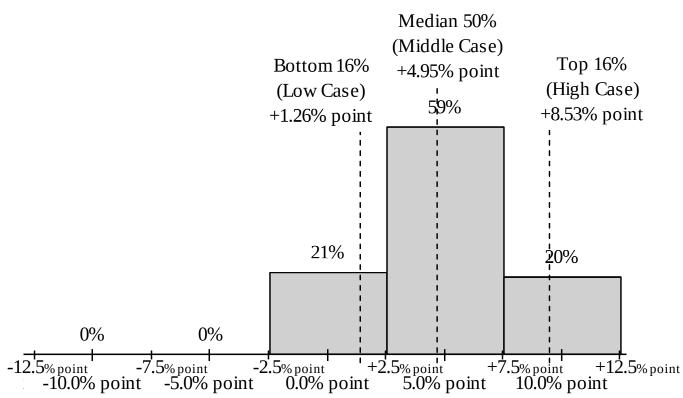

Figure A4 Example of probability distribution function assumed and scenario configuration values (example of 2010 values for Chinese secondary school advancement rate)

In this study, the range of answers (excluding non-responses) corresponding to the top 16%

(represented as median value +1σ), 50% (median value), and the bottom 16% (median value -1σ) for each time point is used as the set value for the high, middle, and low cases, respectively. Specifically, the values provided by respondents for "Answer 5" are taken as being uniformly distributed between +7.5% points and +12.5% points in the above example. When the same distribution is assumed for all answers, as shown in Figure A4, this probability distribution function makes it possible to set values for each scenario. The methods outlined here are also used for each parameter below.

In the survey, these questions were prepared only for China and other developing Asian economies. Therefore, the values for other economies are assumed as follows:
1. Developed economies, based on the current circumstance of unchanged high school advancement rates, are assumed to maintain the current level (zero growth rate) in the middle case and change by +2.0% points and -2.0% points in each period in the high and low cases, respectively.
2. For convenience, the result of other developing Asian economies is substituted for the other developing economies outside of Asia.

Based on the rate of change in post-secondary education advancement for each scenario for every five year period, the rate of change in the share of skilled labor is calculated as follows: The rate of change for post-secondary education advancement as *dHS* is converted to the rate of change in the share of skilled labor *dSHR_SkLab* using the conversion coefficient α and the rate of productivity of individual skilled laborers against the rate of productivity of individual unskilled laborers β. That is,

$$dSHR\_SkLab = dHS \cdot \alpha \cdot \beta \qquad \text{(A2)}$$

In this study, the conversion coefficient α is assumed to be α = 1/48. Regarding β, based on statistics on the number of skilled and unskilled laborers provided by the International Labor Organization (ILO) and the skilled labor force and unskilled labor force values (monetary base) contained in the GTAP database, the average figure of β is approximated as 3.0.

A2.4 Factors of Production IV: Capital

In this study, as stated above, the authors use the standard GTAP static model. Therefore, for capital accumulation, in addition to the increase in capital stock obtained from the results of the model calculations for the previous period, consideration of changes in capital stock over a five year period is required. In terms of the former rate of change, this corresponds to the (*KE* - *KB*) used in the GTAP model (*KE* and *KB* used here refer, respectively, to capital stock before and after calculation). For the latter rate of change, this is displayed by the parameter *qo*(*Capital*) as an exogenous variable. Here, *qo*(*Cap*), which is shown in Table A3 for each scenario and period, is set by the method shown below.

(1) Baseline scenario
Basically, a constant value of gross fixed capital formation to GDP ratio in each region is assumed. That is to say, the growth rate in capital stock should be configured at the same value as the GDP growth rate (see A2.6). However, as stated above, because the capital stocks are endogenously changed in the model calculations, the exogenous capital stock growth rate should be determined by subtracting the endogenous growth rate of capital stock from the GDP growth rate. In this research, for the sake of simplification, these are assumed to be fixed

at 50% of the GDP growth rate across the board, based on trial calculation, while the values for 2005 are assumed to be 100% of the GDP growth rate in order to maintain a broad correspondence between the actual trade value and the estimated value in the model.

(2) High, middle, and low cases
In the questionnaire survey conducted by Shibasaki et al. (2009), the following questions were posed and the answers to each provided.

(A40) Gross fixed capital formation (public investment plus private investment) in Japan accounted for about 24% of GDP in 2006. How do you foresee this situation changing in the future?
(A41) Gross fixed capital formation in China accounted for about 43% of GDP in 2006. How do you foresee this situation changing in the future?
(A42) Gross fixed capital formation in other East Asian developing countries accounted for about 20-30% of GDP in 2006. How do you foresee this situation changing in the future?
(A43) Gross fixed capital formation worldwide accounted for about 22% of GDP in 2006 on average. How do you foresee this situation changing in the future?

Here, when the initial share *SHR_cap* (%) of gross fixed capital formation for GDP amount and its growth *dSHR_cap* (% point) are defined from the above questionnaire survey results by scenario, the relationship among the capital stock rate of change *qo*(*Cap*) (%), overall GDP (*GDP*) and its growth rate *qgdp* (%) is as follows.

$$(1+qo(Cap))\cdot SHR\_cap\cdot GDP=(1+\gamma\cdot qgdp)\cdot GDP\cdot(SHR\_cap+dSHR\_cap) \quad \text{(A3)}$$

Both sides of Equation (2) display the change total for each capital stock. In this case, γ is the parameter considering capital accumulation within the model, and in line with the argument of the (1) baseline configuration, $\gamma = 0.5$. Based on Equation (2) the authors obtain the following:

$$qo(Cap)=(1+\gamma\cdot qgdp)\cdot\left(1+\frac{dSHR\_cap}{SHR\_cap}\right)-1 \quad \text{(A4)}$$

Economies, countries and regions that do not fall under "Japan," "China," or "Other East Asian developing country" are all included as part of "worldwide" in the question answers.

A2.5 Factors of Production V: Natural Resources

The rate of change in natural resources, which is one of the factors of production, is expressed in the GTAP model as the parameter *qo*(*NatRes*). Table A4 shows the configuration values for *qo*(*NatRes*) for each scenario and period.

(1) Baseline scenario
According to the authors' calculations based on U.N. data, total production of the world's three largest energy sources (oil, coal, and natural gas) was a total of 6.56 billion tons of oil equivalent in 2005. This was a rise of 1.153 times over the total for 2001 (an average annual rise of 3.6%). The annual average growth rate for the 10 year period from 1997 to 2006 was 2.1% (the same figure for the period 1996 to 2005 was 1.9%). Based on these figures, this study uses the rate of growth stipulated above (3.6% annually) for the baseline until 2005 and

a uniform annual growth rate of 2.0% after that period. Although these figures may actually vary by economy and country, due to the lack of data, in this study, the authors assume a globally uniform value.

(2) High, middle, and low cases
In the questionnaire survey conducted by Shibasaki et al. (2009), the following question was posed and answered.

(A76) What are your forecasts for crude oil production volume in the future? (please respond in terms of the increase/decrease in absolute amount, rather than growth rate)

As this question asks about production volume of "crude oil," the trend may be slightly different from the change in overall natural resources required at this time. However, because the responses to Questions A77 ("Do you anticipate that alternative energy will grow to eventually occupy an equal proportion of shares with conventional energies?") showed a generally skeptical trend (most answers for the period up to 2015 were negative; from 2020, most answers suggested a possibility of this, but answers indicating belief that this would occur being in the minority), applying this trend for overall natural resources can be said to be valid. In addition, since the questionnaire survey only posed the questions regarding changes in global terms, the authors have also configured this as the same rate of change for every economy/country.

A2.6 Total Factor Productivity (Technical Change of Factors of Production)

The rate of change in total factor productivity for each region is expressed in the GTAP model as the parameter *afereg*. Table A5 shows the configuration value *afereg* (%) for each scenario and period.

(1) Baseline scenario
In this study, the total factor productivity rate of change is endogenously sought by model calculations when GDP growth rate is exogenously given as model input, reflecting the basic economic growth theory of macro-economics (e.g., Solow model) that total factor productivity is defined as residual factors of economic growth. Although it might be a case of putting the cart before the horse, this reflects actual practical needs, in which the focus of argument is the future value of GDP rather than total factor productivity, and the fact that, in a large number of cases, GDP growth rate is configured.

At this point, for Japan, the actual and future values of the real GDP growth rate *qgdp*(%) for input are based on the configured values provided by the Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism of Japan, and for other economies and regions, actual and forecast data from the International Monetary Fund (IMF) are used. See Table A5 for further information on these values.

(2) High, middle, and low cases
The following question was included in the questionnaire survey conducted by Shibasaki et al. (2009).

(A17) In the future, can you expect to see structural adjustments and technical innovations outweigh the persistent decrease in the labor force in Japan?

The rate of change for the baseline configuration value is established as much as possible to have variety in the calculation results from the scenarios within the range of convergence. Since the questionnaire survey only asked questions regarding Japan, the rates of change for other developed economies are assumed to be the same as Japan's. On the other hand, because the baseline configuration value for developing economies is relatively large, the rates of change for them are assumed to be half as that for developed economies.

A2.7 Tariff Rate (Import Tax Rate)

Changes in the tariff rate are divided between those which impact on the overall tariff system of one particular economy such as entry to the WTO (World Trade Organization), and those which are only applied between two specific economies, such as conclusion of FTA or EPA. In the GTAP model, the former change is referred to as *tm*(*s*) and the latter change as *tms*(*r*,*s*) (in this case, *r*: export economy, *s*: import economy), as explained below.

A2.7.1 Changes in Average Tariff Rate, *tm*(*s*)

Changes in the average tariff rate *tm*(*s*) can be configured for individual commodities, but for the purpose of simplicity in this study, a common value is used for all items. Table A6 shows the configuration values for *tm*(*s*) (% point) for each scenario and period.

(1) Baseline scenario

Regarding the rate of change for the period from 2001 to 2005, considering new accessions to the WTO by China and Chinese Taipei, a uniform rate of -10.0% points is applied for these economies irrespective of the item (however, it is assumed that items do not fall below a tariff rate of zero; same below), while in other regions, a uniform rate of -2.0% points is applied. For the period after 2005, since the reduction in tariff rates is thought to depend on policy, a neutral stance is adopted; i.e. assuming no changes in the baseline.

(2) High, middle, and low cases

The following question was included in the questionnaire survey conducted by Shibasaki et al. (2009).

(A28) Do you anticipate tariff rates across the world will decline in the future through successful WTO negotiations?

The rate of change (% point) in each selection is established as shown in Table A6 as much as possible to have variety of calculation results from the scenarios within the range of convergence. Based on the text of the questions in the questionnaire, the same value is configured for all regions.

A2.7.2 Changes in Bilateral Tariff Rates, *tms*(*r*,*s*)

Similar to Shibasaki et al. (2008b), changes in the bilateral tariff rate *tms*(*r*,*s*) can be configured, based on the state of progress of FTA and EPA as summarized in Table A7. In particular, for the APEC economies, the progress of the Bogor Declaration, "Achieving free trade in developed economies by 2010 and in developing economies by 2020", is also considered.

(1) Baseline scenario
Of the combinations shown in Table A7, the tariff rates for each pair of economies/countries in states of progress 1 and 2 are taken to be zero for all commodities as of 2005. From 2005 onwards, no further reductions are considered as well as the rate of change *tm*(*s*).

(2) High, middle, low case configuration
For the high case, as shown in Table A7, the tariff rates for each pair of economies/countries/ regions in states of progress 1 to 5 as of 2010 are taken to be zero for all commodities. The tariff rate for all commodities in state of progress 6 will also be taken to be zero in 2020. For the middle case, the tariff rates for each pair of economies/countries/regions in states of progress 1 to 3 as of 2010 are taken to be zero for all commodities, while that in state of progress 4 will also be taken to be zero in 2020. For the low case, the tariff rates for each pair of economies/countries/regions in states of progress 1 to 3 as of 2010 are taken to be zero for all commodities, while from 2010 onwards no further progress is assumed.

A2.8 International Transportation Technology (International Transportation Margin)

In the GTAP model, the technical change in international transportation (reduction rate of the international transportation margin) can be configured separately for each economy of departure, economy of arrival, transportation mode, and item. In this study, the rate of change for each departure economy (for use in all transportation modes and all items) *ats*(*r*) and the rate of change for each arrival economy (same as above) *atd*(*s*) are as described below.

(1) Baseline scenario
In this simulation, various infrastructure investment and related measures in each economy can be taken as a 5% point reduction in transportation costs in all economies on a departing base and arrival base as of 2005. From 2005 onwards, further decreases in the baseline are not considered, based on thinking similar to that in connection with tariff rates.

(2) High, middle, and low cases
The effect of declining transportation costs on the global economy is the subject of most interest to the authors. Ultimately, this effect will be obtained from the results of calculations using the International Cargo Flow Model introduced in Chapter 4 of the main body and Annex C. Therefore, in this simulation, no additional configuration in transportation technology is considered.

A2.9 Elasticity of Substitution of Imported and Domestic Goods

Elasticity of substitution of imported and domestic goods is known as the Armington parameter and is expressed in the GTAP model as σ_d. As σ_d increases, the elasticity between imported and domestic commodities increases, and sensitivity to trade promotion policies also increases.

(1) Baseline scenario
In 2005, σ_d is assumed to be twice as the default configuration value for all items. This is an expedient assumption for replicating the actual value of global trade in 2005 and can be said to reflect the recent overall expansion of trade and globalization. In other words, the actual value of total trade in 2005 can be interpreted as reflecting the imbalances associated with the economic bubble conditions that existed until the second half of 2008. In this case, despite the

possibility of a hypothetical further change in σ_d in the future, this study assumes that there is no further change in σ_d from 2010 onwards and the 2005 value remains unchanged.

(2) High, middle, low case configuration
No additional changes to the baseline configuration are made.

A3. Estimated Future Trade Volume and Economic Growth

Using the model described in Chapter A1 and the parameters configured in the previous chapter, the estimated amounts for 2008 (baseline) and 2015, 2020, and 2025 (baseline, high, middle, and low cases) are as follows for each economy and total global values.

A3.1 Estimated Future Trade Value

A3.1.1 Total Value of Imports and Exports (see Figure A5 at end of this Annex)

The estimated amounts of future trade value are given as total amounts of imports and exports in Figure A5. These totals are indexed values assuming that the actual results in 2008 = 100 (actual results are based on the GTAP database). The actual results from the Global Insight Database are also shown within the range of available economies and years. When comparing the estimated amounts with the actual amounts, while some economies do have corresponding estimated and actual amounts for 2005, the actual results for many economies exceed the estimated amounts. As mentioned in the main body of this paper, the reason for this is that the years up to the financial crisis in 2008 can generally be interpreted as a time of imbalance as part of a global economic bubble.

When looking at the estimated results for each economy and region, most economies and regions have a baseline estimated amount between the middle and low case scenarios. Also, in many cases, this rate of growth gradually increases over the years. However, the rate of growth differs significantly between economies and regions, and while the rate is small in developed economies such as Japan, the United States, Canada, and Europe, it is extremely large in economies such as China and India.

A3.1.2 Export and Import Trade Values (Figure A6 and A7)

The export trade values in each economy and region are shown in Figure A6. In most economies and regions, the amount of exports displays the same trend (i.e., increasing more rapidly over time) as the estimated results for total imports and exports. On the one hand, in a few economies and regions such as Japan, the United States, and Europe, the rate of growth appears to have peaked at the present or will peak in the near future. This trend is particularly noticeable in Japan, where a negative growth rate is predicted in the low case. This is thought to be as a result of a relative decline in export competitiveness as developing economies such as China and India catch up with Japan in competiveness. In addition, the reason why this trend is most noticeable in Japan can be thought to be a preoccupation with future growth in order to replicate the actual amounts as much as possible in the estimation for 2008.

In the import amounts in Figure A7, the same trend as in the estimated results for total imports and exports can be observed, with little variation in the rate of growth between economies and regions.

A3.2 Estimated Results of Future GDP (Figure A8)

The estimated results of future GDP (actual amounts in 2004 prices) are shown in Figure A8. As described in A2.6 and shown in Table A5, this is given exogenously in the baseline scenario. In the figure, the baseline configuration amount and middle case estimates are almost the same or the baseline configuration amount is slightly smaller. In the low case scenario for Japan, a negative rate of GDP growth is estimated. This is thought to be due to multiple factors, including a decrease in the total factor productivity growth rate and decrease in the capital growth rate.

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Table A1 Rate of population change (pop) in each scenario and period (%)

No	ID	Economy / Region	Baseline, Middle Case					High Case				Low Case			
			2004-2008	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	Japan	0.07	-0.04	-0.90	-1.67	-2.31	0.27	0.21	-0.40	-1.07	-0.37	-2.07	-3.04	-3.66
2	kor	Republic of Korea	1.47	0.66	0.91	0.21	-0.41	1.04	2.30	1.81	1.09	0.28	-0.50	-1.46	-2.03
3	prc	China	2.43	1.15	2.74	2.35	1.73	1.50	4.15	4.05	3.33	0.78	1.29	0.67	0.18
4	hkg	Hong Kong, China	4.25	1.99	4.38	3.82	3.30	2.37	5.79	5.39	4.70	1.61	2.94	2.18	1.79
5	tpe	Chinese Taipei	1.57	0.75	1.54	1.04	0.46	0.77	1.67	1.27	0.75	0.73	1.41	0.75	0.11
6	xea	Rest of East Asia	1.84	0.80	2.09	2.07	1.82	1.15	3.52	3.84	3.51	0.45	0.64	0.22	-0.00
7	phl	Philippines	8.12	3.76	8.70	7.58	6.56	4.13	10.24	9.40	8.29	3.40	7.12	5.66	4.68
8	vnm	Vietnam	5.58	2.63	6.19	5.38	4.62	3.05	7.91	7.31	6.32	2.21	4.45	3.30	2.74
9	lao	Lao PDR	7.05	3.41	8.52	7.82	6.78	3.78	10.15	9.79	8.63	3.04	6.86	5.75	4.79
10	khm	Cambodia	7.26	3.45	9.31	8.78	7.66	3.81	10.95	10.74	9.41	3.08	7.64	6.72	5.76
11	tha	Thailand	2.78	1.32	2.52	1.84	1.20	1.70	3.94	3.46	2.73	0.94	1.06	0.14	-0.45
12	mys	Malaysia	7.29	3.36	7.62	6.57	5.46	3.72	9.18	8.40	7.17	2.98	6.03	4.64	3.62
13	sgp	Singapore	5.18	2.36	4.71	3.24	2.80	2.65	5.92	4.79	4.28	2.06	3.50	1.66	1.21
14	mmr	Myanmar	3.51	1.69	3.89	3.43	2.96	2.08	5.47	5.26	4.64	1.30	2.28	1.49	1.14
15	idn	Indonesia	4.93	2.31	4.99	4.09	3.57	2.71	6.59	5.94	5.30	1.91	3.36	2.15	1.71
16	xse	Rest of Southeast Asia (incl. Brunei Darussalam)	14.77	6.15	16.14	14.44	13.29	6.46	17.49	16.00	14.71	5.85	14.77	12.82	11.78
17	bgd	Bangladesh	7.16	3.31	8.09	7.34	6.56	3.65	9.55	9.11	8.28	2.83	6.18	5.17	4.49
18	ind	India	6.19	2.89	6.75	5.89	4.95	3.26	8.27	7.69	6.68	2.53	5.20	3.99	3.10
19	lka	Sri Lanka	1.86	0.94	1.96	1.35	0.49	1.33	3.50	3.15	2.17	0.55	0.39	-0.55	-1.33
20	pak	Pakistan	7.66	3.65	9.98	9.26	7.99	3.89	11.21	10.91	9.59	3.40	8.67	7.49	6.24
21	xsa	Rest of South Asia	12.27	5.65	13.49	12.16	11.52	5.93	14.72	13.64	12.92	5.31	11.97	10.39	9.90
22	rus	Russian Federation	-1.99	-1.03	-2.74	-2.98	-3.18	-0.63	-1.25	-1.38	-1.73	-1.43	-4.27	-4.73	-4.81
23	kaz	Kazakhstan	2.51	1.41	3.43	2.60	1.58	1.82	5.07	4.38	3.13	0.99	1.75	0.70	-0.14
24	kgz	Kyrgyztan	4.41	2.18	5.19	4.19	3.04	2.58	6.85	6.13	4.81	1.78	3.49	2.15	1.12
25	xsu	Rest of Former Soviet Union	0.56	0.33	1.11	0.80	0.22	0.73	2.70	2.60	1.83	-0.06	-0.50	-1.11	-1.55
26	usa	United States	4.01	1.92	4.55	4.11	3.61	2.25	5.88	5.70	5.14	1.59	3.20	2.46	1.99
27	can	Canada	3.77	1.79	4.26	3.97	3.62	2.11	5.58	5.52	5.06	1.46	2.93	2.35	2.08
28	mex	Mexico	4.38	2.23	4.95	4.15	3.43	2.64	6.58	6.05	5.25	1.83	3.28	2.14	1.46
29	xcm	Central America	5.69	2.70	6.82	6.23	5.51	3.06	8.30	7.99	7.22	2.34	5.28	4.36	3.67
30	per	Peru	4.80	2.29	6.49	5.76	4.94	2.67	8.05	7.60	6.67	1.91	4.87	3.83	3.07
31	chl	Chile	4.22	2.00	4.62	3.98	3.36	2.37	6.14	5.73	5.01	1.62	3.08	2.15	1.61
32	xap	South America West Coast	5.76	2.70	6.91	6.14	5.29	3.04	8.37	7.91	7.03	2.34	5.41	4.27	3.39
33	sae	South America East Coast	5.32	2.51	5.69	4.92	4.21	2.89	7.23	6.71	5.93	2.12	4.11	3.04	2.35
34	xme	Rest of Middle East	8.32	3.93	10.04	9.11	7.81	4.30	11.67	10.94	9.41	3.55	8.38	7.18	6.07
35	med	Mediterranean	3.83	1.82	4.02	3.38	2.79	2.19	5.49	5.06	4.32	1.44	2.52	1.61	1.11
36	eur	Europe	0.81	0.36	0.68	0.51	0.29	0.69	1.94	2.00	1.69	0.04	-0.60	-1.06	-1.24
37	afr	Africa	10.17	4.72	12.06	11.27	10.41	5.00	13.35	12.87	11.93	4.41	10.71	9.62	8.80
38	aus	Australia	4.31	2.01	4.84	4.56	4.17	2.34	6.15	6.10	5.58	1.68	3.51	2.95	2.64
39	nzl	New Zealand	3.98	1.78	4.01	3.57	3.21	2.11	5.31	5.14	4.67	1.46	2.68	1.94	1.63
40	xoc	Rest of Oceania (incl. Papua New Guinea)	7.61	3.48	8.06	7.47	7.03	3.83	9.54	9.28	8.78	3.13	6.55	5.59	5.16

Table A2 Rate of unskilled and skilled labor force change in each scenario and period

- Rate of change in labor population: *lab* (%)

No	ID	Economy / Region	Baseline, Middle Case					High Case				Low Case			
			2004-2008	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	Japan	-2.29	-1.59	-4.33	-3.25	-3.36	-1.29	-3.25	-2.00	-2.13	-1.91	-5.45	-4.59	-4.70
2	kor	Republic of Korea	3.54	1.46	3.18	1.57	1.54	1.84	4.60	3.19	3.08	1.08	1.74	-0.13	-0.11
3	prc	China	3.51	1.33	1.59	-0.94	-0.95	1.68	2.99	0.70	0.61	0.95	0.15	-2.57	-2.45
4	hkg	Hong Kong, China	6.22	1.96	1.95	-1.69	-1.72	2.34	3.33	-0.21	-0.39	1.58	0.55	-3.24	-3.15
5	tpe	Chinese Taipei	4.85	2.30	5.61	5.32	5.05	2.31	5.75	5.55	5.35	2.27	5.48	5.01	4.68
6	xea	Rest of East Asia	3.90	1.97	4.63	3.80	3.66	2.33	6.09	5.60	5.38	1.62	3.14	1.91	1.80
7	phl	Philippines	13.46	6.09	13.73	10.79	9.74	6.46	15.35	12.67	11.53	5.71	12.09	8.82	7.81
8	vnm	Vietnam	9.29	3.99	7.79	5.20	4.94	4.42	9.54	7.13	6.64	3.57	6.02	3.12	3.05
9	lao	Lao PDR	12.64	5.98	14.73	13.80	12.12	6.36	16.45	15.88	14.06	5.60	12.97	11.61	10.03
10	khm	Cambodia	12.17	5.34	11.86	10.68	9.65	5.70	13.54	12.67	11.44	4.97	10.15	8.59	7.72
11	tha	Thailand	4.74	2.04	3.58	1.82	1.78	2.42	5.02	3.44	3.33	1.65	2.12	0.12	0.13
12	mys	Malaysia	10.22	4.64	11.58	10.08	9.15	5.01	13.20	11.97	10.92	4.26	9.93	8.08	7.24
13	sgp	Singapore	5.79	2.65	5.12	0.64	0.64	2.94	6.33	2.15	2.09	2.35	3.90	-0.90	-0.92
14	mmr	Myanmar	7.87	3.54	7.65	6.01	5.67	3.93	9.28	7.89	7.39	3.13	5.98	4.03	3.80
15	idn	Indonesia	7.84	3.54	7.97	6.87	6.43	3.94	9.61	8.76	8.20	3.13	6.29	4.87	4.51
16	xse	Rest of Southeast Asia (incl. Brunei Darussalam)	25.05	7.67	12.21	13.34	11.77	7.98	13.51	14.89	13.17	7.36	10.88	11.73	10.28
17	bgd	Bangladesh	9.75	4.68	11.03	9.82	8.94	5.02	12.53	11.62	10.70	4.19	9.07	7.59	6.82
18	ind	India	7.77	3.60	8.77	7.58	7.04	3.97	10.32	9.41	8.80	3.23	7.20	5.65	5.16
19	lka	Sri Lanka	4.24	1.63	2.94	1.28	1.26	2.02	4.50	3.08	2.95	1.24	1.35	-0.62	-0.57
20	pak	Pakistan	15.05	7.25	17.75	15.38	13.33	7.50	19.06	17.12	15.01	6.98	16.34	13.51	11.50
21	xsa	Rest of South Asia	16.05	7.02	17.38	16.39	14.08	7.30	18.65	17.92	15.52	6.67	15.80	14.55	12.43
22	rus	Russian Federation	0.21	-0.50	-4.20	-6.44	-6.89	-0.10	-2.74	-4.89	-5.48	-0.90	-5.71	-8.13	-8.45
23	kaz	Kazakhstan	4.54	1.84	1.79	-1.41	-1.43	2.25	3.41	0.30	0.08	1.42	0.14	-3.24	-3.09
24	kgz	Kyrgyztan	9.03	4.08	8.35	6.31	5.93	4.49	10.07	8.28	7.75	3.67	6.60	4.23	3.96
25	xsu	Rest of Former Soviet Union	3.37	1.79	2.93	0.23	0.23	2.19	4.55	2.02	1.84	1.38	1.29	-1.67	-1.54
26	usa	United States	4.04	1.73	3.30	2.40	2.35	2.05	4.61	3.97	3.86	1.40	1.96	0.77	0.74
27	can	Canada	5.87	2.31	3.91	1.94	1.91	2.63	5.22	3.47	3.32	1.98	2.58	0.36	0.39
28	mex	Mexico	6.80	3.44	8.80	7.60	7.06	3.84	10.48	9.56	8.95	3.02	7.06	5.52	5.03
29	xcm	Central America	9.46	4.41	10.24	8.66	7.97	4.77	11.77	10.47	9.72	4.04	8.66	6.75	6.09
30	per	Peru	11.89	5.54	13.21	11.08	9.97	5.93	14.87	13.00	11.79	5.15	11.50	9.04	8.01
31	chl	Chile	5.14	2.72	6.78	4.90	4.67	3.09	8.32	6.67	6.34	2.34	5.21	3.06	2.90
32	xap	South America West Coast	12.22	5.49	12.76	10.68	9.65	5.85	14.30	12.52	11.46	5.13	11.17	8.72	7.67
33	sae	South America East Coast	8.14	3.54	7.89	6.56	6.16	3.92	9.47	8.38	7.91	3.15	6.28	4.65	4.26
34	xme	Rest of Middle East	15.26	6.52	14.79	11.97	10.69	6.90	16.49	13.86	12.34	6.13	13.06	9.99	8.91
35	med	Mediterranean	5.60	2.30	4.49	2.99	2.91	2.67	5.96	4.66	4.45	1.92	2.97	1.23	1.23
36	eur	Europe	1.22	0.26	-0.43	-1.65	-1.67	0.58	0.81	-0.18	-0.30	-0.07	-1.70	-3.19	-3.17
37	afr	Africa	10.21	5.10	13.41	13.51	11.91	5.38	14.72	15.15	13.45	4.78	12.04	11.83	10.27
38	aus	Australia	5.72	2.28	4.28	2.76	2.68	2.61	5.58	4.27	4.07	1.95	2.96	1.17	1.18
39	nzl	New Zealand	6.30	2.17	3.59	2.14	2.09	2.50	4.89	3.69	3.54	1.84	2.27	0.53	0.53
40	xoc	Rest of Oceania (incl. Papua New Guinea)	10.86	5.32	12.93	11.28	10.14	5.67	14.48	13.15	11.93	4.96	11.35	9.33	8.21

- Rate of change in share of skilled labor force: *dSHR_SkLab* (% point)

No	ID	Classification in the questionnaire survey	High Case				Middle Case				Low Case			
			2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
2	kor	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
3	prc	China	0.70	0.66	0.60	0.67	0.41	0.40	0.36	0.36	0.18	0.23	0.18	0.06
4	hkg	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
5	tpe	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
6	xea	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
7	phl	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
8	vnm	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
9	lao	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
10	khm	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
11	tha	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
12	mys	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
13	sgp	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
14	mmr	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
15	idn	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
16	xse	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
17	bgd	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
18	ind	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
19	lka	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
20	pak	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
21	xsa	Other developing Asian economies	0.59	0.56	0.54	0.57	0.34	0.37	0.35	0.36	0.09	0.20	0.18	0.18
22	rus	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
23	kaz	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
24	kgz	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
25	xsu	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
26	usa	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
27	can	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
28	mex	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
29	xcm	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
30	per	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
31	chl	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
32	xap	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
33	sae	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
34	xme	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
35	med	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
36	eur	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
37	afr	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
38	aus	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
39	nzl	Developed Economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07
40	xoc	Other economies	0.59	0.59	0.59	0.59	0.31	0.31	0.31	0.31	-0.07	-0.07	-0.07	-0.07

Table A3 Rate of capital stock change *qo(Capital)* in each scenario and period (%)

No	ID	Classification in the questionnaire survey	Baseline					High Case				Middle Case				Low Case			
			2004-2008	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	Japan	3.9	1.2	2.9	2.4	2.4	3.6	6.4	5.0	4.4	0.5	1.5	0.1	-0.8	-3.8	-3.2	-4.1	-4.4
2	kor	Other economies	9.8	5.3	12.9	12.9	12.9	11.2	18.9	18.5	18.5	8.5	16.1	14.8	14.9	5.0	12.4	11.7	11.4
3	prc	China	24.9	10.3	30.5	30.5	30.5	16.5	36.6	35.6	35.5	12.8	33.2	30.7	30.0	9.7	28.7	26.3	25.3
4	hkg	Other economies	13.6	4.3	13.7	13.7	13.7	12.3	22.0	21.5	21.4	8.6	18.2	16.4	16.5	3.8	13.1	12.1	11.6
5	tpe	Other economies	10.0	3.9	13.8	13.8	13.8	12.1	22.3	21.8	21.7	8.3	18.4	16.5	16.7	3.4	13.1	12.1	11.6
6	xea	Other developing Asian economies	24.2	7.5	14.7	14.7	14.7	17.2	24.4	24.0	23.7	12.7	20.6	20.2	19.2	7.2	15.3	14.1	12.8
7	phl	Other developing Asian economies	11.9	4.6	15.3	15.3	15.3	16.6	27.6	27.2	26.8	11.0	22.9	22.4	21.0	4.3	16.1	14.5	12.9
8	vnm	Other developing Asian economies	17.6	6.4	21.6	21.6	21.6	12.5	28.1	27.9	27.7	9.7	25.6	25.3	24.6	6.2	22.0	21.2	20.3
9	lao	Other developing Asian economies	16.9	7.8	20.5	20.5	20.5	17.5	30.6	30.2	29.9	13.0	26.7	26.2	25.1	7.5	21.1	19.8	18.5
10	khm	Other developing Asian economies	23.9	6.7	21.4	21.4	21.4	15.3	30.5	30.2	29.9	11.3	27.0	26.6	25.6	6.5	22.0	20.9	19.6
11	tha	Other developing Asian economies	10.2	5.3	16.9	16.9	16.9	13.1	24.8	24.6	24.3	9.5	21.8	21.4	20.6	5.1	17.4	16.4	15.3
12	mys	Other developing Asian economies	12.6	6.2	16.9	16.9	16.9	16.1	27.0	26.6	26.3	11.5	23.1	22.7	21.6	5.9	17.5	16.3	14.9
13	sgp	Other economies	14.2	5.4	15.2	15.2	15.2	12.7	22.8	22.3	22.3	9.3	19.3	17.7	17.8	4.9	14.6	13.7	13.3
14	mmr	Other developing Asian economies	7.2	4.1	10.9	10.9	10.9	13.5	20.2	19.9	19.6	9.1	16.6	16.2	15.2	3.8	11.5	10.3	9.0
15	idn	Other developing Asian economies	12.9	6.5	19.1	19.1	19.1	15.8	28.8	28.5	28.2	11.5	25.1	24.7	23.6	6.3	19.7	18.5	17.2
16	xse	Other developing Asian economies	3.7	2.8	8.1	8.1	8.1	12.2	17.2	16.9	16.6	7.8	13.7	13.3	12.3	2.6	8.7	7.5	6.3
17	bgd	Other developing Asian economies	14.3	4.9	19.3	19.3	19.3	13.1	27.9	27.6	27.3	9.3	24.6	24.2	23.3	4.7	19.8	18.7	17.6
18	ind	Other developing Asian economies	20.4	8.0	23.4	23.4	23.4	17.1	33.0	32.6	32.3	12.9	29.3	28.9	27.8	7.8	24.0	22.8	21.5
19	lka	Other developing Asian economies	14.5	5.5	13.8	13.8	13.8	14.8	23.0	22.7	22.4	10.5	19.5	19.1	18.1	5.3	14.3	13.2	12.0
20	pak	Other economies	14.1	5.1	16.9	16.9	16.9	16.3	28.7	27.9	27.9	11.2	23.2	20.7	20.9	4.5	16.0	14.6	13.9
21	xsa	Other developing Asian economies	8.7	5.8	15.9	15.9	15.9	15.4	25.6	25.2	24.9	11.0	21.8	21.4	20.3	5.6	16.4	15.2	13.9
22	rus	Other economies	15.7	6.2	15.3	15.3	15.3	15.9	25.4	24.8	24.7	11.5	20.8	18.6	18.8	5.6	14.6	13.3	12.8
23	kaz	Other economies	19.0	6.7	19.5	19.5	19.5	13.7	27.0	26.5	26.5	10.5	23.5	21.9	22.0	6.3	18.9	18.0	17.6
24	kgz	Other economies	9.6	7.8	17.9	17.9	17.9	20.9	31.5	30.6	30.6	14.9	25.2	22.3	22.5	7.0	16.8	15.1	14.4
25	xsu	Other economies	21.1	5.7	13.5	13.5	13.5	12.3	20.2	19.7	19.7	9.3	17.1	15.6	15.7	5.3	13.0	12.1	11.8
26	usa	Other economies	5.2	2.1	6.0	6.0	6.0	11.1	14.9	14.3	14.3	7.0	10.8	8.9	9.0	1.5	5.3	4.2	3.7
27	can	Other economies	4.7	2.8	7.5	7.5	7.5	11.2	15.8	15.2	15.2	7.3	11.9	10.2	10.3	2.3	6.8	5.8	5.3
28	mex	Other economies	6.7	3.7	11.9	11.9	11.9	12.5	20.9	20.3	20.3	8.5	16.8	14.8	15.0	3.2	11.2	10.1	9.6
29	xcm	Other economies	12.0	4.3	12.3	12.3	12.3	14.3	22.5	21.8	21.8	9.7	17.8	15.6	15.7	3.8	11.5	10.3	9.7
30	per	Other economies	18.4	6.7	18.5	18.5	18.5	16.5	28.9	28.2	28.2	12.0	24.1	21.9	22.0	6.1	17.7	16.4	15.8
31	chl	Other economies	10.3	4.6	13.9	13.9	13.9	13.2	22.7	22.2	22.1	9.2	18.6	16.7	16.9	4.1	13.2	12.1	11.6
32	xap	Other economies	8.6	4.2	12.3	12.3	12.3	13.1	21.5	20.9	20.8	9.0	17.2	15.3	15.4	3.7	11.6	10.5	10.0
33	sae	Other economies	12.8	3.9	9.7	9.7	9.7	13.2	19.1	18.5	18.4	8.9	14.7	12.8	12.9	3.4	9.0	7.9	7.4
34	xme	Other economies	8.4	4.9	13.4	13.4	13.4	13.0	21.8	21.3	21.2	9.3	17.9	16.1	16.2	4.4	12.8	11.7	11.3
35	med	Other economies	5.7	2.3	8.3	8.3	8.3	9.6	15.7	15.2	15.2	6.3	12.2	10.7	10.8	1.9	7.7	6.8	6.4
36	eur	Other economies	4.8	1.8	6.8	6.8	6.8	11.0	15.9	15.4	15.3	6.8	11.7	9.7	9.9	1.3	6.1	4.9	4.4
37	afr	Other economies	12.5	6.1	14.5	14.5	14.5	18.2	27.0	26.2	26.1	12.7	21.2	18.6	18.7	5.4	13.6	12.0	11.3
38	aus	Other economies	6.2	3.1	9.7	9.7	9.7	9.8	16.5	16.0	16.0	6.7	13.3	11.9	12.0	2.7	9.2	8.4	8.0
39	nzl	Other economies	3.8	2.3	7.6	7.6	7.6	9.5	14.8	14.3	14.3	6.2	11.4	9.9	10.0	1.9	7.0	6.1	5.7
40	xoc	Other economies	7.8	3.7	7.1	7.1	7.1	11.9	15.2	14.6	14.6	8.2	11.4	9.7	9.8	3.3	6.5	5.5	5.1

Table A4 Rate of natural resource change *qo(Netras)* in each scenario and period (%)

No	ID	Classification in the questionnaire survey	Baseline					High Case				Middle Case				Low Case			
			2004-2008	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
2	kor	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
3	prc	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
4	hkg	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
5	tpe	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
6	xea	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
7	phl	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
8	vnm	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
9	lao	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
10	khm	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
11	tha	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
12	mys	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
13	sgp	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
14	mmr	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
15	idn	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
16	xse	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
17	bgd	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
18	ind	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
19	lka	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
20	pak	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
21	xsa	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
22	rus	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
23	kaz	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
24	kgz	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
25	xsu	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
26	usa	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
27	can	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
28	mex	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
29	xcm	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
30	per	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
31	chl	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
32	xap	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
33	sae	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
34	xme	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
35	med	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
36	eur	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
37	afr	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
38	aus	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
39	nzl	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6
40	xoc	World	15.2	4.0	10.4	10.4	10.4	5.5	13.9	13.7	12.8	4.6	12.2	11.3	9.7	3.8	10.0	8.3	6.6

Table A5 Rate of total factor productivity and GDP change in each scenario and period

- Rate of total factor productivity change (%): *afereg*

No	ID	Classification in the questionnaire survey	Baseline 2004-2008	Baseline 2008-2010	Baseline 2010-2015	Baseline 2015-2020	Baseline 2020-2025	High Case 2008-2010	High Case 2010-2015	High Case 2015-2020	High Case 2020-2025	Middle Case 2008-2010	Middle Case 2010-2015	Middle Case 2015-2020	Middle Case 2020-2025	Low Case 2008-2010	Low Case 2010-2015	Low Case 2015-2020	Low Case 2020-2025
1	jpn	Japan	7.5	2.9	7.3	5.8	5.8	4.3	11.4	9.3	10.4	2.4	8.3	6.9	7.6	1.0	3.9	3.6	5.4
2	kor	Developed Economies	11.7	7.1	16.8	17.6	17.6	10.7	26.0	28.2	31.6	6.0	19.0	21.0	22.8	2.5	9.0	11.1	16.2
3	prc	Other economies	33.3	14.7	41.8	43.3	43.2	18.3	53.3	56.3	60.4	13.5	44.5	47.5	49.6	9.9	32.1	35.3	41.5
4	hkg	Developed Economies	15.5	5.2	17.7	19.5	19.3	7.8	27.4	31.1	34.7	4.3	20.0	23.2	25.1	1.8	9.5	12.3	17.8
5	tpe	Developed Economies	12.3	4.7	17.3	17.5	17.6	7.1	26.8	27.9	31.6	3.9	19.6	20.8	22.8	1.7	9.3	11.0	16.2
6	xea	Other economies	31.0	9.9	18.2	18.6	18.7	12.4	23.2	24.2	26.1	9.1	19.4	20.4	21.4	6.7	14.0	15.2	17.9
7	phl	Other economies	10.2	4.1	14.8	16.0	16.5	5.1	18.9	20.8	23.1	3.8	15.8	17.5	19.0	2.8	11.4	13.0	15.9
8	vnm	Other economies	19.7	8.3	28.8	30.3	30.5	10.4	36.8	39.4	42.7	7.6	30.7	33.2	35.1	5.6	22.1	24.7	29.3
9	lao	Other economies	18.7	9.8	25.6	27.2	28.9	12.3	32.6	35.3	40.4	9.0	27.3	29.8	33.2	6.6	19.7	22.2	27.8
10	khm	Other economies	26.6	7.9	25.7	27.2	28.8	9.9	32.7	35.3	40.2	7.3	27.4	29.8	33.1	5.3	19.7	22.2	27.6
11	tha	Other economies	10.7	6.4	19.7	20.3	20.4	8.0	25.2	26.4	28.5	5.9	21.0	22.3	23.4	4.3	15.2	16.6	19.6
12	mys	Other economies	11.8	6.8	17.8	18.6	19.2	8.5	22.7	24.2	26.8	6.2	18.9	20.4	22.1	4.6	13.7	15.2	18.4
13	sgp	Developed Economies	16.7	6.4	18.2	20.6	20.4	9.6	28.3	32.9	36.6	5.4	20.7	24.5	26.5	2.3	9.8	13.0	18.8
14	mmr	Other economies	7.2	4.9	13.6	14.5	14.8	6.2	17.3	18.8	20.7	4.5	14.5	15.8	17.0	3.3	10.4	11.8	14.2
15	idn	Other economies	14.1	7.9	22.6	23.1	23.4	9.8	28.8	30.1	32.7	7.2	24.1	25.3	26.9	5.3	17.3	18.8	22.5
16	xse	Other economies	-6.4	1.0	5.9	5.5	6.0	1.2	7.5	7.1	8.3	0.9	6.3	6.0	6.9	0.7	4.5	4.5	5.7
17	bgd	Other economies	16.2	5.3	23.1	24.4	25.5	6.7	29.4	31.7	35.6	4.9	24.6	26.7	29.3	3.6	17.7	19.9	24.5
18	ind	Other economies	24.8	10.3	28.6	29.6	30.2	12.8	36.5	38.4	42.2	9.4	30.5	32.4	34.7	6.9	22.0	24.1	29.0
19	lka	Other economies	18.1	7.3	18.1	18.9	19.0	9.2	23.0	24.6	26.5	6.7	19.3	20.7	21.8	5.0	13.9	15.4	18.2
20	pak	Other economies	13.5	4.6	16.9	18.7	20.2	5.7	21.6	24.3	28.2	4.2	18.1	20.4	23.2	3.1	13.0	15.2	19.4
21	xsa	Other economies	4.8	5.6	15.1	16.1	17.7	6.9	19.2	21.0	24.8	5.1	16.1	17.7	20.4	3.8	11.6	13.2	17.0
22	rus	Developed Economies	21.2	9.0	22.8	23.6	23.5	13.6	35.3	37.8	42.2	7.6	25.8	28.1	30.5	3.2	12.2	14.9	21.6
23	kaz	Other economies	25.2	9.3	27.6	29.5	29.2	11.7	35.2	38.3	40.8	8.6	29.4	32.3	33.6	6.3	21.2	24.0	28.0
24	kgz	Other economies	9.5	9.0	20.0	20.9	21.2	11.3	25.5	27.2	29.6	8.3	21.3	22.9	24.4	6.1	15.3	17.1	20.4
25	xsu	Developed Economies	28.7	7.8	18.1	19.4	19.1	11.7	28.0	31.0	34.3	6.5	20.5	23.0	24.8	2.7	9.7	12.2	17.6
26	usa	Developed Economies	5.8	2.3	7.6	8.2	8.3	3.4	11.7	13.2	14.8	1.9	8.6	9.8	10.7	0.8	4.1	5.2	7.6
27	can	Developed Economies	3.7	3.0	9.2	10.4	10.4	4.6	14.2	16.7	18.7	2.5	10.4	12.4	13.5	1.1	4.9	6.6	9.6
28	mex	Other economies	6.0	3.6	11.8	12.3	12.6	4.5	15.1	16.0	17.5	3.3	12.6	13.5	14.4	2.5	9.1	10.1	12.0
29	xcm	Other economies	11.9	4.1	11.9	12.7	13.1	5.1	15.2	16.6	18.3	3.8	12.7	14.0	15.1	2.8	9.2	10.4	12.6
30	per	Other economies	20.0	7.2	19.6	21.0	21.8	9.1	25.0	27.3	30.4	6.6	20.9	23.0	25.0	4.9	15.0	17.1	20.9
31	chl	Other economies	11.8	5.4	15.9	16.8	16.9	6.7	20.2	21.8	23.6	4.9	16.9	18.4	19.5	3.6	12.2	13.7	16.3
32	xap	Other economies	6.4	3.7	11.5	12.5	12.9	4.6	14.7	16.2	18.1	3.4	12.3	13.7	14.9	2.5	8.9	10.2	12.4
33	sae	Other economies	14.0	4.0	10.1	10.9	11.1	5.0	12.9	14.1	15.5	3.7	10.8	11.9	12.8	2.7	7.8	8.8	10.7
34	xme	Other economies	5.4	4.3	11.8	12.6	13.0	5.4	15.0	16.4	18.2	3.9	12.6	13.8	15.0	2.9	9.1	10.3	12.5
35	med	Developed Economies	5.4	2.2	9.6	10.4	10.4	3.3	14.9	16.6	18.6	1.9	10.9	12.3	13.5	0.8	5.2	6.5	9.5
36	eur	Developed Economies	6.8	2.7	10.8	11.5	11.5	4.1	16.8	18.5	20.6	2.3	12.2	13.7	14.9	1.0	5.8	7.3	10.5
37	afr	Other economies	12.2	6.3	13.6	13.6	14.5	7.9	17.3	17.7	20.2	5.8	14.5	14.9	16.6	4.3	10.4	11.1	13.9
38	aus	Developed Economies	6.0	3.5	12.2	13.2	13.2	5.3	18.9	21.1	23.6	2.9	13.8	15.7	17.1	1.2	6.6	8.3	12.1
39	nzl	Developed Economies	2.4	2.3	9.1	9.9	9.8	3.5	14.1	15.8	17.6	2.0	10.3	11.7	12.8	0.8	4.9	6.2	9.1
40	xoc	Other economies	5.9	2.9	4.0	4.7	5.1	3.6	5.1	6.0	7.1	2.7	4.2	5.1	5.9	2.0	3.0	3.8	4.9

- Real GDP growth rate (%): *qgdp*

No	ID	Classification in the questionnaire survey	Baseline 2004-2008	Baseline 2008-2010	Baseline 2010-2015	Baseline 2015-2020	Baseline 2020-2025
1	jpn	Japan	7.8	2.4	5.9	4.8	4.8
2	kor	Developed Economies	19.6	10.6	25.8	25.8	25.8
3	prc	Other economies	49.8	20.6	61.1	61.1	61.1
4	hkg	Developed Economies	27.3	8.6	27.4	27.4	27.4
5	tpe	Developed Economies	19.9	7.7	27.6	27.6	27.6
6	xea	Other economies	48.4	15.0	29.5	29.5	29.5
7	phl	Other economies	23.8	9.2	30.7	30.7	30.7
8	vnm	Other economies	35.3	12.8	43.2	43.2	43.2
9	lao	Other economies	33.7	15.5	41.0	41.0	41.0
10	khm	Other economies	47.8	13.4	42.9	42.9	42.9
11	tha	Other economies	20.4	10.7	33.8	33.8	33.8
12	mys	Other economies	25.3	12.4	33.8	33.8	33.8
13	sgp	Developed Economies	28.4	10.7	30.4	30.4	30.4
14	mmr	Other economies	14.4	8.2	21.8	21.8	21.8
15	idn	Other economies	25.7	13.0	38.3	38.3	38.3
16	xse	Other economies	7.4	5.7	16.3	16.3	16.3
17	bgd	Other economies	28.6	9.9	38.6	38.6	38.6
18	ind	Other economies	40.7	16.1	46.8	46.8	46.8
19	lka	Other economies	29.0	11.1	27.6	27.6	27.6
20	pak	Other economies	28.3	10.3	33.8	33.8	33.8
21	xsa	Other economies	17.4	11.7	31.7	31.7	31.7
22	rus	Developed Economies	31.3	12.4	30.7	30.7	30.7
23	kaz	Other economies	38.1	13.4	38.9	38.9	38.9
24	kgz	Other economies	19.2	15.5	35.7	35.7	35.7
25	xsu	Developed Economies	42.2	11.4	27.0	27.0	27.0
26	usa	Developed Economies	10.5	4.1	11.9	11.9	11.9
27	can	Developed Economies	9.4	5.6	15.0	15.0	15.0
28	mex	Other economies	13.4	7.4	23.9	23.9	23.9
29	xcm	Other economies	24.0	8.7	24.6	24.6	24.6
30	per	Other economies	36.7	13.4	37.0	37.0	37.0
31	chl	Other economies	20.7	9.2	27.7	27.7	27.7
32	xap	Other economies	17.2	8.4	24.6	24.6	24.6
33	sae	Other economies	25.5	7.8	19.5	19.5	19.5
34	xme	Other economies	16.8	9.8	26.8	26.8	26.8
35	med	Developed Economies	11.4	4.6	16.5	16.5	16.5
36	eur	Developed Economies	9.6	3.7	13.5	13.5	13.5
37	afr	Other economies	24.9	12.1	29.0	29.0	29.0
38	aus	Developed Economies	12.4	6.2	19.4	19.4	19.4
39	nzl	Developed Economies	7.7	4.7	15.2	15.2	15.2
40	xoc	Other economies	15.5	7.5	14.3	14.3	14.3

Table A6 Rate of average tariff rate change *tm(s)* in each scenario and period (% point)

No	ID	Classification in the questionnaire survey	High Case				Middle Case				Low Case			
			2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1	jpn	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
2	kor	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
3	prc	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
4	hkg	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
5	tpe	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
6	xea	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
7	phl	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
8	vnm	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
9	lao	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
10	khm	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
11	tha	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
12	mys	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
13	sgp	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
14	mmr	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
15	idn	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
16	xse	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
17	bgd	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
18	ind	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
19	lka	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
20	pak	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
21	xsa	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
22	rus	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
23	kaz	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
24	kgz	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
25	xsu	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
26	usa	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
27	can	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
28	mex	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
29	xcm	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
30	per	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
31	chl	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
32	xap	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
33	sae	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
34	xme	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
35	med	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
36	eur	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
37	afr	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
38	aus	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
39	nzl	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64
40	xoc	World	-3.06	-0.13	-0.19	-0.12	-1.50	-0.12	-0.50	-0.09	0.64	0.13	0.06	-0.64

Table A7 State of progress in FTA and EPA

- Assumed state indices in each combination of economies/regions

No.		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	33	34	35	36	37	38	39	40
	ID	jpn	kor	prc	hkg	tpe	xea	phl	vnm	lao	khm	tha	mys	sgp	mmr	idn	xse	bgd	ind	lka	pak	xsa	rus	kaz	kgz	xsu	usa	can	mex	xcm	per	chl	xap	sae	xme	med	eur	afr	aus	nzl	xoc
1	jpn		3	4	5	5		2	3	1	1	1	1	1	1	2	1		3				5				5	5	1		6	1					4		3	4	6
2	kor	3		4	5	5		1	1	1	1	3	1	1	1	1	1		3				4				2	3	3		4	1		4		3	3		4	4	6
3	prc	4	4		1	6		1	1	1	1	1	1	1	1	1	1		4				6				6	6	6	4	3	1							3	3	6
4	hkg	5	5	1		5		6	6	6	6	6	6	5	6	6	6						5				5	5	5		6	5							5	5	6
5	tpe	5	5	6	5			6	6	6	6	6	6	5	6	6	6						5				5	5	5	1	6	5							5	5	6
6	xea																																								
7	phl	2	1	1	6	6			1	1	1	1	1	1	1	1	1		3				6				4	6	6		6	6				3	3		3	3	6
8	vnm	3	1	1	6	6		1		1	1	1	1	1	1	1	1		3				6				4	6	6		6	6				3	3		3	3	6
9	lao	1	1	1	6	6		1	1		1	1	1	1	1	1	1		3				6				6	6	6		6	6			1	3	3		3	3	6
10	khm	1	1	1	6	6		1	1	1		1	1	1	1	1	1		3				6				6	6	6		6	6				3	3		3	3	6
11	tha	1	3	1	6	6		1	1	1	1		1	1	1	1	1	3	3	3			6				3	6	6		3	6				3	3		1	1	6
12	mys	1	1	1	6	6		1	1	1	1	1		1	1	1	1		3				6				3	6	6		6	4				3	3		3	3	6
13	sgp	1	1	1	5	5		1	1	1	1	1	1		1	1	1		1	4			5				1	3	3		3	1				1	1		1	1	6
14	mmr	1	1	1	6	6		1	1	1	1	1	1	1		1	1		3		1	1	6				6	6	6		6	6				3	3		3	3	6
15	idn	2	1	1	6	6		1	1	1	1	1	1	1	1		1		3				6				6	6	6		6	6				3	3		3	3	6
16	xse	1	1	1	6	6		1	1	1	1	1	1	1	1	1	1		3				6	1	1	1	6	6	6		6	6				3	3		3	3	6
17	bgd											3							1	1																					
18	ind	3	3	4				3	3	3	3	3	3	1	3	3	3	1		1			3									3		3		3	3		4		
19	lka											3		4				1	1																						
20	pak														1			1	1	1																					
21	xsa														1			1	1	1																					
22	rus	5	4	6	5	5		6	6	6	6	6	6	5	6	6	6		3					1	1	1	5	5	5		6	5							5	5	6
23	kaz																1						1																		
24	kgz																1						1																		
25	xsu																1						1																		
26	usa	5	2	6	5	5		4	4	6	6	3	3	1	6	6	6						5					1	1	1	2	1	4	4	4				1	5	6
27	can	5	3	6	5	5		6	6	6	6	6	6	3	6	6	6						5				1		1	3	4	1	3	3					5	5	6
28	mex	1	3	6	5	5		6	6	6	6	6	6	3	6	6	6						5				1	1		1	4	1	1	1		1	1		4	5	6
29	xcm			4		1																					1	3	1		4	1	4	4		3	3				
30	per	6	4	3	6	6		6	6	6	6	3	6	3	6	6	6						6				2	4	4	4		2	1	1		4	4		6	6	6
31	chl	1	1	1	5	5		6	6	6	6	6	4	1	6	6	6		3				5				1	1	1	1	2		4	1		1	1		3	1	6
32	xap																										4	3	1	4	1	4	1	1		4	4				
33	sae		4																3								4	3	1	4	1	1	1			3	3				
34	xme									1																	4												4		
35	med		3					3	3	3	3	3	3	1	3	3	3		3										1	3	4	1	4	3		1	1				
36	eur	4	3					3	3	3	3	3	3	1	3	3	3		3										1	3	4	1	4	3		1	1	1			
37	afr																																				1				
38	aus	3	4	3	5	5		3	3	3	3	1	3	1	3	3	3		4				5				1	5	4		6	3			4					1	4
39	nzl	4	4	3	5	5		3	3	3	3	1	3	1	3	3	3						5				5	5	5		6	1							1		6
40	xoc	6	6	6	6	6		6	6	6	6	6	6	6	6	6	6						6				6	6	6		6	6							4	6	

- Assumed progress by time period for each scenario (expressed in state index)

Baseline					High Case				Middle Case				Low Case			
2004-2008	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025	2008-2010	2010-2015	2015-2020	2020-2025
1,2	1,2	1,2	1,2	1,2	1-5	1-5	1-6	1-6	1-3	1-3	1-4	1-4	1-3	1-3	1-3	1-3

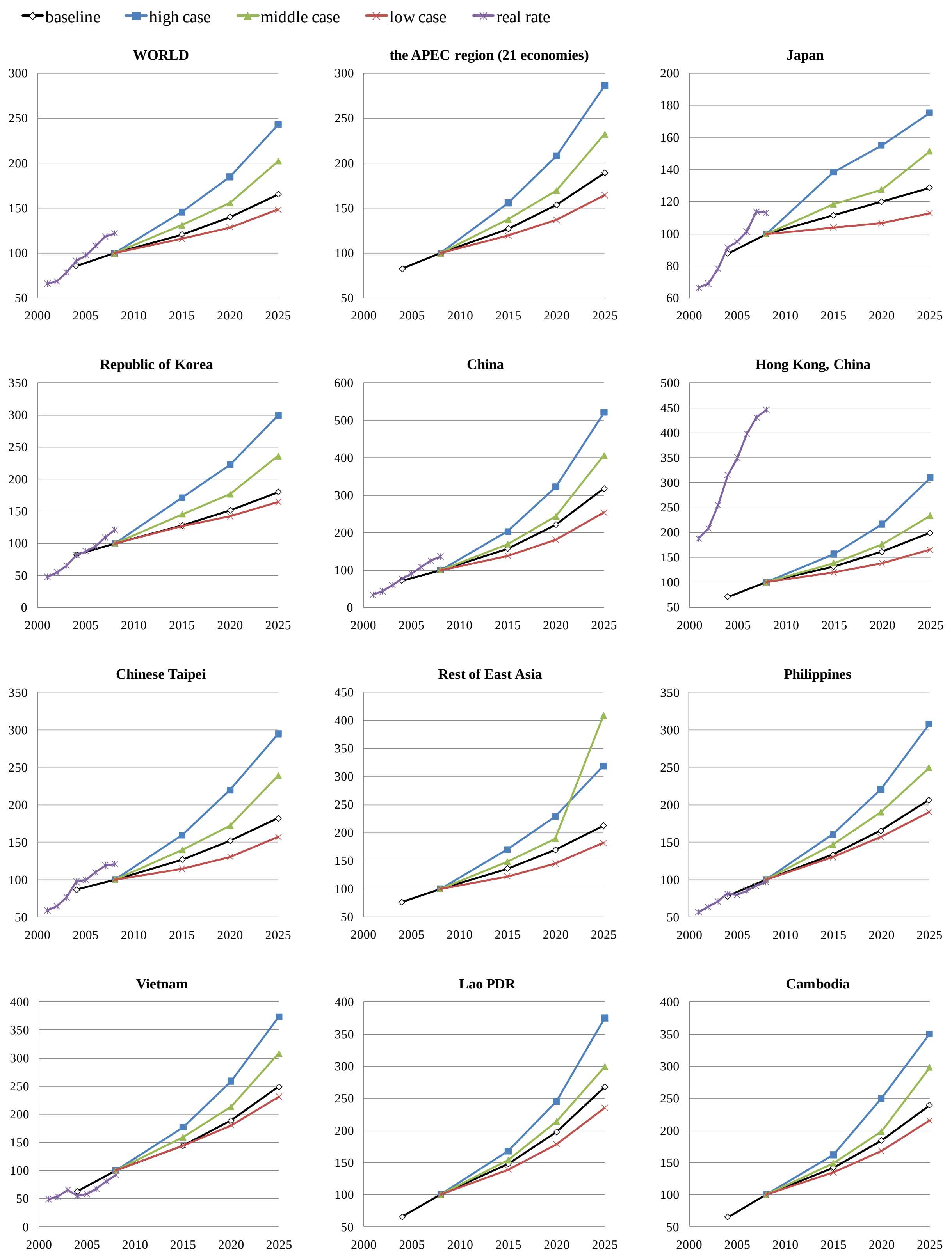


Figure A5 Results of estimated trade value (total imports and exports) in each economy and region (2008 = 100) (1/4)

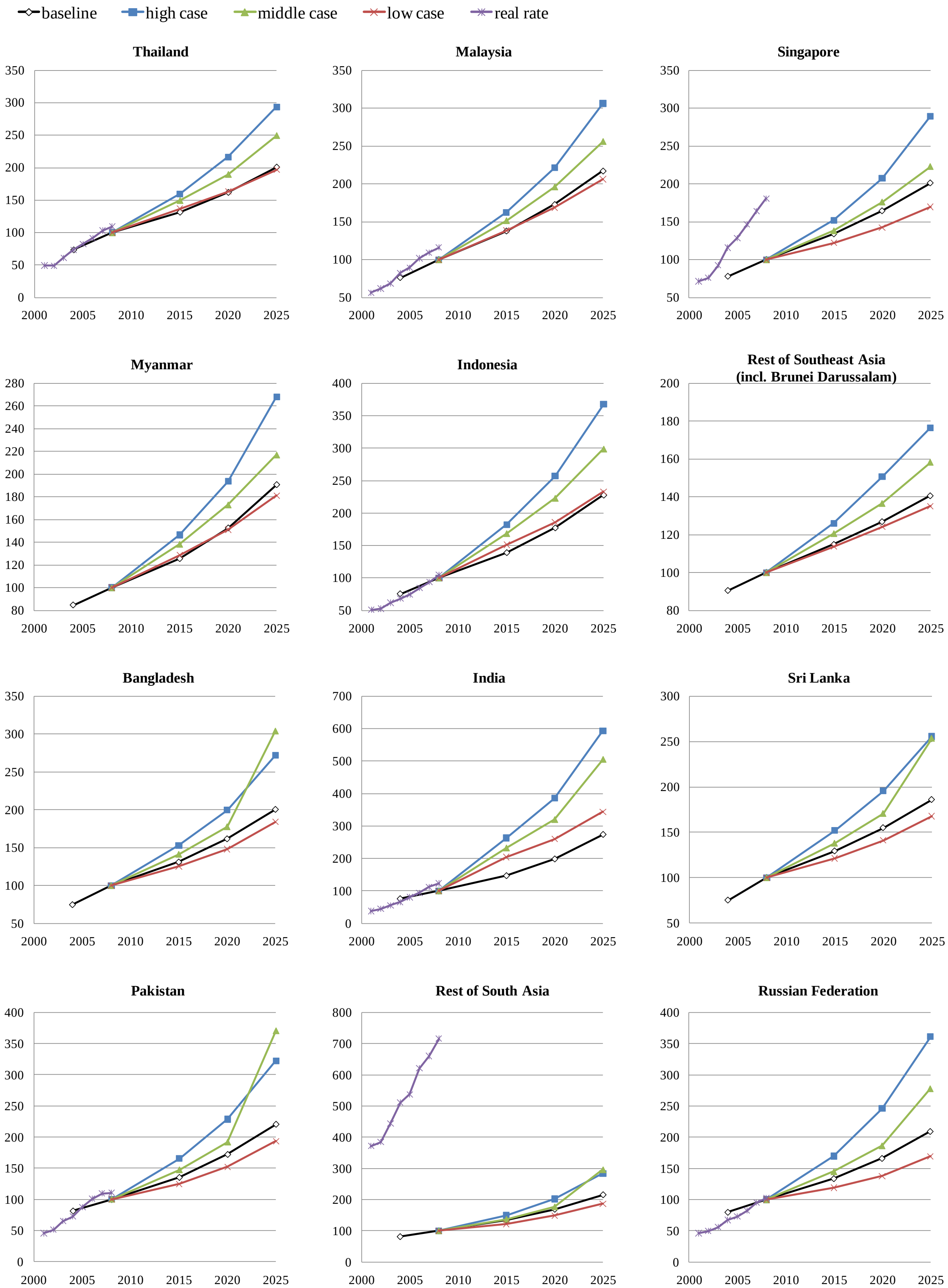


Figure A5 Results of estimated trade value (total imports and exports) in each economy and region (2008 = 100) (2/4)

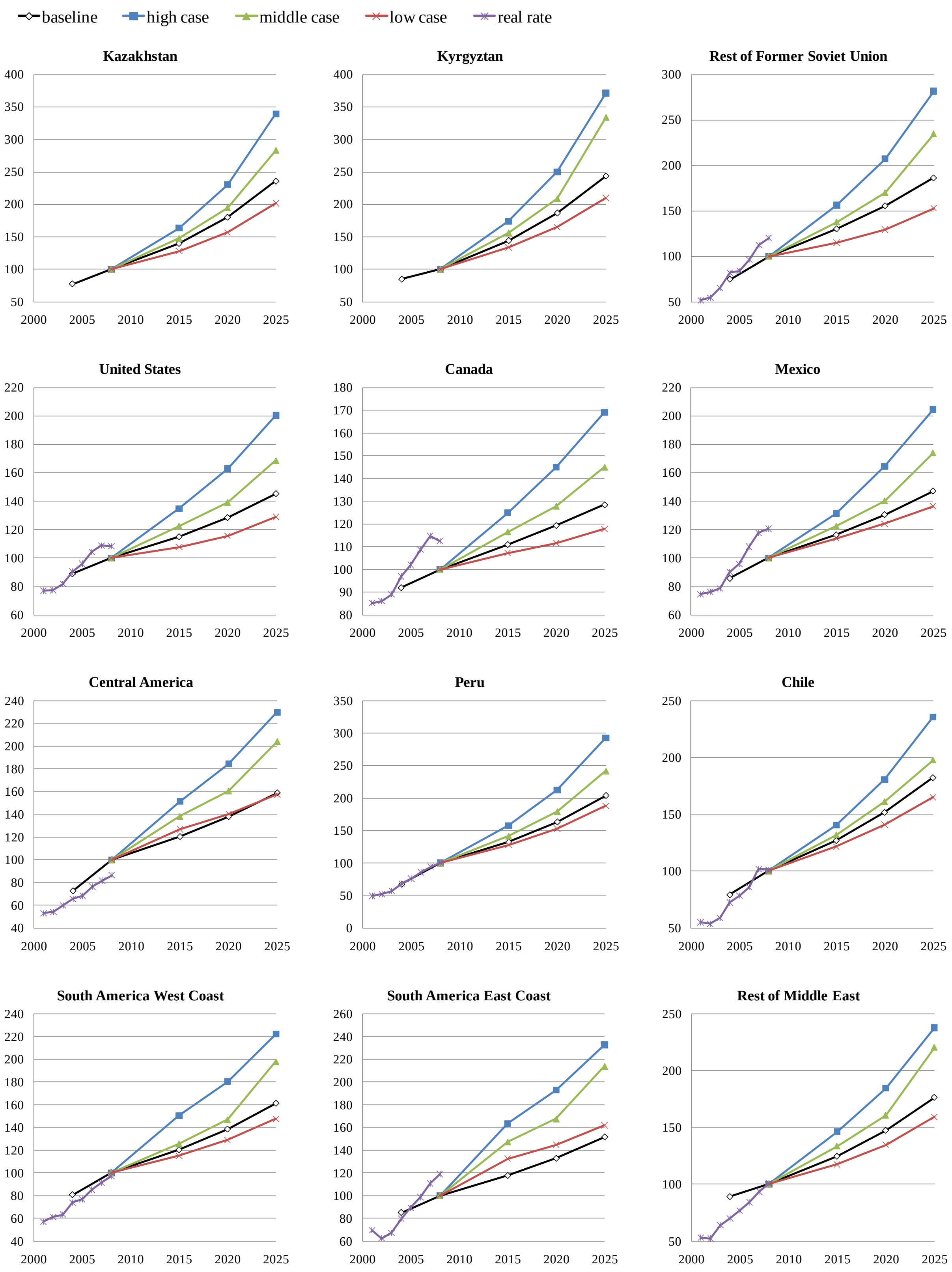


Figure A5 Results of estimated trade vallue (total imports and exports) in each economy and region (2008 = 100) (3/4)

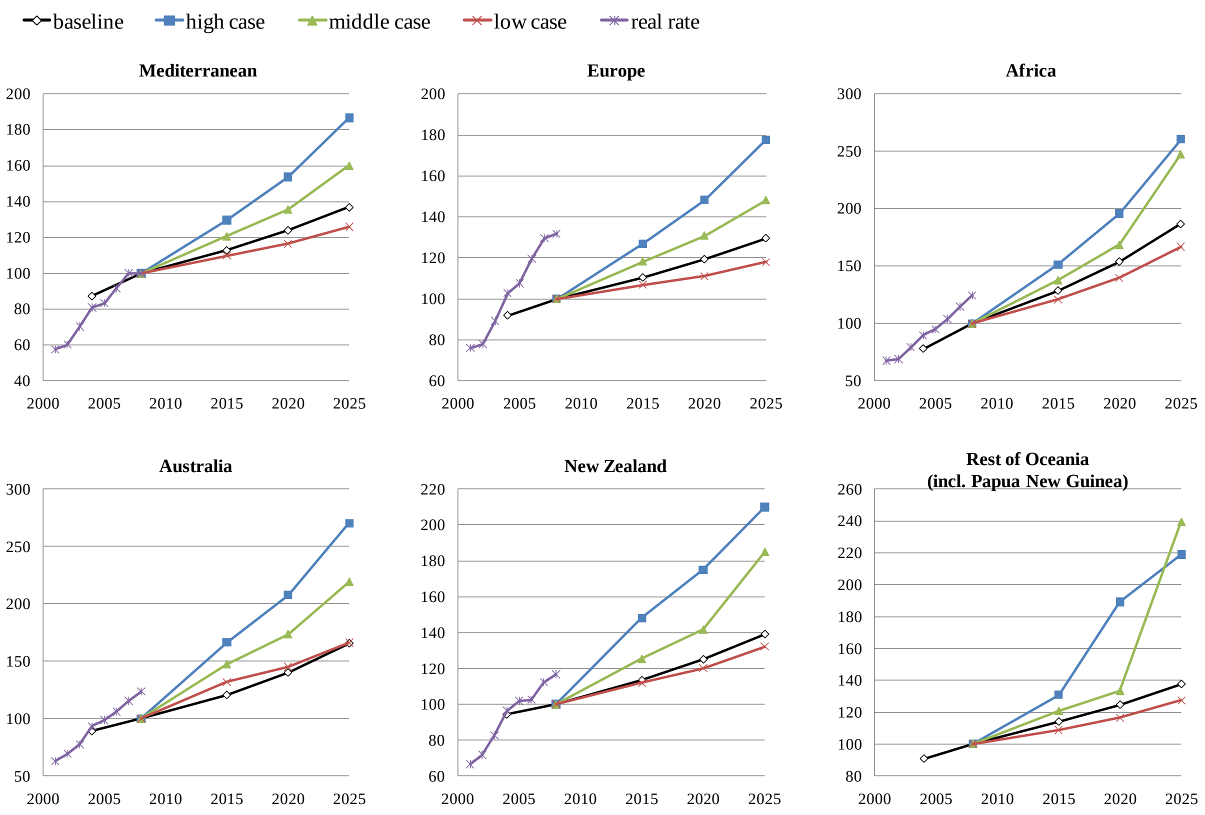


Figure A5. Results of estimated trade value (total imports and exports) in each economy and region (2008 = 100) (4/4)

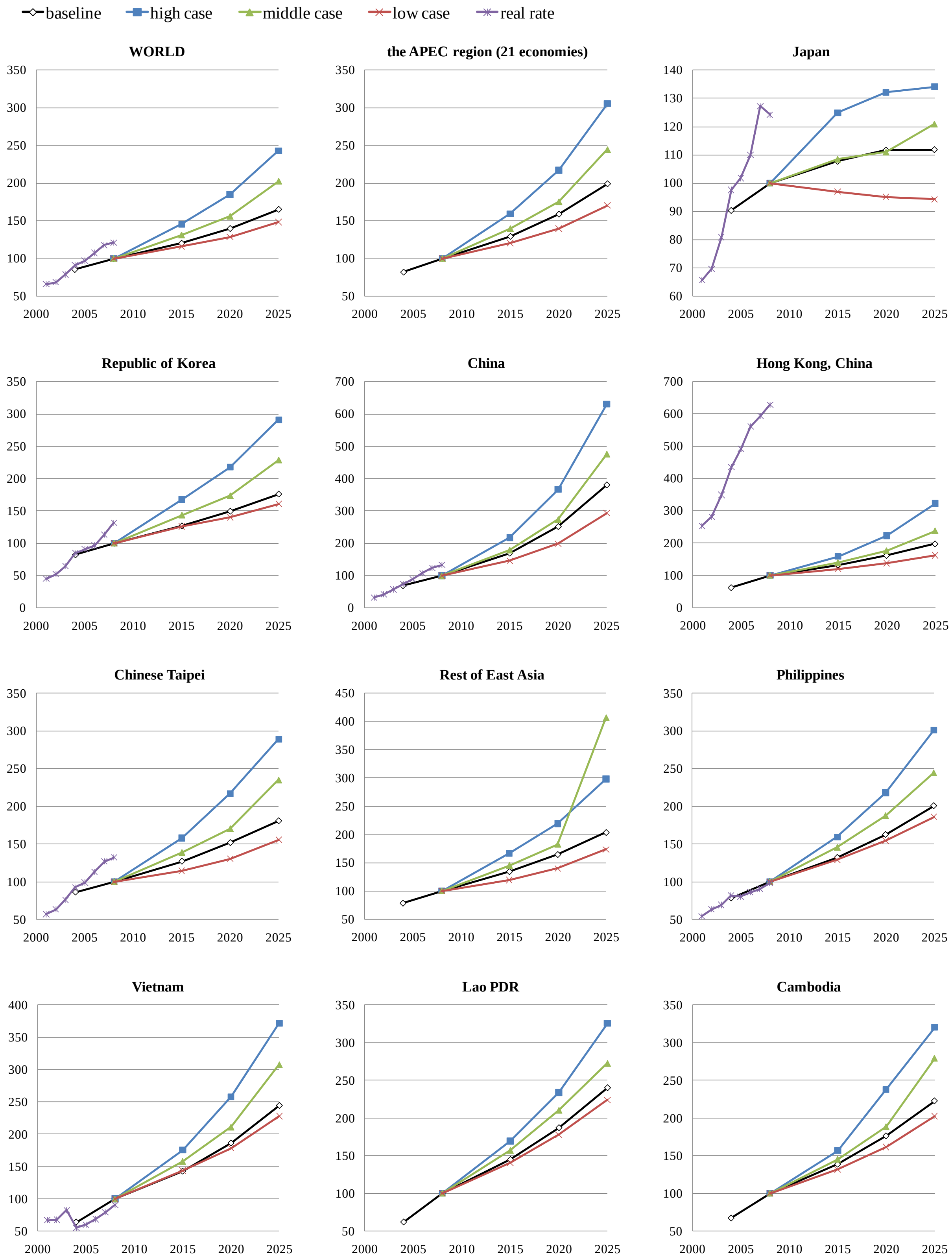


Figure A6 Results of estimated *export* trade value in each economy and region (2008 = 100) (1/4)

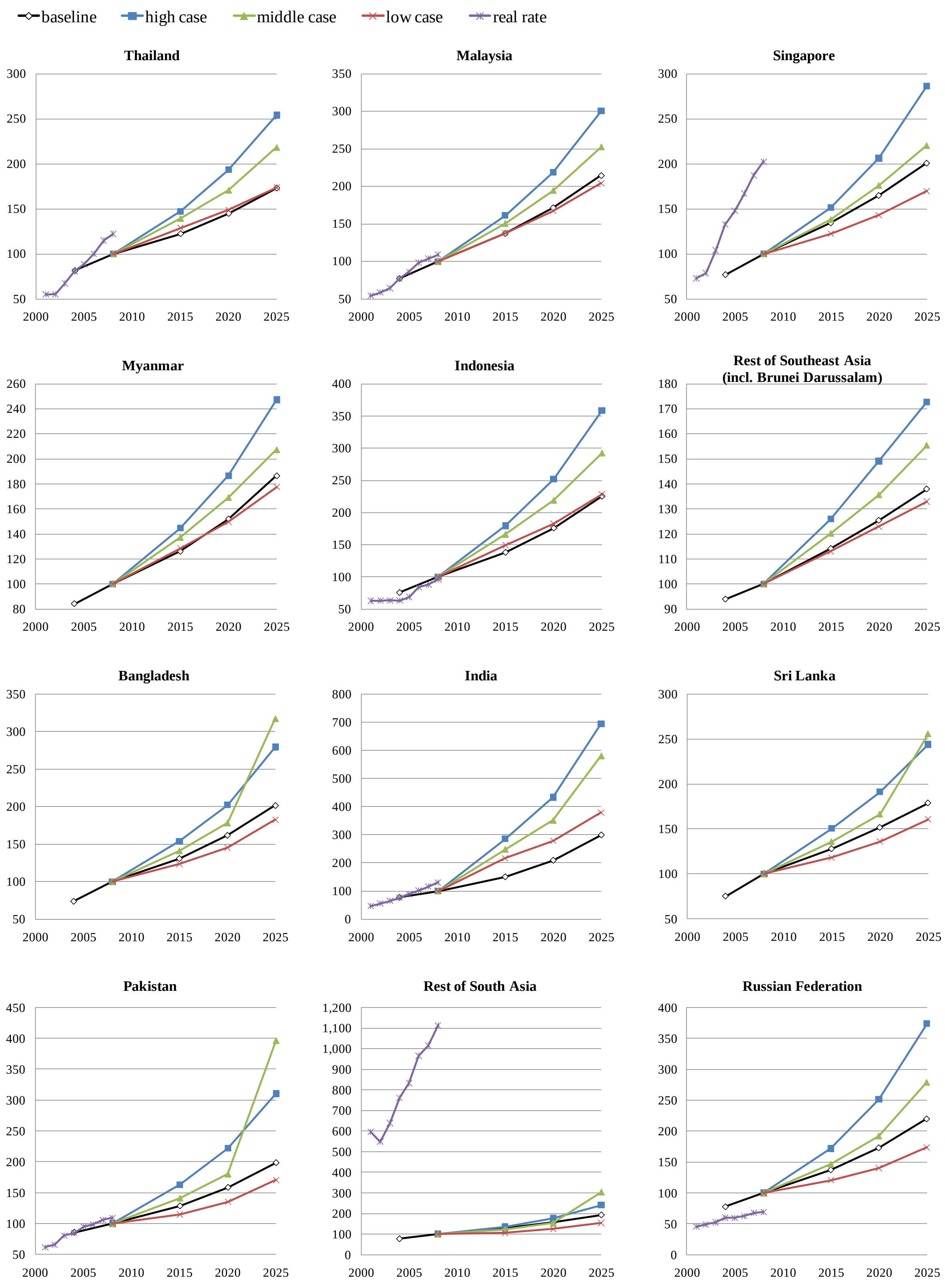


Figure A6 Results of estimated *export* trade value in each economy and region (2008 = 100) (2/4)

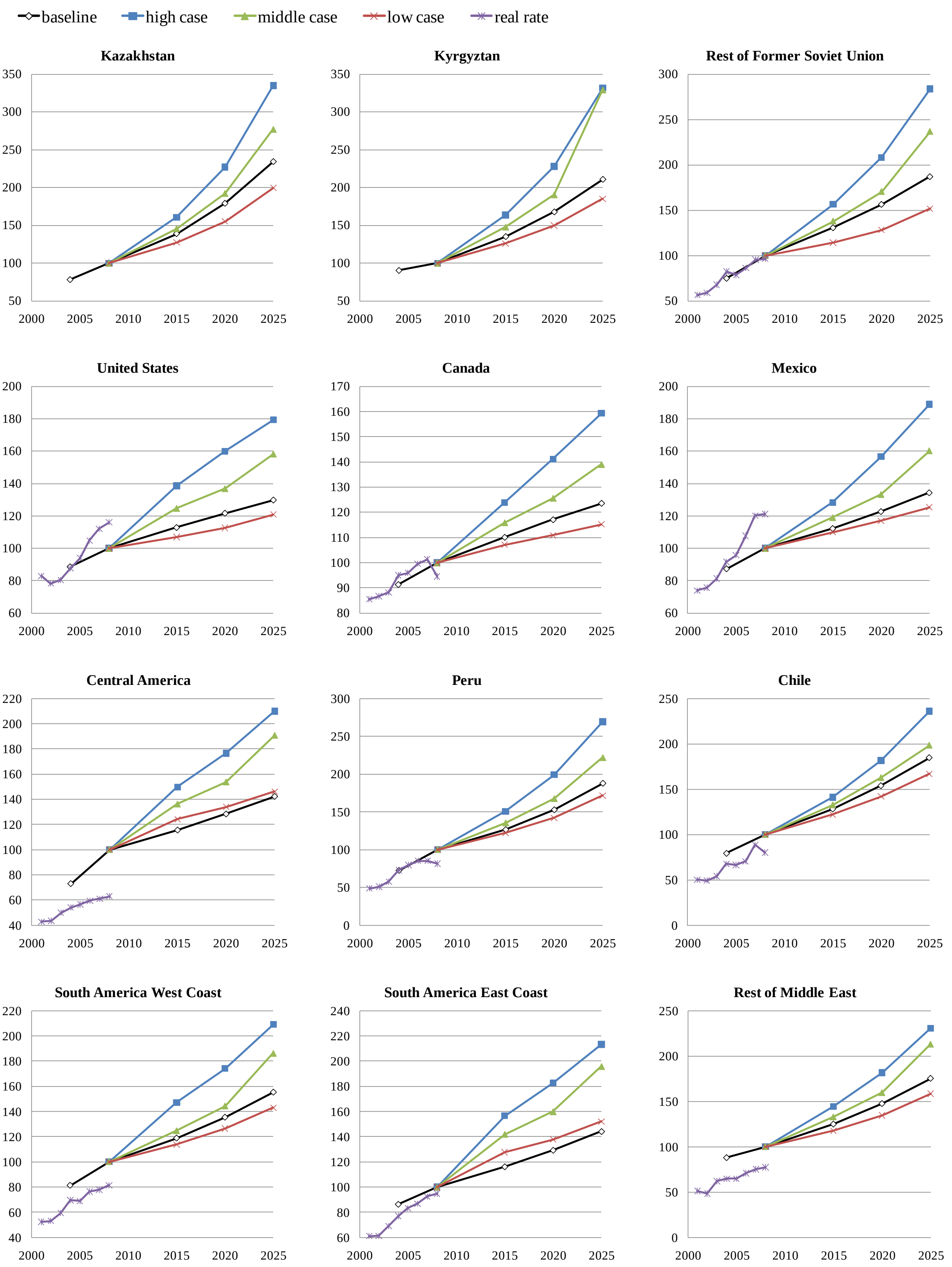


Figure A6 Results of estimated *export* trade value in each economy and region (2008 = 100) (3/4)

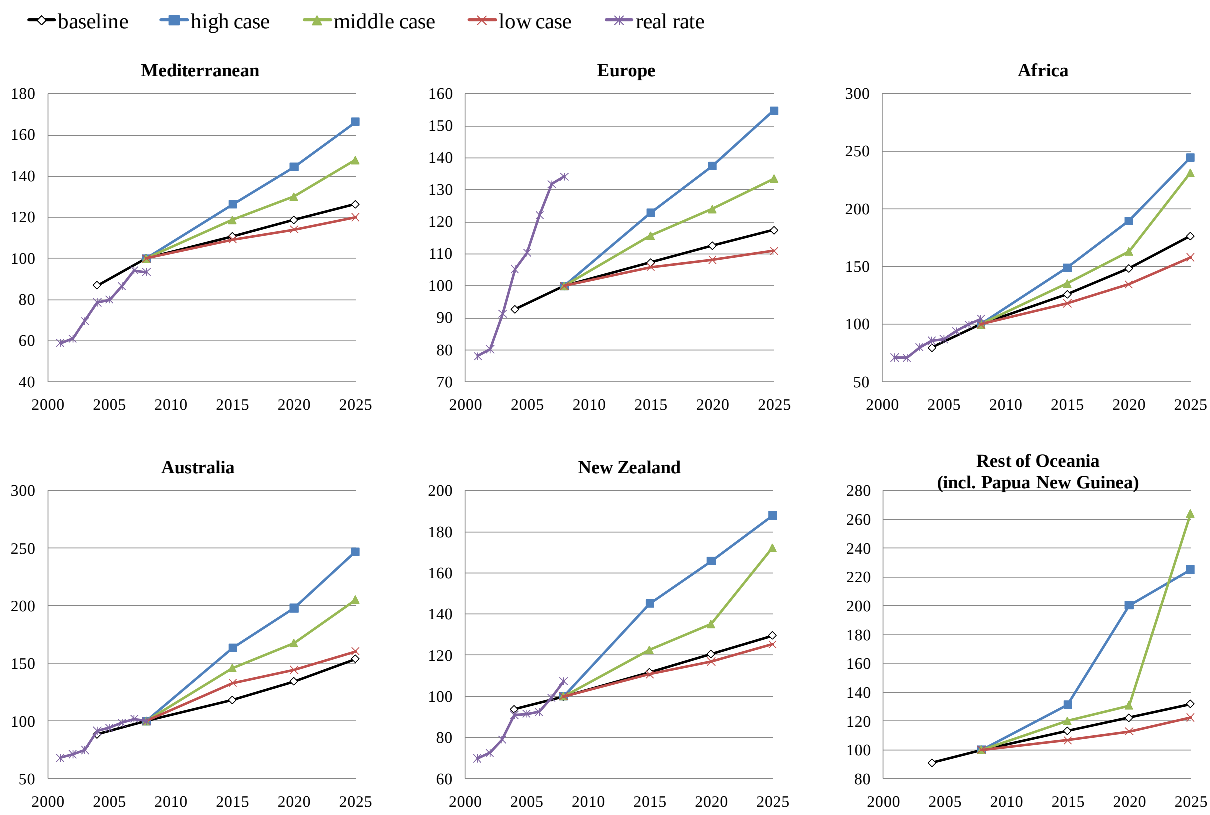


Figure A6 Results of estimated *export* trade value in each economy and region (2008 = 100) (4/4)

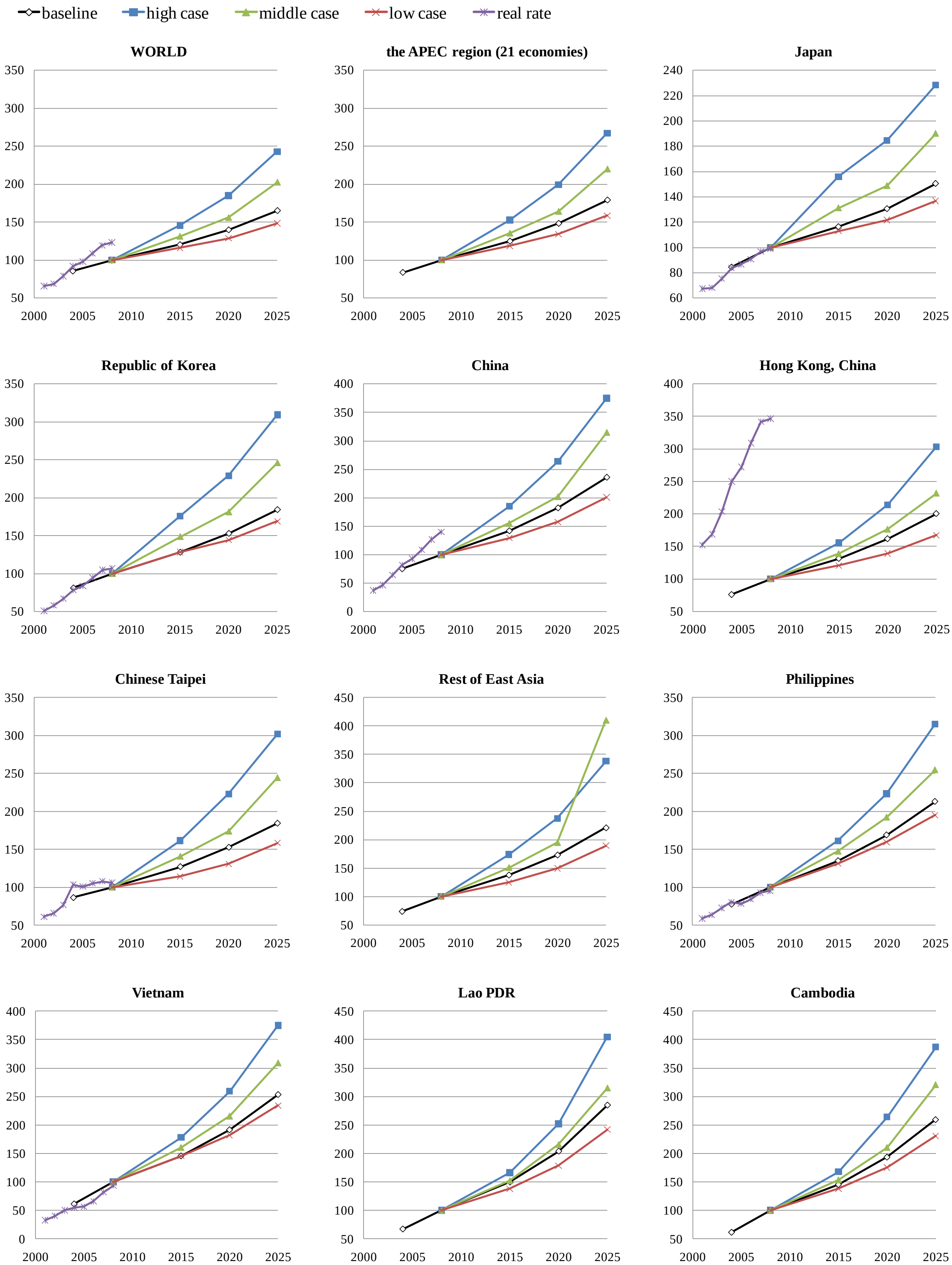


Figure A7 Results of estimated *import* trade value in each economy and region (2008 = 100) (1/4)

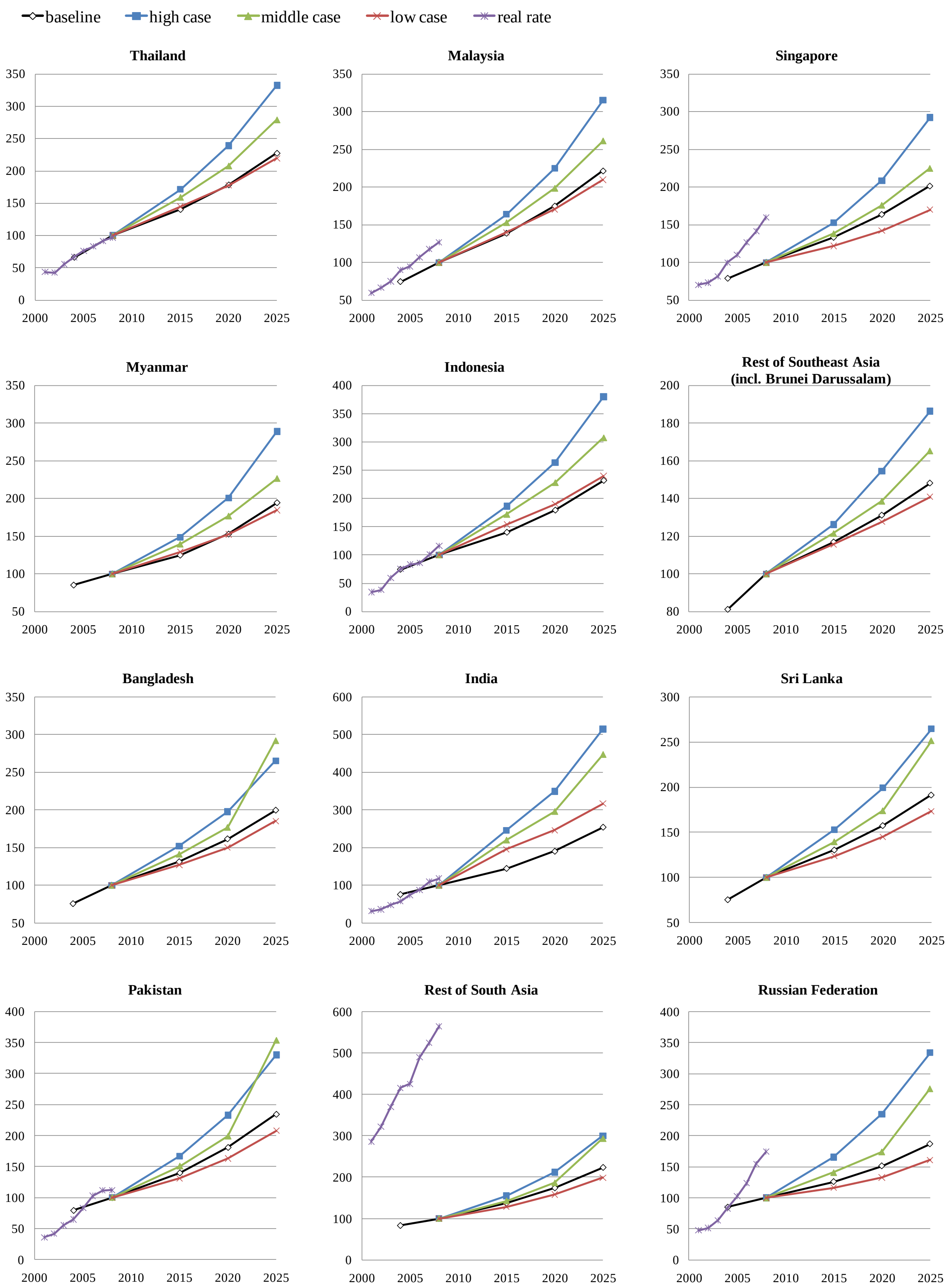


Figure A7 Results of estimated *import* trade value in each economy and region (2008 = 100) (2/4)

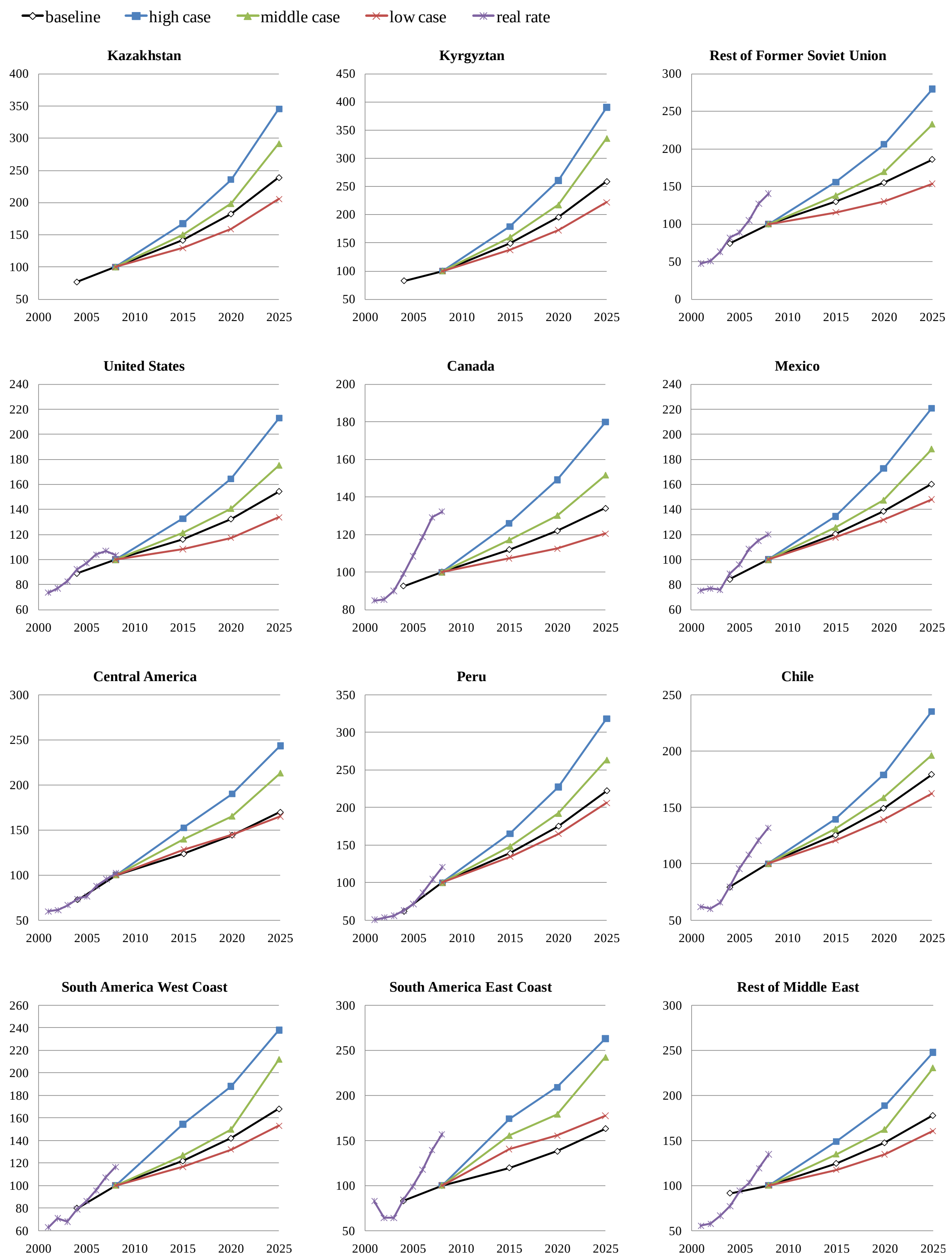


Figure A7 Results of estimated *import* trade value in each economy and region (2008 = 100) (3/4)

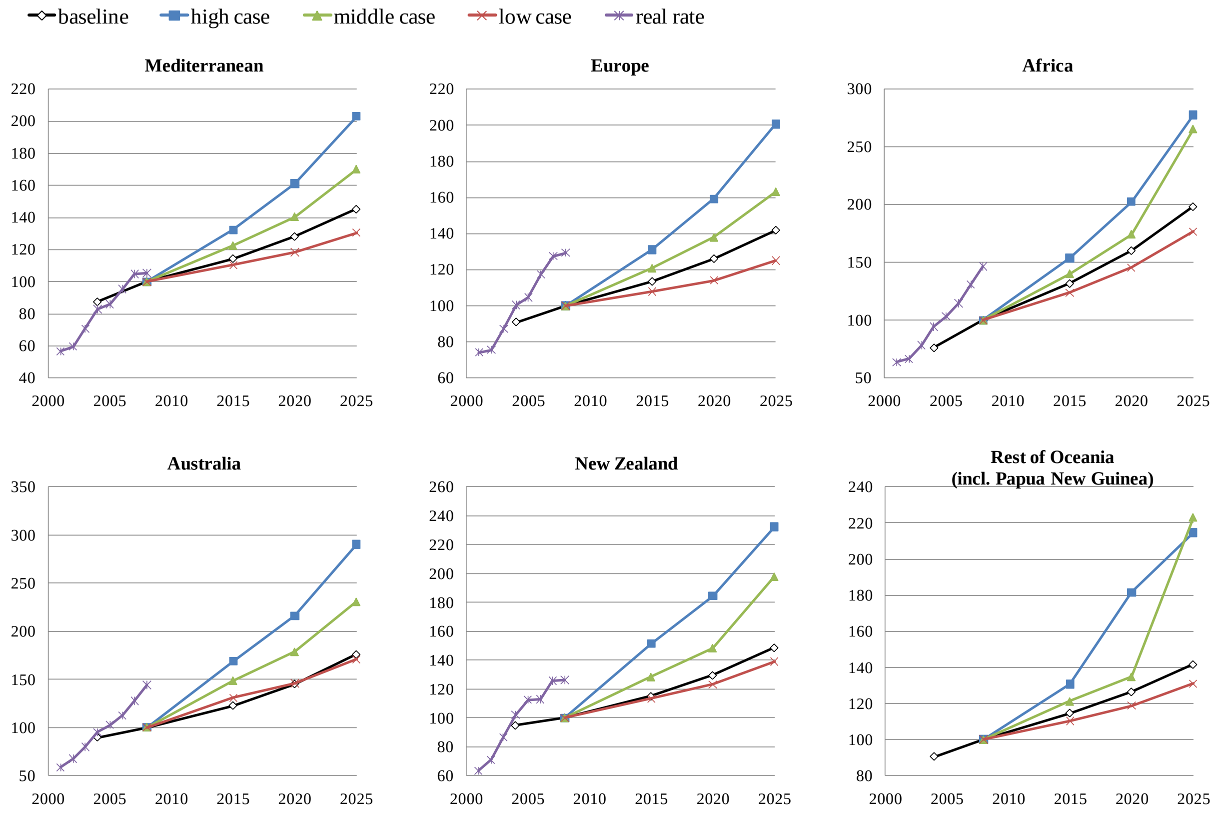


Figure A7 Results of estimated *import* trade value in each economy and region (2008 = 100) (4/4)

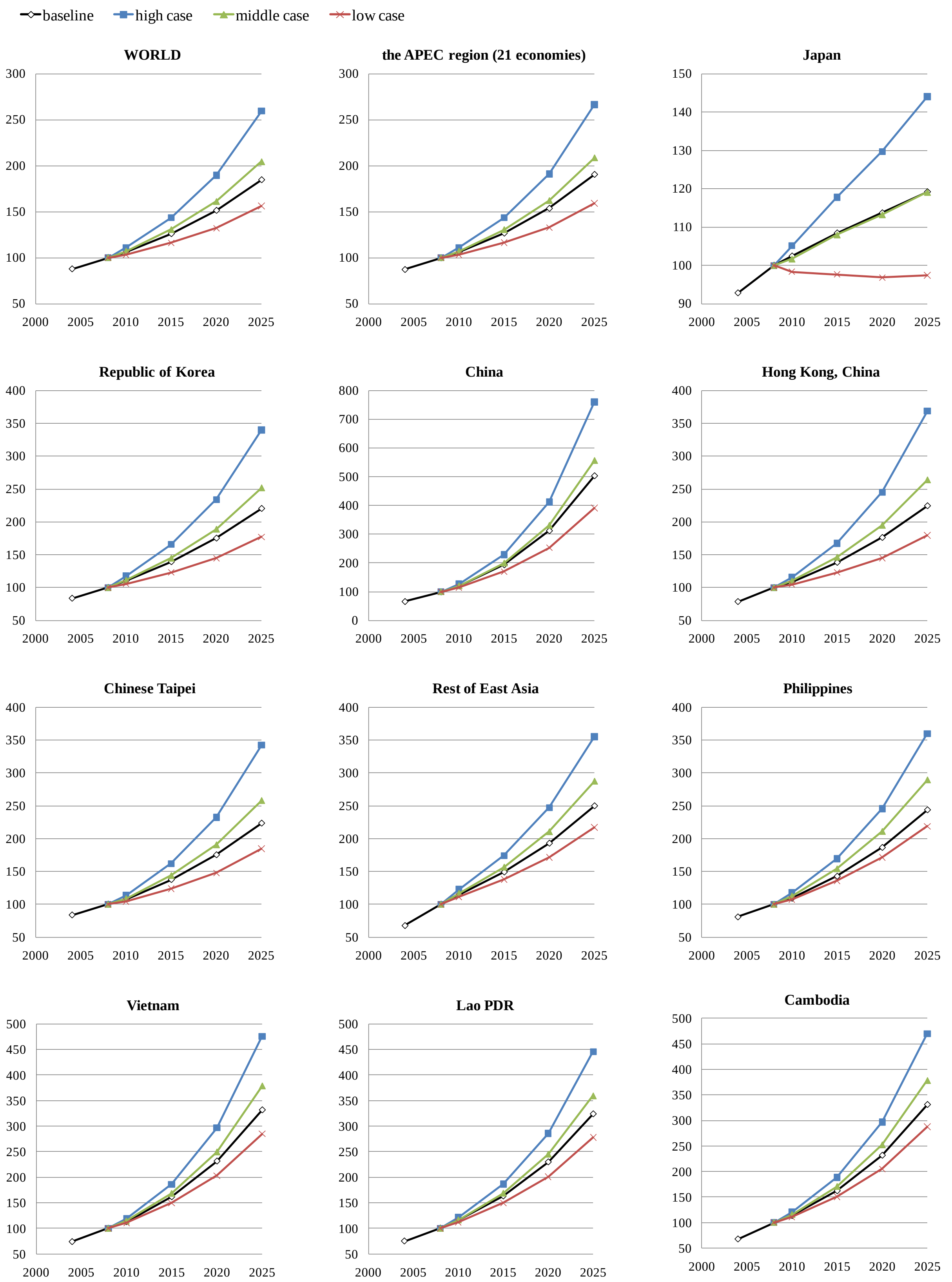


Figure A8 Results of estimated real GDP (2004 prices, USD) in each economy and region (2008 = 100) (1/4)

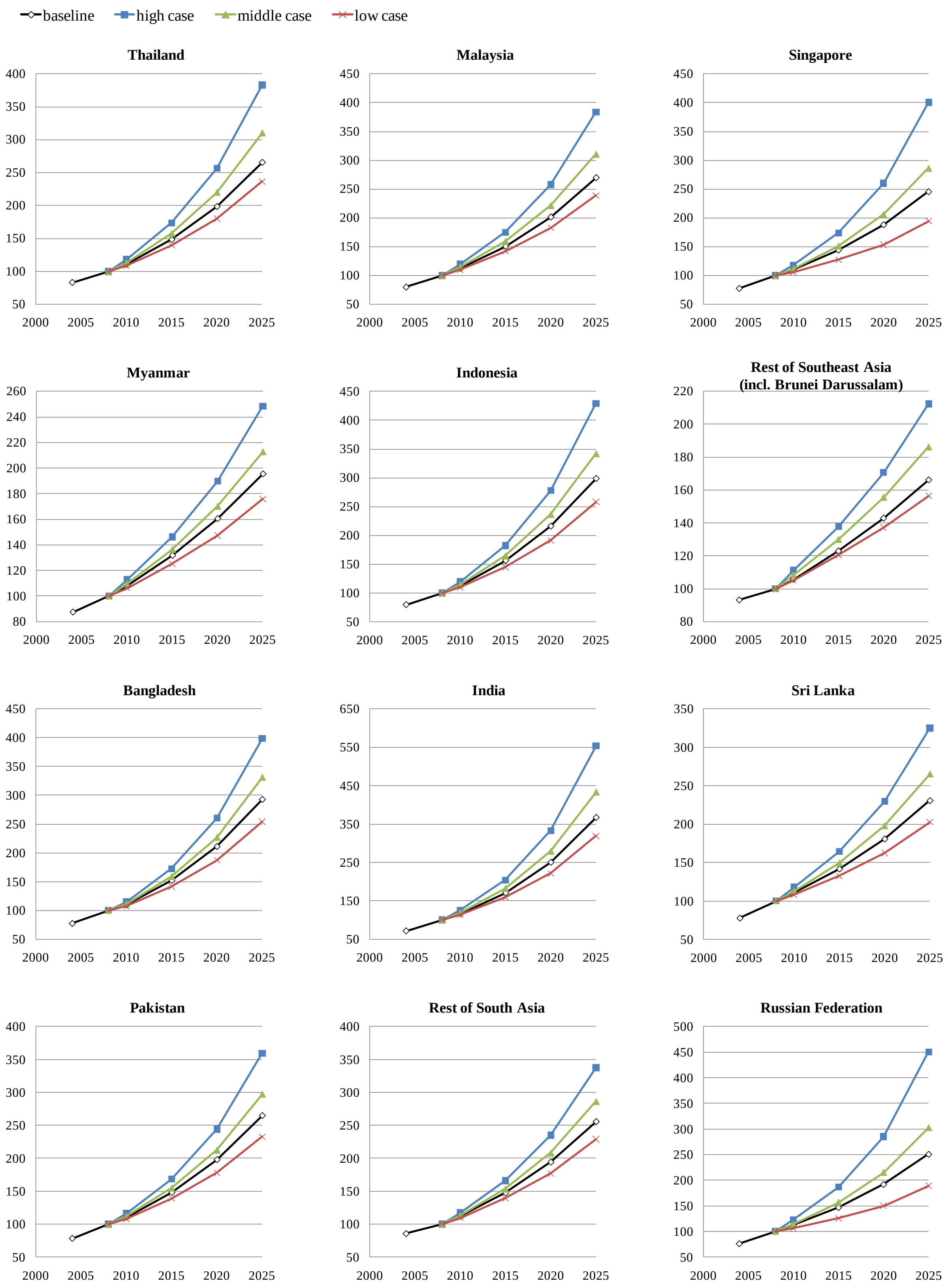


Figure A8 Results of estimated real GDP (2004 prices, USD) in each economy and region (2008 = 100) (2/4)

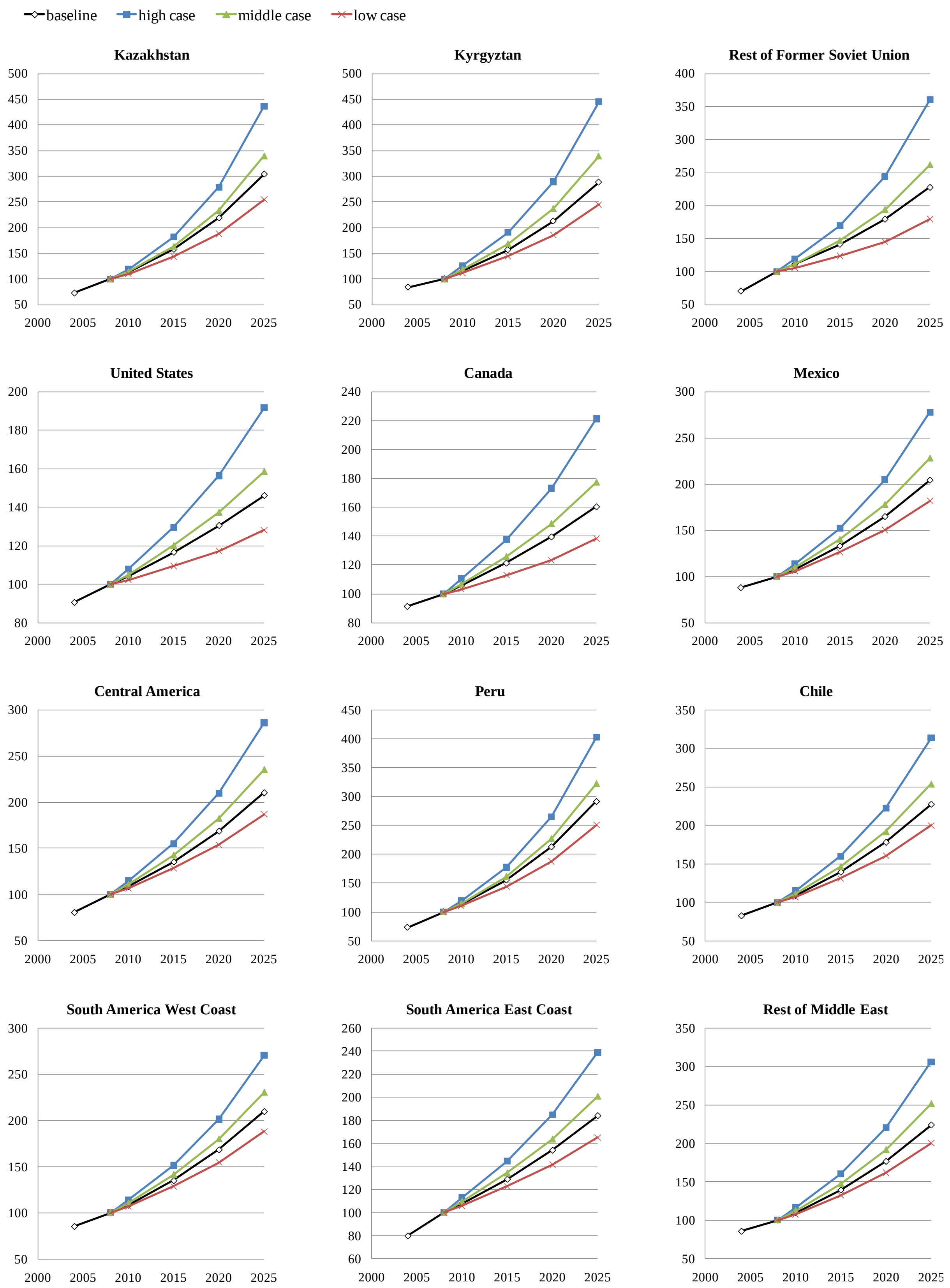


Figure A8 Results of estimated real GDP (2004 prices, USD) in each economy and region (2008 = 100) (3/4)

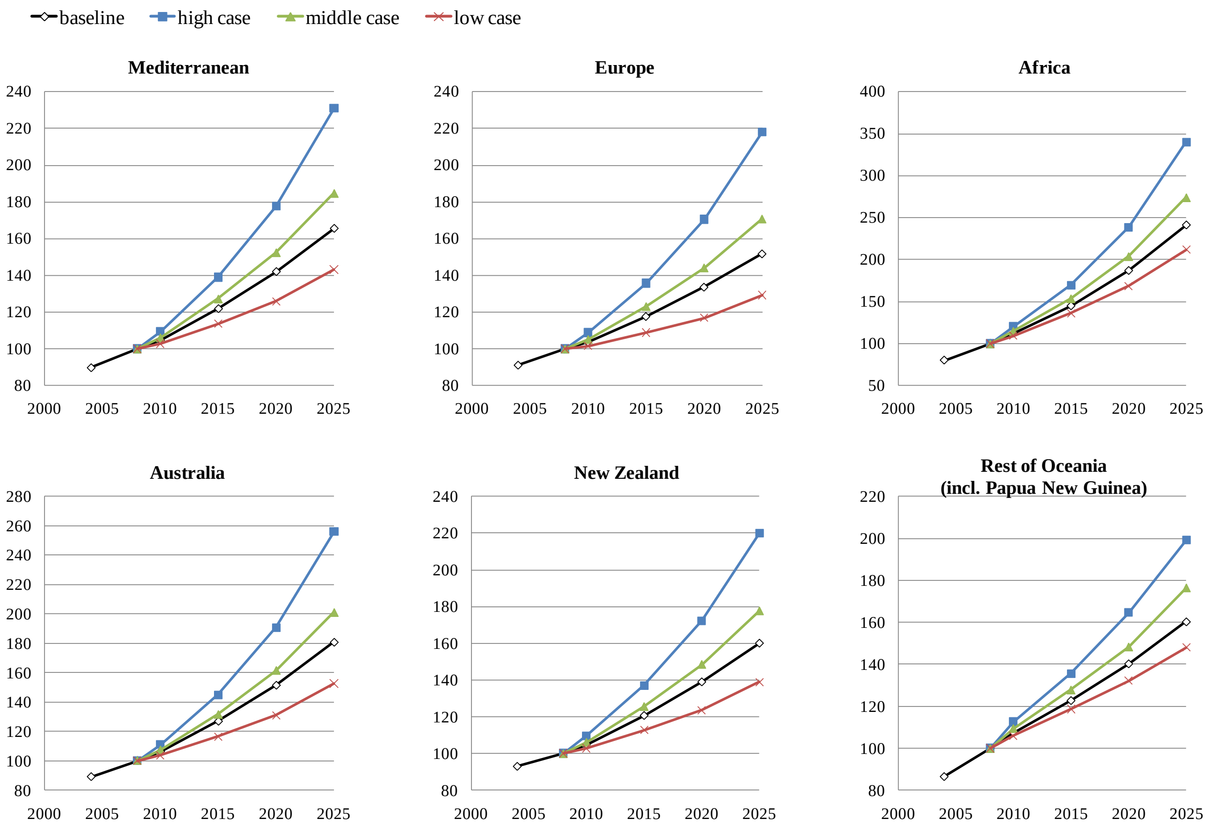


Figure A8 Results of estimated real GDP (2004 prices, USD) in each economy and region (2008 = 100) (4/4)

ANNEX B. INPUT DATA AND ESTIMATION RESULTS OF INTERNATIONAL CARGO SHIPPING DEMAND FORECASTING

B1. Description of Process of Conversion into International Cargo Shipping Demand

The procedure for data conversion from trade amounts to international cargo shipping demand is shown below.

Table B1. Description of conversion procedure by step

1. The estimated bilateral trade values between APEC economies and other regions in each year obtained with the trade forecasting model described in Chapter 2 of the main body and Annex A are divided into detailed pairs using Global Trade Atlas (GTA) database and other statistics.
2. These amounts are divided by the share of transportation mode (air, sea, and land) using the Global Insight (GI) database.
3. The results are then converted to tonnage basis data (metric ton) by unit price for each transportation mode using the GI database.
4. The volumes of international maritime container cargo are obtained by multiplying the volumes of total maritime cargo by the containerization ratio in the GI database.
5. The volumes of international maritime container cargo in step 4 are converted from a tonnage basis to TEU basis data using the GI database.
6. The volumes of international land cargo on a unit basis are assumed to be obtained from the volume on a tonnage basis by dividing the tonnage volume by 10 (ton/unit).
7. The volumes of international maritime container and land cargo are integrated, assuming that one unit of land cargo equals one TEU of maritime container cargo. The cargo shipping demand between economies/countries is then divided into detailed zones for each economy/country utilizing various logistics, trade, and economic statistics for each economy/country.

In step 7, shipping demand for international cargo between the APEC economies (and other countries; same below) is divided into demand between multiple zones in each economy using the relevant statistics on logistics, trade, and economics by economy. For example, for Japanese and U.S. cargo, since partner economy data for each export/import cargo are available for each zone (i.e., prefecture or state) in Japan (from the Japanese container cargo flow survey) and the U.S. (from the PIERS data), Japanese and U.S. shipping demand by partner economies are divided on a prefectural and state basis using these data. Similarly, for domestic Chinese cargo, since partner economy data on a trade value basis are available for each province from China Custom Statistics data, Chinese shipping demand estimated by partner economies is divided on a provincial basis using this data. For other economies, partner economy data are not available either on a cargo volume basis or a trade value basis. Therefore, cargo shipping demand for each economy is divided into a regional basis according to the share of regional trade. If it is not available, cargo shipping demand is divided regionally using some other variable representing regional economic power, such as GRDP (Gross Regional Domestic Product) or population. The source list of databases used in the above regional division is shown in Table B2 for each economy.

Table B2 Databases used in regional division of international cargo shipping demand

No	Economy	Number of Division*1	Economic Indicators Utilized	Year	Source
1	Japan	47	Container Cargo Volume by Prefectures, Commodities and Partner Economics	2008	Ports and Harbors Bureau, Ministry of Land, Infrastructure, and Transport, Tokyo, Japan: *Survey Report of International Container Cargo Flow* , 2008
2	Republic of Korea	16	GRDP	2006	Korea National Statistics: *Social Indicators in Korea* , 2007
3	China	31	Trade Amount by Commodities, Partner Economies, and Transport mode	2008	Goodwill China Business Information Limited: *China Custom Statistics* , 2008
4	Hong Kong, China	1	-	-	-
5	Chinese Taipei	4	Population	2008	Dept. of Household Registration, M.O.I. HP
6	Philippines	17	GRDP	2007	National Statistics Coordination Board: *Philippine Statistical Yearbook* , 2008
7	Vietnam	64	Trade Amount by Export and Import	2007	Statistical Publishing House: *Socio-Economic Statistical Data of 63 Provinces and Cities* , 2009
8	Thailand	76	GRDP	2006	Alpha Research Co., Ltd.: *Thailand in Figures 13th Edition* , 2008~2009
9	Malaysia	13	Industrial Production	2005	Department of Statistics, Malaysia: *Bank Data Negeri/Daerah State/District Data Bank MALAYSIA* , 2008
10	Singapore	1	-	-	-
11	Indonesia	30	GRDP	2007	Badan Pusat Statistik Statistics-Indonesia: *Statistik Indonesia* , 2008
12	Brunei Darussalam	1	-	-	-
13	Russian Federation	7	Trade Amount by Export and Import	2004	Japan Association for Trade with Russia & NIS: *Handbook of Russian Region* , 2006~2007
14	United States	50	Container Cargo Volume by Commodities and Partner	2007 or	Rayden Research Limited: *PIERS (Port Import Export Reporting Service) Data*
15	Canada	13	Trade Amount (Total of Export and Import)	2006	Canada's National Statistical Agency HP
16	Mexico	5	GRDP	2004	Promexico: *Industrial Costs in Mexico* , 2008
17	Peru	3	GRDP	2007	Cuanto: *Anuario Estadistico Peru En Numeros* , 2008
18	Chile	3	GRDP	2007	Coleccion Estrategia: *Informe Sobre Chile* , 2009
19	Australia	8	GRDP	2007	*The Outline of Australia* , 2008
20	New Zealand	2	Population	2006	*New Zealand Official Yearbook* , 2008
21	Papua New Guinea	1	-	-	-
22	Lao PDR (non-APEC member)	17	GRDP	2002	JICA: *Statistical Report of Champasak Province*
23	Cambodia (non-APEC member)	24	Number of Garment Factory	2006	*Number of Factory in Each City/Town and Province* , 2006
24	Myanmar (non-APEC member)	14	Number of Firm	2006	Central Statistical Organization Nay Pyi Taw, Myanmar: *Statistical Yearbook* , 2007

*1: Other regions and countries are treated as one zone, or divided by container cargo throughput of each port.

*2: For Asian economies, year 2008 data. For other economies, year 2007 data.

B2. Features of Input Data

Table B3 shows the input data used in estimation of international cargo shipping demand for each economy and each commodity. It should be noted that by-partner-economy data are used in the actual conversion process, although the table shows aggregated data on an export/import basis.

Table B3 Summary of input data for estimation of international cargo shipping demand by economy and commodity (1/5)

1 Agriculture (Export)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	703	5.3%	94.7%	0.0%	14.66	2.63	0.00	71.4%	9.9	17,680
2	Republic of Korea	1,440	4.0%	96.0%	0.0%	10.49	2.62	0.00	85.6%	10.0	39,961
3	China	10,143	1.8%	94.3%	3.8%	6.24	1.17	1.01	64.7%	9.3	839,145
4	Hong Kong, China	42	4.1%	60.8%	35.1%	5.50	1.38	1.27	73.1%	9.7	1,295
5	Chinese Taipei	898	4.0%	96.0%	0.0%	8.55	2.19	0.00	81.6%	10.0	34,215
6	Philippines	1,674	2.5%	97.5%	0.0%	3.23	0.72	0.00	89.8%	9.3	206,806
7	Vietnam	5,396	1.0%	95.8%	3.2%	5.40	0.92	0.37	38.6%	9.8	266,009
8	Thailand	2,897	1.1%	94.3%	4.5%	2.74	0.96	0.76	52.1%	9.6	259,242
9	Malaysia	2,320	1.4%	86.0%	12.6%	7.07	1.06	1.13	43.8%	10.7	108,857
10	Singapore	517	3.4%	92.7%	3.8%	7.66	1.53	0.57	57.7%	10.1	23,621
11	Indonesia	3,845	1.1%	98.9%	0.0%	3.37	1.48	1.37	70.1%	10.6	201,432
12	Brunei	4	0.9%	99.0%	0.0%	3.38	0.94	0.59	28.4%	9.6	60
13	Russian Federation	4,411	0.2%	74.4%	25.4%	4.97	0.52	0.35	3.2%	8.7	822,184
14	United States	46,805	2.5%	77.2%	20.3%	8.16	0.48	0.69	14.2%	9.1	2,718,842
15	Canada	12,021	0.9%	53.5%	45.6%	2.02	0.52	0.79	12.5%	9.9	833,466
16	Mexico	5,525	1.4%	19.7%	78.9%	5.43	1.43	1.31	43.0%	9.1	391,093
17	Peru	908	13.5%	83.3%	3.2%	3.11	1.28	1.05	82.0%	8.9	43,760
18	Chile	3,147	11.1%	84.4%	4.5%	5.58	1.03	1.50	48.6%	8.9	119,090
19	Australia	9,764	1.9%	98.1%	0.0%	5.40	0.64	0.00	9.2%	9.8	178,957
20	New Zealand	2,561	2.4%	97.6%	0.0%	5.74	2.10	0.00	55.2%	9.4	57,004
21	Papua New Guinea	978	0.9%	99.0%	0.0%	3.38	0.94	0.59	28.4%	9.6	23,761

2 Mining (Export)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	273	2.0%	98.0%	0.0%	41.04	0.29	0.00	7.4%	13.6	7,096
2	Republic of Korea	95	1.0%	99.0%	0.0%	79.28	0.80	0.00	3.5%	12.6	413
3	China	7,057	0.5%	95.2%	4.3%	31.15	0.18	0.13	3.9%	13.0	147,262
4	Hong Kong, China	7	1.9%	72.5%	25.6%	31.26	0.43	0.51	6.7%	14.1	621
5	Chinese Taipei	81	1.8%	98.2%	0.0%	191.24	0.76	0.00	1.6%	13.5	345
6	Philippines	297	0.6%	99.4%	0.0%	22.67	0.28	0.00	1.5%	13.8	1,243
7	Vietnam	6,991	0.0%	92.3%	7.7%	12.92	0.32	0.13	0.5%	11.2	1,102,733
8	Thailand	463	0.5%	92.8%	6.7%	11.25	0.14	0.09	1.8%	11.8	62,422
9	Malaysia	9,433	0.0%	89.4%	10.6%	16.68	0.59	0.50	0.3%	11.4	198,588
10	Singapore	112	0.6%	89.0%	10.4%	97.17	0.99	0.61	3.4%	14.0	2,955
11	Indonesia	17,480	0.1%	99.8%	0.1%	254.29	0.22	0.01	0.3%	11.4	14,587
12	Brunei	3,369	0.0%	99.9%	0.1%	105.02	0.45	0.86	0.1%	10.6	3,966
13	Russian Federation	109,012	0.0%	92.8%	7.2%	194.39	0.34	0.36	0.3%	10.5	27,633,716
14	United States	9,308	8.7%	69.2%	22.1%	123.81	0.31	0.35	13.3%	12.6	1,248,472
15	Canada	31,485	0.3%	28.7%	71.1%	49.35	0.25	0.76	3.1%	13.4	3,439,171
16	Mexico	26,752	0.3%	95.2%	4.6%	44.59	0.27	0.54	0.7%	13.2	243,550
17	Peru	3,315	0.7%	92.0%	7.4%	427.88	0.89	1.30	0.6%	13.7	41,350
18	Chile	6,471	1.0%	93.5%	5.4%	692.10	1.08	1.66	1.7%	13.5	40,280
19	Australia	24,185	0.4%	99.6%	0.0%	48.77	0.19	0.00	0.1%	13.9	10,865
20	New Zealand	186	0.1%	99.9%	0.0%	24.56	0.49	0.00	1.8%	14.0	684
21	Papua New Guinea	1,637	0.0%	99.9%	0.1%	105.02	0.45	0.86	0.1%	10.6	1,087

Table B3 Summary of input data for estimation of international cargo shipping demand by economy and commodity (2/5)

3 Household Consumption Products (Export)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	21,692	11.4%	88.6%	0.0%	71.67	4.00	0.00	75.6%	8.6	480,251
2	Republic of Korea	39,255	7.3%	92.7%	0.0%	34.38	4.34	0.00	88.9%	7.3	992,796
3	China	277,722	10.2%	81.7%	8.1%	33.90	5.06	10.54	90.3%	4.9	8,146,781
4	Hong Kong, China	31,507	11.2%	60.8%	28.0%	39.28	8.65	6.09	93.6%	6.5	566,317
5	Chinese Taipei	23,731	8.4%	91.6%	0.0%	35.86	4.24	0.00	93.9%	6.1	727,030
6	Philippines	8,071	6.8%	93.2%	0.0%	29.47	1.79	0.00	46.0%	7.5	234,629
7	Vietnam	24,483	4.5%	94.8%	0.7%	20.23	4.10	1.94	89.7%	6.0	847,543
8	Thailand	34,727	11.0%	85.1%	4.0%	57.03	1.67	0.95	50.2%	7.9	1,191,257
9	Malaysia	26,850	2.2%	88.7%	9.1%	14.34	1.27	1.66	27.9%	7.5	826,594
10	Singapore	11,918	8.9%	87.0%	4.1%	96.91	3.45	2.54	64.5%	9.6	355,391
11	Indonesia	30,571	3.3%	96.7%	0.0%	28.27	1.57	1.33	33.9%	7.5	899,476
12	Brunei	669	5.3%	94.7%	0.0%	25.15	3.42	0.57	51.8%	6.9	10,314
13	Russian Federation	12,243	15.4%	79.5%	5.0%	558.40	1.86	0.40	42.8%	8.9	2,135,481
14	United States	102,133	40.7%	33.4%	26.0%	144.32	0.85	1.53	42.9%	8.3	4,914,821
15	Canada	48,824	4.1%	22.9%	73.0%	32.27	1.58	1.33	47.0%	9.3	3,492,160
16	Mexico	26,518	3.6%	18.5%	77.9%	46.99	1.71	3.14	52.6%	8.8	812,284
17	Peru	4,251	11.2%	80.5%	8.3%	34.90	1.61	1.52	27.9%	9.1	94,803
18	Chile	9,821	2.5%	87.1%	10.4%	10.40	1.05	1.50	69.1%	9.2	501,132
19	Australia	19,313	6.9%	93.1%	0.0%	41.13	1.31	0.00	41.1%	10.2	483,430
20	New Zealand	11,743	3.4%	96.6%	0.0%	13.31	1.80	0.00	64.7%	9.8	416,828
21	Papua New Guinea	1,749	5.3%	94.7%	0.0%	25.15	3.42	0.57	51.8%	6.9	28,285

4 Basic Industrial Materials (Export)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	134,054	7.2%	92.8%	0.0%	44.95	1.84	0.00	43.9%	10.0	2,789,665
2	Republic of Korea	71,189	3.8%	96.2%	0.0%	24.34	1.01	0.00	30.7%	9.3	2,295,170
3	China	159,351	3.6%	91.4%	5.0%	21.15	1.19	1.32	52.2%	9.2	7,738,408
4	Hong Kong, China	14,885	8.9%	51.2%	40.0%	50.45	1.82	1.81	77.2%	7.7	686,874
5	Chinese Taipei	59,157	4.1%	95.9%	0.0%	22.56	1.38	0.00	52.2%	8.9	2,421,088
6	Philippines	4,655	3.8%	96.2%	0.0%	23.17	0.78	0.00	44.1%	10.7	212,763
7	Vietnam	3,417	2.0%	94.2%	3.8%	12.87	1.11	0.90	81.2%	8.7	360,877
8	Thailand	31,005	3.0%	86.8%	10.2%	17.64	0.76	0.58	40.5%	8.9	2,232,830
9	Malaysia	30,550	2.7%	67.1%	30.2%	8.31	0.86	0.80	46.1%	9.3	2,132,000
10	Singapore	55,972	8.0%	86.3%	5.7%	85.95	1.07	0.86	11.4%	8.6	1,103,452
11	Indonesia	29,042	2.8%	97.1%	0.0%	34.66	0.81	0.41	40.8%	9.7	1,543,122
12	Brunei	103	1.7%	98.3%	0.0%	40.76	1.15	1.53	22.0%	9.8	1,069
13	Russian Federation	90,694	1.8%	81.0%	17.2%	52.59	0.54	0.88	4.8%	11.0	6,733,579
14	United States	264,189	18.1%	55.1%	26.7%	52.70	1.10	2.09	19.4%	8.8	7,609,689
15	Canada	90,455	2.5%	32.1%	65.3%	24.51	0.78	1.22	13.6%	10.3	5,606,817
16	Mexico	26,187	3.4%	40.4%	56.2%	16.71	0.68	2.01	14.0%	9.4	1,021,477
17	Peru	6,934	5.2%	76.8%	17.9%	83.03	1.07	1.19	17.2%	10.7	157,481
18	Chile	18,448	8.1%	81.8%	10.1%	78.20	1.92	1.48	25.3%	9.5	376,250
19	Australia	27,873	10.5%	89.5%	0.0%	40.50	1.73	0.00	22.7%	10.5	263,210
20	New Zealand	4,341	5.9%	94.1%	0.0%	12.73	1.40	0.00	36.0%	9.3	111,148
21	Papua New Guinea	1,868	1.7%	98.3%	0.0%	40.76	1.15	1.53	22.0%	9.8	38,548

Table B3 Summary of input data for estimation of international cargo shipping demand by economy and commodity (3/5)

5 Processing and Assembling (Export)

	Economy	Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	458,864	12.0%	84.7%	3.3%	136.31	14.96	1.11	58.4%	6.3	2,307,667
2	Republic of Korea	201,659	17.5%	72.6%	9.9%	134.64	10.94	3.09	66.9%	6.3	1,645,839
3	China	444,804	16.7%	73.0%	10.3%	96.21	10.40	23.03	92.0%	5.8	5,182,356
4	Hong Kong, China	9,661	16.2%	34.8%	49.0%	111.10	32.50	48.65	86.9%	6.1	30,373
5	Chinese Taipei	151,738	21.6%	77.9%	0.5%	228.77	28.77	5.63	93.9%	6.5	569,772
6	Philippines	45,292	23.5%	75.8%	0.7%	230.91	34.58	4.36	93.5%	6.5	126,763
7	Vietnam	5,241	11.9%	78.2%	9.9%	35.63	12.32	10.96	97.9%	6.3	48,357
8	Thailand	57,178	16.7%	79.2%	4.1%	120.99	16.60	11.43	80.0%	6.1	357,867
9	Malaysia	110,956	27.1%	55.8%	17.1%	159.40	24.50	24.86	93.3%	5.7	412,632
10	Singapore	82,209	28.8%	65.0%	6.2%	234.15	32.72	15.28	84.4%	6.0	240,801
11	Indonesia	24,923	12.5%	84.7%	2.9%	88.29	9.48	1.67	86.9%	6.4	308,418
12	Brunei	405	5.3%	81.9%	12.8%	121.53	6.82	6.53	25.3%	4.5	2,032
13	Russian Federation	12,988	2.6%	86.8%	10.6%	264.51	14.68	8.77	59.5%	4.5	157,734
14	United States	476,631	49.1%	23.1%	27.8%	214.28	10.84	8.77	47.2%	6.1	2,665,124
15	Canada	120,530	10.5%	25.7%	63.8%	124.78	17.11	9.21	35.8%	6.2	1,166,589
16	Mexico	117,289	5.2%	15.6%	79.3%	76.68	13.26	13.47	41.0%	5.5	882,336
17	Peru	206	37.0%	59.3%	3.7%	489.59	42.66	7.84	99.7%	5.9	2,706
18	Chile	878	25.2%	59.6%	15.2%	35.30	9.45	3.79	97.5%	5.3	12,525
19	Australia	11,511	16.1%	82.4%	1.5%	141.59	20.54	9.81	45.4%	5.6	46,006
20	New Zealand	2,631	19.5%	74.9%	5.6%	77.91	14.93	18.77	78.1%	6.3	16,378
21	Papua New Guinea	450	5.3%	81.9%	12.8%	121.53	6.82	6.53	25.3%	4.5	2,632

Source: *; authors' estimation. Others; Global Insight Database.

1 Agriculture (Import)

	Economy	Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	15,957	1.8%	98.2%	0.0%	7.10	0.57	0.00	16.7%	9.2	431,686
2	Republic of Korea	9,158	2.0%	98.0%	0.0%	6.17	0.42	0.00	20.6%	9.2	409,281
3	China	23,624	0.8%	89.3%	9.9%	5.24	0.48	0.43	24.0%	9.7	1,257,298
4	Hong Kong, China	3,677	4.5%	83.7%	11.8%	7.34	1.59	1.23	72.2%	9.2	160,325
5	Chinese Taipei	3,613	2.3%	97.7%	0.0%	3.97	0.36	0.00	45.4%	10.3	298,759
6	Philippines	1,459	0.9%	99.1%	0.0%	4.21	0.38	0.00	17.6%	9.5	95,715
7	Vietnam	2,985	0.6%	91.2%	8.2%	4.48	0.71	0.74	48.8%	9.6	334,845
8	Thailand	2,992	1.5%	95.1%	3.4%	4.98	0.77	1.01	36.2%	9.5	138,806
9	Malaysia	3,066	1.2%	85.2%	13.6%	4.12	0.51	0.65	27.8%	9.7	223,613
10	Singapore	1,746	3.0%	80.4%	16.6%	3.33	1.44	1.32	57.3%	9.4	91,680
11	Indonesia	4,338	1.1%	98.9%	0.0%	6.94	0.53	0.59	28.9%	10.2	183,256
12	Brunei	43	0.7%	99.3%	0.0%	5.75	0.39	1.37	5.9%	9.5	1,138
13	Russian Federation	4,944	7.2%	83.6%	9.2%	3.18	0.96	0.93	54.0%	9.7	604,455
14	United States	21,454	6.2%	55.7%	38.0%	6.91	1.49	0.93	74.4%	9.1	1,682,224
15	Canada	6,291	1.7%	35.3%	63.0%	7.46	1.30	0.81	36.5%	9.8	670,890
16	Mexico	6,470	1.0%	30.7%	68.3%	8.32	0.30	0.62	4.3%	10.5	801,517
17	Peru	1,018	1.5%	73.0%	25.5%	3.32	0.36	0.41	15.0%	9.4	73,755
18	Chile	608	2.1%	50.4%	47.5%	1.65	0.43	0.44	22.2%	9.6	72,566
19	Australia	943	3.9%	96.1%	0.0%	6.78	1.88	0.00	61.4%	9.4	29,869
20	New Zealand	284	3.2%	96.8%	0.0%	6.41	1.26	0.00	62.3%	9.7	11,359
21	Papua New Guinea	207	0.7%	99.3%	0.0%	5.75	0.39	1.37	5.9%	9.5	5,438

Table B3 Summary of input data for estimation of international cargo shipping demand by economy and commodity (4/5)

2 Mining (Import)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	80,607	0.1%	99.9%	0.0%	30.33	0.41	0.00	1.0%	12.6	120,703
2	Republic of Korea	43,577	0.2%	99.8%	0.0%	38.39	0.46	0.00	1.5%	12.5	34,579
3	China	65,282	0.3%	98.9%	0.9%	43.73	0.30	0.14	1.2%	12.7	1,272,650
4	Hong Kong, China	1,130	0.4%	84.0%	15.7%	14.53	0.20	0.11	5.5%	12.3	49,221
5	Chinese Taipei	19,945	0.1%	99.9%	0.0%	9.11	0.43	0.00	2.6%	12.5	31,616
6	Philippines	4,378	0.1%	99.9%	0.0%	30.01	0.36	0.00	0.3%	13.2	4,444
7	Vietnam	210	0.1%	82.8%	17.0%	27.41	0.27	0.19	15.1%	12.5	15,497
8	Thailand	13,972	0.0%	96.9%	3.0%	9.47	0.47	0.68	2.0%	12.4	106,311
9	Malaysia	2,362	0.1%	96.7%	3.1%	10.24	0.24	0.24	5.1%	12.5	32,888
10	Singapore	15,229	0.1%	93.1%	6.8%	17.30	0.57	0.16	0.4%	13.1	130,398
11	Indonesia	4,912	0.1%	99.4%	0.6%	16.27	0.59	0.86	3.6%	12.7	11,838
12	Brunei	5	0.0%	96.3%	3.7%	112.63	0.47	0.51	0.2%	10.1	89
13	Russian Federation	2,833	0.5%	94.6%	4.9%	79.03	0.44	0.25	1.4%	12.0	560,408
14	United States	148,428	0.3%	78.4%	21.3%	95.80	0.55	0.76	1.6%	12.8	4,209,273
15	Canada	9,419	3.2%	73.7%	23.1%	404.50	0.41	0.36	0.1%	12.9	609,666
16	Mexico	2,485	0.6%	56.6%	42.8%	27.02	0.29	0.40	0.4%	13.1	418,006
17	Peru	2,070	0.1%	45.2%	54.7%	2.68	0.68	0.52	2.0%	13.1	438,845
18	Chile	5,184	0.1%	56.0%	43.9%	55.85	0.45	0.62	0.8%	12.8	824,566
19	Australia	4,170	0.1%	99.9%	0.0%	10.63	0.49	0.00	0.4%	12.5	4,253
20	New Zealand	1,066	0.1%	99.9%	0.0%	7.75	0.62	0.00	0.8%	13.2	1,411
21	Papua New Guinea	37	0.0%	96.3%	3.7%	112.63	0.47	0.51	0.2%	10.1	251

3 Household Consumption Products (Import)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	111,432	11.2%	88.8%	0.0%	38.83	3.02	0.00	60.6%	7.3	2,734,766
2	Republic of Korea	23,691	10.0%	90.0%	0.0%	29.38	1.39	0.00	47.6%	7.6	1,057,915
3	China	63,985	4.7%	75.6%	19.7%	24.08	1.02	5.69	52.4%	8.4	2,582,767
4	Hong Kong, China	27,337	15.3%	43.5%	41.2%	82.09	8.54	11.28	81.9%	6.9	326,438
5	Chinese Taipei	11,876	8.5%	91.5%	0.0%	32.23	1.55	0.00	67.5%	8.6	469,388
6	Philippines	8,559	4.0%	96.0%	0.0%	15.93	0.94	0.00	41.5%	8.4	627,483
7	Vietnam	13,265	3.0%	85.8%	11.2%	19.68	1.37	1.67	34.9%	8.2	385,144
8	Thailand	17,082	8.0%	84.7%	7.2%	53.51	1.66	2.79	48.4%	8.6	623,928
9	Malaysia	12,647	4.8%	87.1%	8.1%	28.98	1.16	1.16	37.5%	8.6	534,490
10	Singapore	15,668	10.3%	73.2%	16.5%	59.51	3.81	1.57	49.5%	8.2	354,396
11	Indonesia	11,614	3.1%	96.9%	0.0%	12.68	0.67	0.57	46.3%	8.9	842,066
12	Brunei	515	2.1%	97.8%	0.1%	21.18	2.32	1.33	47.5%	8.8	9,742
13	Russian Federation	27,852	10.8%	83.1%	6.1%	52.72	2.29	7.93	29.6%	7.3	996,228
14	United States	314,508	22.4%	66.2%	11.4%	85.56	4.53	1.75	87.0%	6.1	10,633,622
15	Canada	40,847	7.5%	51.9%	40.6%	37.94	4.81	1.94	58.9%	6.7	1,563,662
16	Mexico	25,998	6.9%	46.0%	47.1%	52.97	2.55	1.24	30.8%	6.4	1,393,717
17	Peru	2,242	5.9%	70.4%	23.6%	17.31	1.32	0.75	38.3%	7.4	144,233
18	Chile	4,578	8.7%	74.1%	17.1%	25.95	2.01	0.71	43.8%	6.9	243,362
19	Australia	17,248	11.1%	88.9%	0.0%	57.00	4.53	0.00	57.0%	7.4	269,406
20	New Zealand	3,535	8.4%	91.6%	0.0%	37.30	2.53	0.00	38.5%	7.7	63,080
21	Papua New Guinea	2,320	2.1%	97.8%	0.1%	21.18	2.32	1.33	47.5%	8.8	58,583

Table B3 Summary of input data for estimation of international cargo shipping demand by economy and commodity (5/5)

4 Basic Industrial Materials (Import)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	103,280	8.7%	91.3%	0.0%	48.37	1.36	0.00	26.2%	9.3	1,993,495
2	Republic of Korea	72,467	6.3%	93.7%	0.0%	31.61	1.20	0.00	32.9%	11.1	1,537,094
3	China	191,092	4.4%	88.4%	7.2%	35.74	1.26	1.50	40.7%	8.8	8,059,122
4	Hong Kong, China	23,704	6.5%	74.5%	19.0%	33.05	1.35	1.71	44.8%	7.9	1,054,641
5	Chinese Taipei	54,595	7.0%	93.0%	0.0%	31.68	1.46	0.00	40.0%	10.4	1,307,399
6	Philippines	12,667	4.4%	95.6%	0.0%	20.24	0.93	0.00	33.1%	9.6	517,896
7	Vietnam	18,929	1.2%	84.5%	14.3%	11.97	0.88	0.57	33.9%	10.3	1,178,617
8	Thailand	35,965	4.7%	89.7%	5.6%	21.49	1.27	1.11	34.8%	10.4	1,018,313
9	Malaysia	29,447	4.7%	79.2%	16.1%	20.33	0.93	0.84	40.7%	10.1	1,546,619
10	Singapore	34,714	6.6%	80.0%	13.4%	32.43	0.91	0.78	16.7%	10.2	1,082,619
11	Indonesia	28,820	1.9%	98.1%	0.0%	14.84	0.84	1.53	21.8%	10.1	815,729
12	Brunei	346	3.2%	96.8%	0.0%	40.75	1.14	0.41	20.8%	9.6	11,770
13	Russian Federation	26,214	2.9%	87.9%	9.2%	24.15	1.51	0.74	69.7%	8.8	1,638,495
14	United States	328,334	18.6%	61.2%	20.2%	153.01	1.16	1.32	20.0%	8.8	11,245,558
15	Canada	75,609	6.2%	35.5%	58.3%	40.64	1.25	2.22	16.4%	9.3	2,888,941
16	Mexico	62,720	5.5%	45.7%	48.8%	42.28	0.88	1.90	11.2%	9.5	2,070,351
17	Peru	4,845	4.0%	82.0%	13.9%	13.89	0.75	1.16	36.9%	9.4	254,378
18	Chile	7,240	5.8%	78.6%	15.6%	17.29	0.58	0.84	16.1%	8.7	358,625
19	Australia	30,158	11.0%	89.0%	0.0%	46.51	1.12	0.00	23.4%	9.7	625,495
20	New Zealand	6,578	6.7%	93.3%	0.0%	16.11	1.12	0.00	22.1%	9.6	128,881
21	Papua New Guinea	3,045	3.2%	96.8%	0.0%	40.75	1.14	0.41	20.8%	9.6	65,549

5 Processing and Assembling (Import)

Economy		Estimated Trade Amount* (2008, million USD)	Modal Share (average) (%)			Unit Price (average) (1,000USD/MT)			Containerized Ratio of Maritime Cargo (average) (%)	Conversion Ratio (average) (MT/TEU)	Estimated Cargo Demand* (TEU/year)
			Air	Maritime	Land	Air	Maritime	Land			
1	Japan	169,938	23.3%	76.1%	0.5%	161.04	20.66	6.39	92.9%	6.0	973,204
2	Republic of Korea	102,177	25.1%	73.4%	1.6%	198.66	23.01	2.15	90.2%	6.3	453,448
3	China	327,229	15.1%	65.4%	19.5%	168.61	33.16	51.79	90.9%	6.3	1,217,920
4	Hong Kong, China	47,033	24.6%	42.2%	33.2%	222.30	36.64	20.64	91.7%	6.2	135,508
5	Chinese Taipei	87,444	26.7%	72.5%	0.8%	246.86	32.64	3.87	89.9%	6.2	307,153
6	Philippines	28,445	27.4%	71.7%	1.0%	291.09	18.72	10.83	82.3%	6.2	217,944
7	Vietnam	13,708	5.0%	86.4%	8.6%	48.84	7.45	7.35	64.2%	5.9	233,613
8	Thailand	58,873	16.7%	74.2%	9.1%	113.20	16.87	12.98	89.9%	6.2	494,891
9	Malaysia	71,747	25.2%	64.1%	10.6%	240.58	22.76	9.63	88.4%	5.9	390,530
10	Singapore	88,534	28.2%	54.3%	17.5%	215.44	29.61	8.30	81.1%	6.3	304,439
11	Indonesia	27,441	11.7%	83.7%	4.5%	59.88	8.53	3.92	90.0%	6.3	480,977
12	Brunei	806	6.7%	90.1%	3.2%	375.34	32.12	13.41	52.8%	4.6	3,730
13	Russian Federation	45,145	5.8%	89.7%	4.4%	79.67	9.29	6.53	48.2%	6.2	482,565
14	United States	709,384	32.2%	40.3%	27.4%	135.94	10.38	11.71	67.6%	5.9	5,327,043
15	Canada	144,983	10.3%	30.1%	59.5%	106.99	18.75	8.18	73.5%	6.5	1,558,574
16	Mexico	97,938	13.3%	43.1%	43.5%	77.36	15.31	7.95	71.8%	7.5	877,062
17	Peru	4,083	19.6%	70.8%	9.6%	54.49	7.56	10.49	77.5%	5.9	45,255
18	Chile	9,233	21.1%	66.0%	12.9%	73.32	9.62	11.04	76.7%	5.8	107,367
19	Australia	53,722	16.8%	80.4%	2.8%	150.45	15.94	64.76	58.4%	6.8	207,241
20	New Zealand	9,503	15.8%	78.4%	5.7%	91.27	14.80	30.16	61.7%	6.6	43,743
21	Papua New Guinea	4,374	6.7%	90.1%	3.2%	375.34	32.12	13.41	52.8%	4.6	24,359

Source: *; authors' estimation. Others; Global Insight Database.

B3. Estimated International Cargo Shipping Demand

B3.1 Estimated Results for Each APEC Economy by Future Economic Scenario

The estimated results of international maritime container cargo shipping demand for each economy by future economic scenario are shown in Figure B1 for the total of exports and imports, Figure B2 for export cargos, and Figure B3 for import cargos. In most economies and other regions, cargo shipping demand gradually increases in the future for both exports and imports. However, for both exports and imports, the rate of growth in developed economies such as Japan and the U.S. increases moderately compared with that in emerging economies such as China and India.

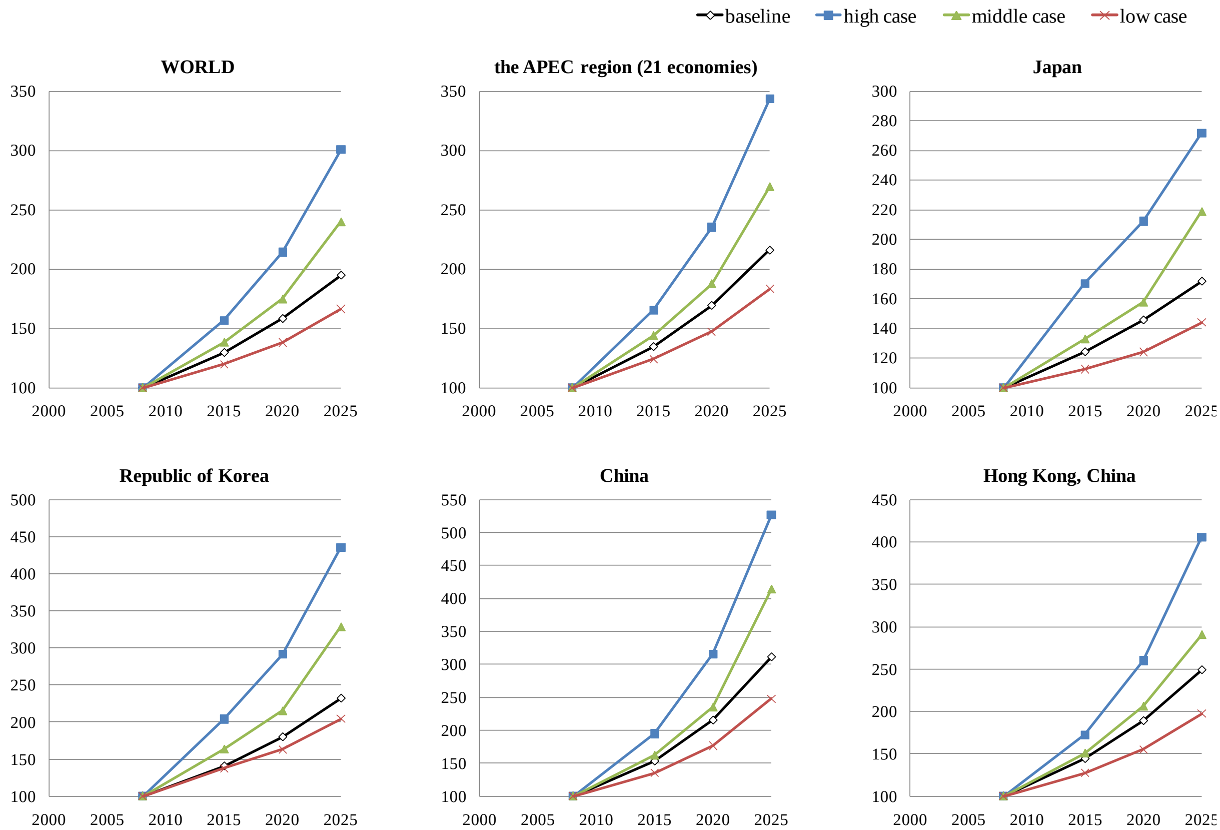


Figure B1 Estimated results of international maritime container cargo shipping demand (total exports and imports) in each APEC economy and the entire world (2008 = 100) (1/3)

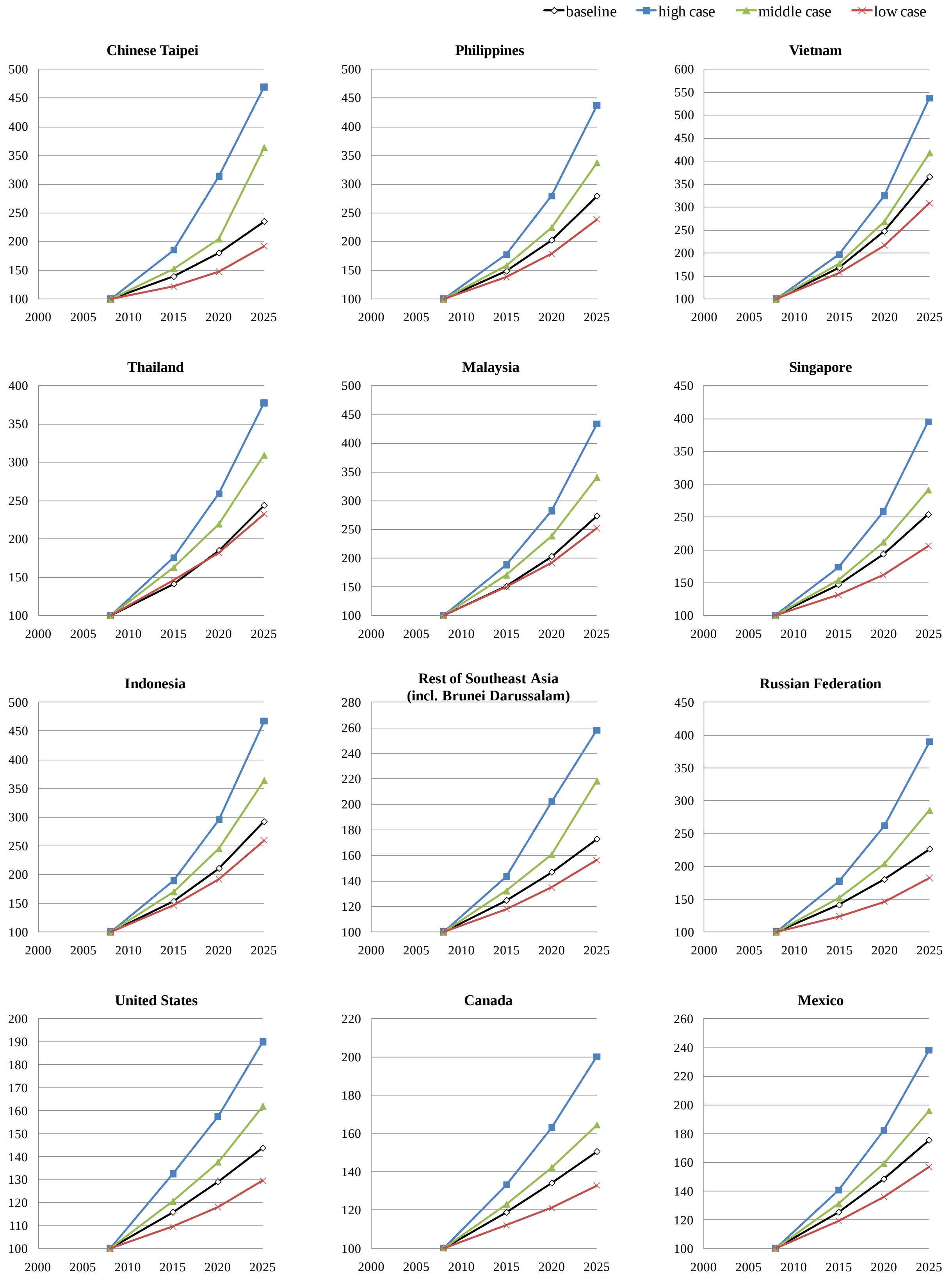


Figure B1 Estimated results of international maritime container cargo shipping demand (total exports and imports) in each APEC economy and the entire world (2008 = 100) (2/3)

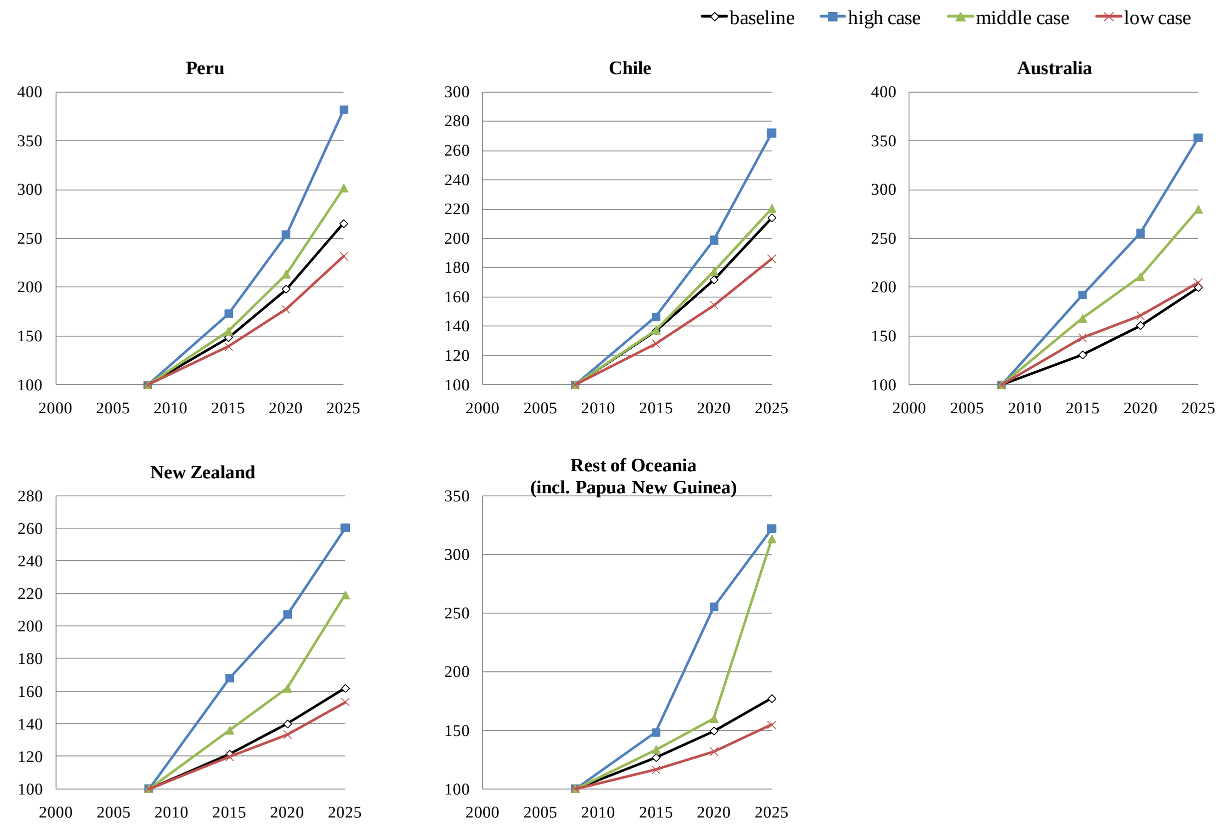


Figure B1 Estimated results of international maritime container cargo shipping demand (total exports and imports) in each APEC economy and the entire world (2008 = 100) (3/3)

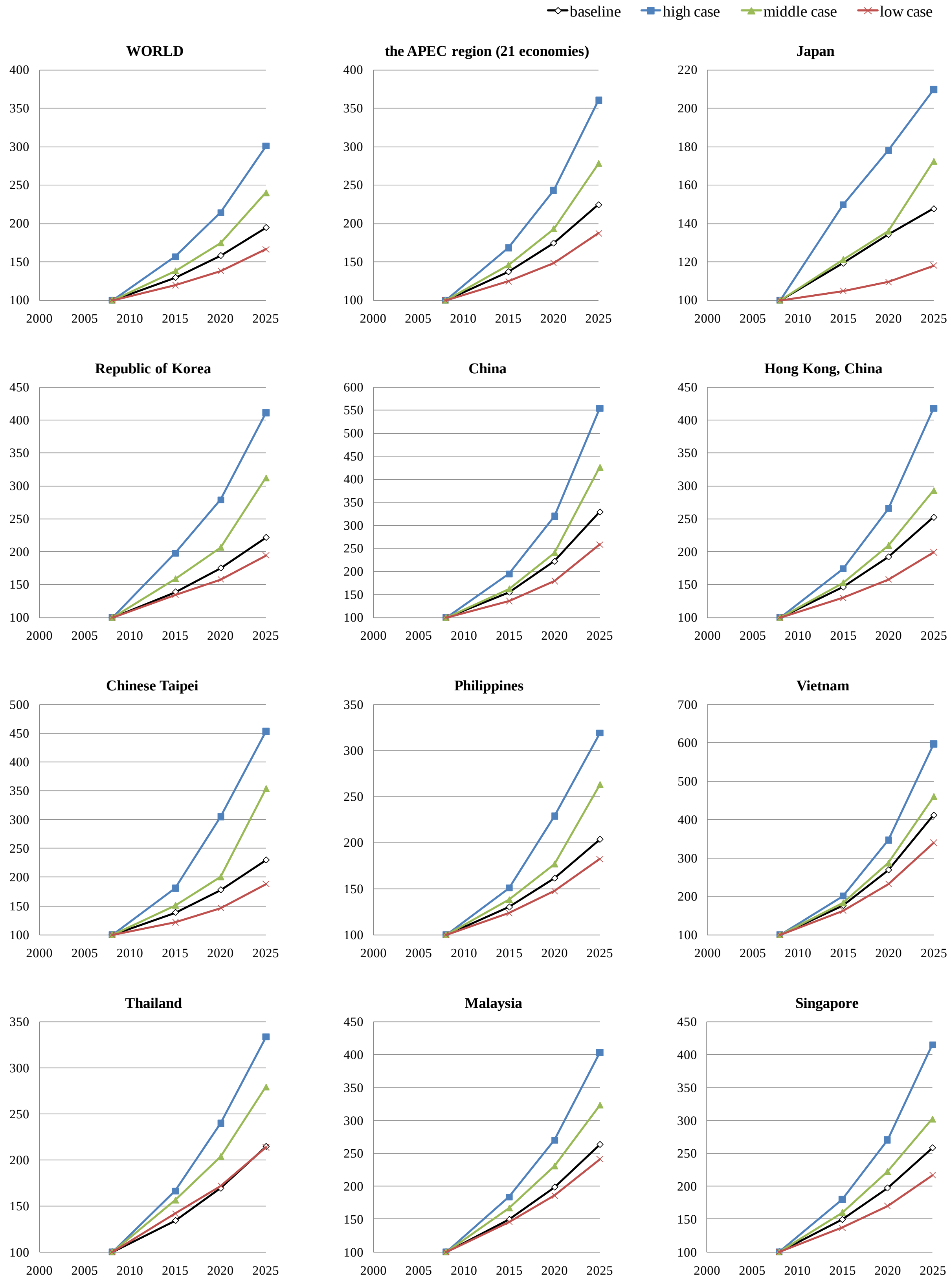


Figure B2. Estimated results of *export* international maritime container cargo shipping demand in each APEC economy and the entire world (2008 = 100) (1/2)

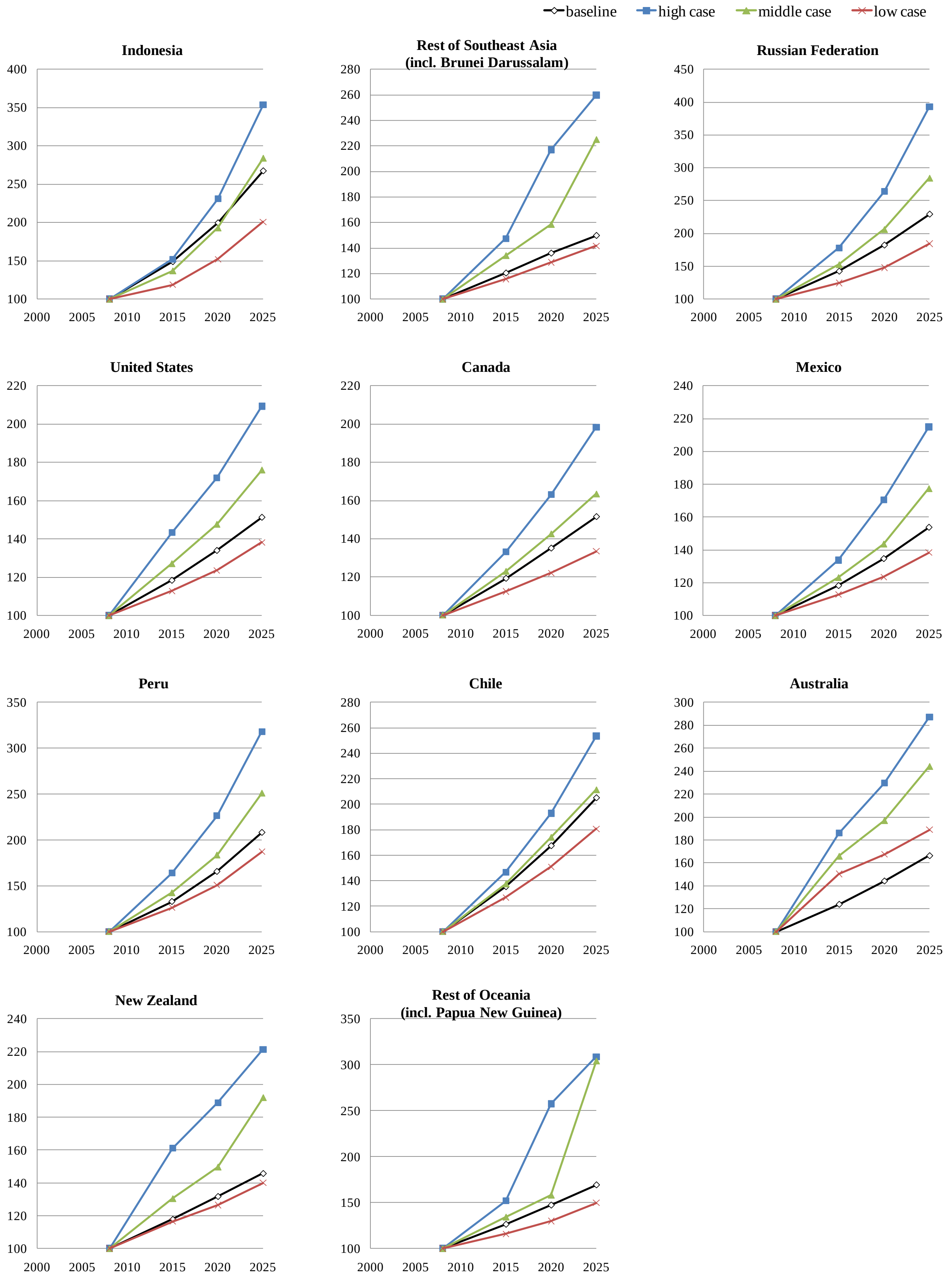


Figure B2 Estimated results of *export* international maritime container cargo shipping demand in each APEC economy and the entire world (2008 = 100) (2/2)

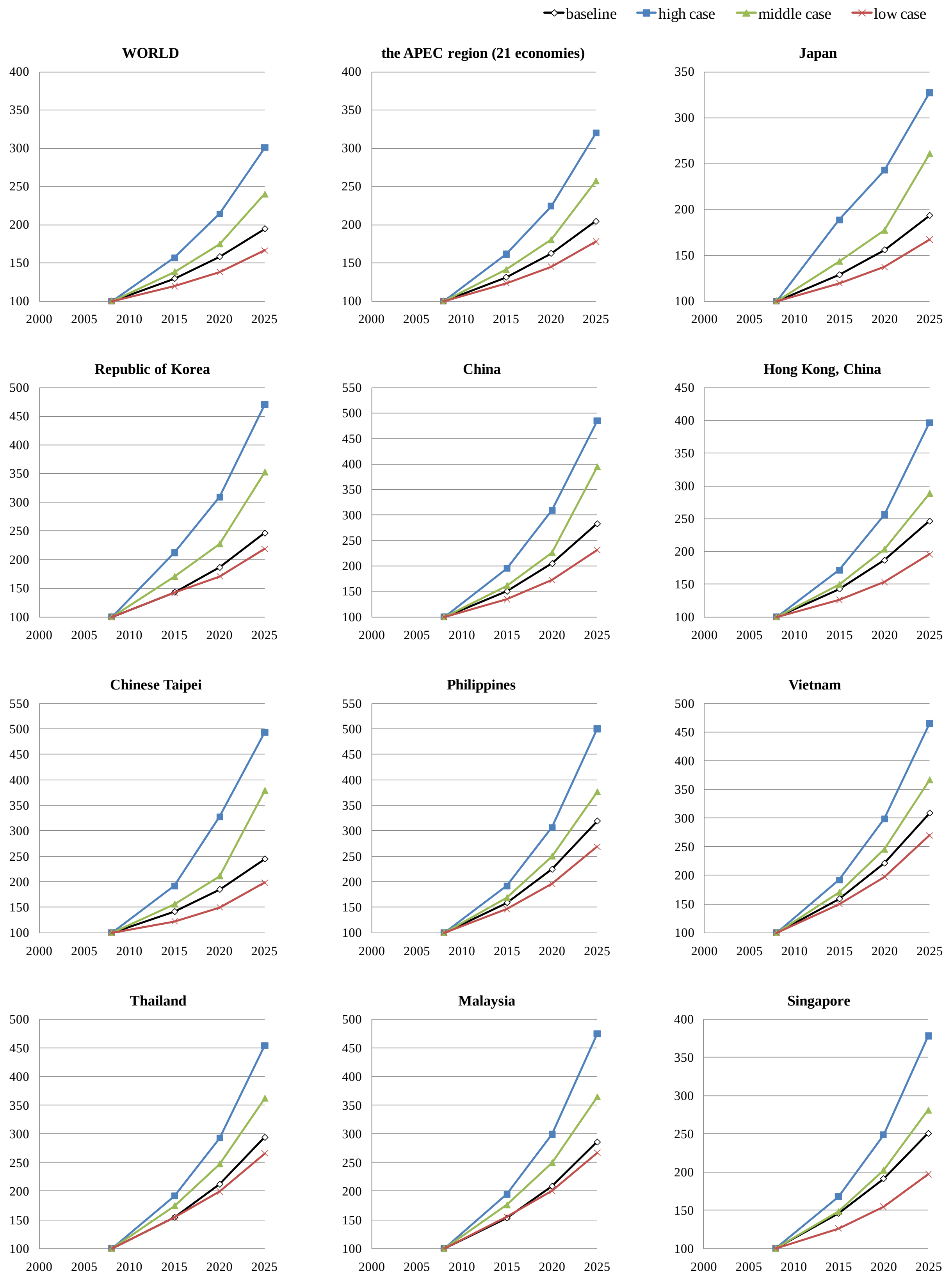


Figure B3 Estimated results of *import* international maritime container cargo shipping demand in each APEC economy and the entire world (2008 = 100) (1/2)

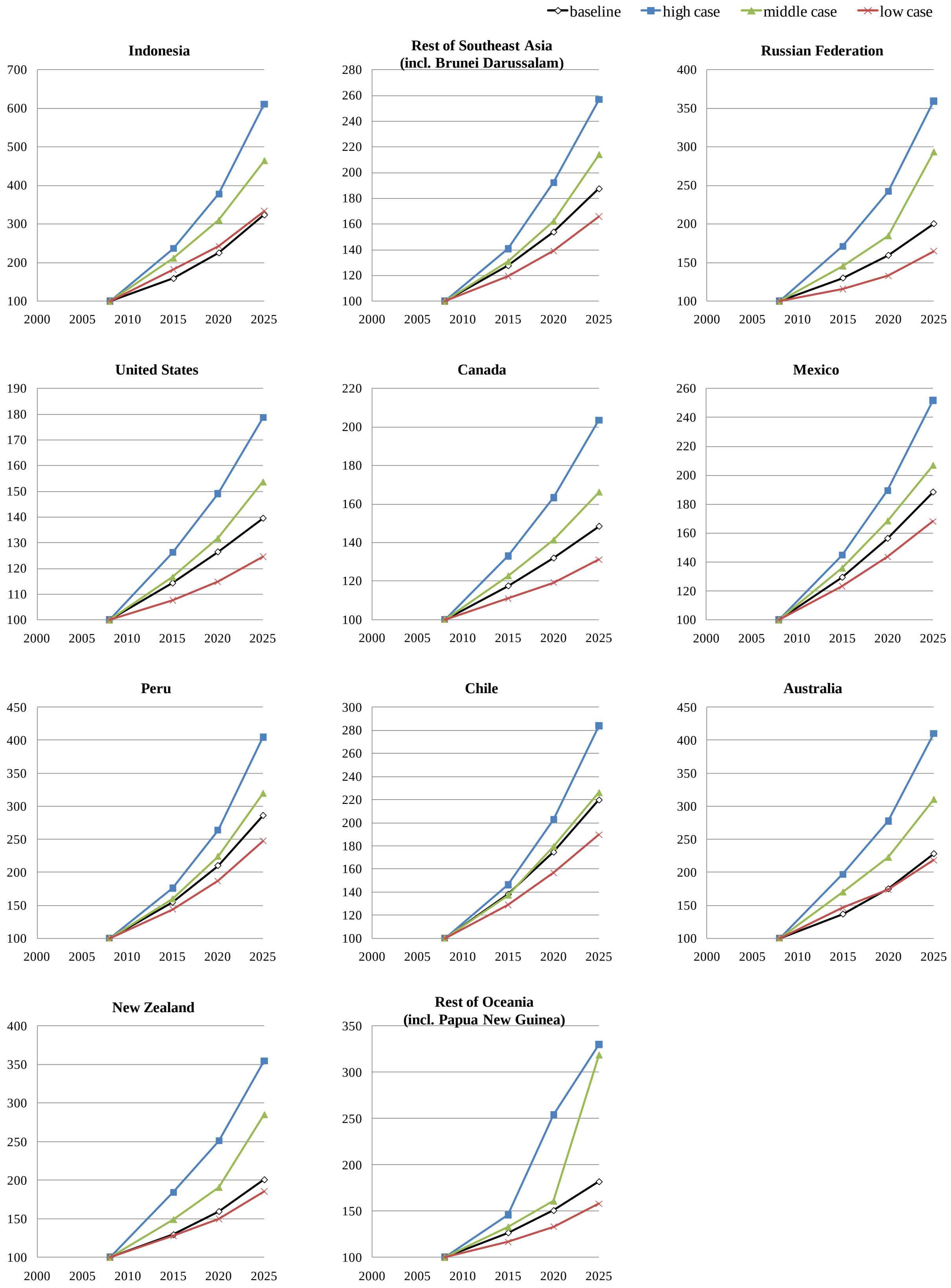


Figure B3 Estimated results of *import* international maritime container cargo shipping demand in each APEC economy and the entire world (2008 = 100) (2/2)

B3.2 Estimated Results by Zone in Middle Case Scenario

The estimated results of international maritime container cargo shipping demand when each economy is divided into multiple zones are shown in Figure B4. This figure shows the results for the total of export and import cargos in the middle case scenario.

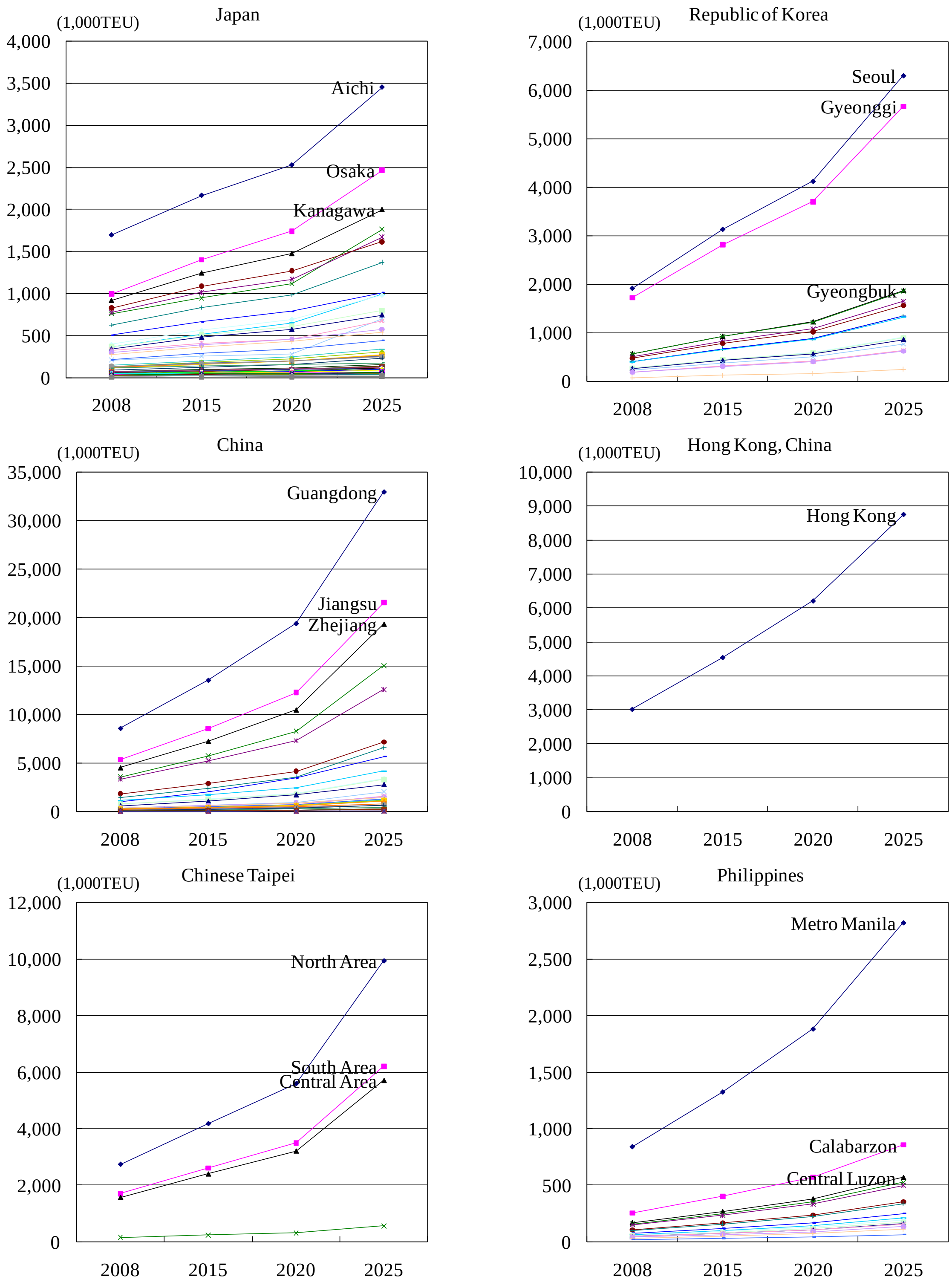


Figure B4 Estimated results of international maritime container cargo shipping demand (total of exports and imports) by multiple zones for each economy in middle case scenario (1/4)

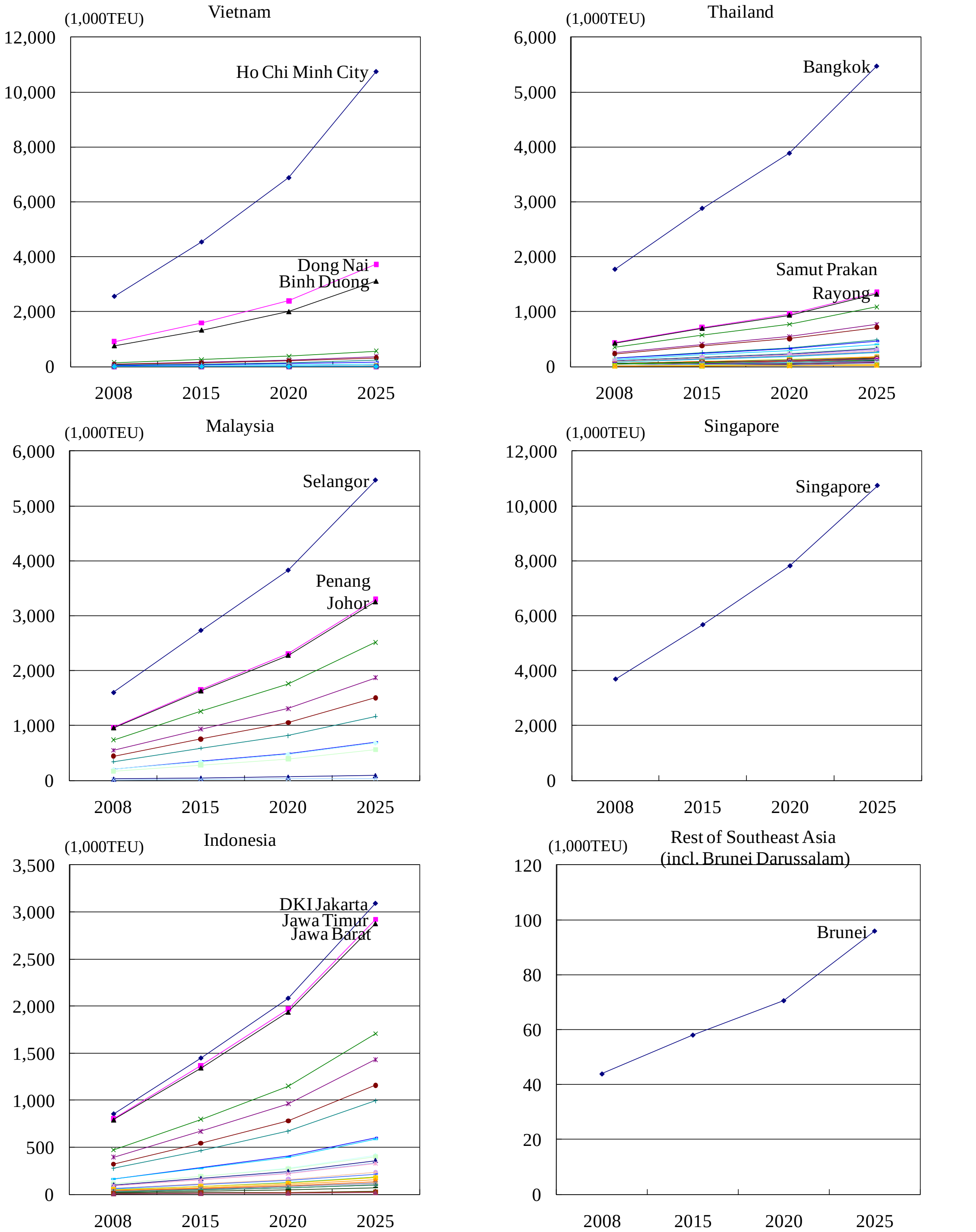


Figure B4 Estimated results of international maritime container cargo shipping demand (total of exports and imports) by multiple zones for each economy in middle case scenario (2/4)

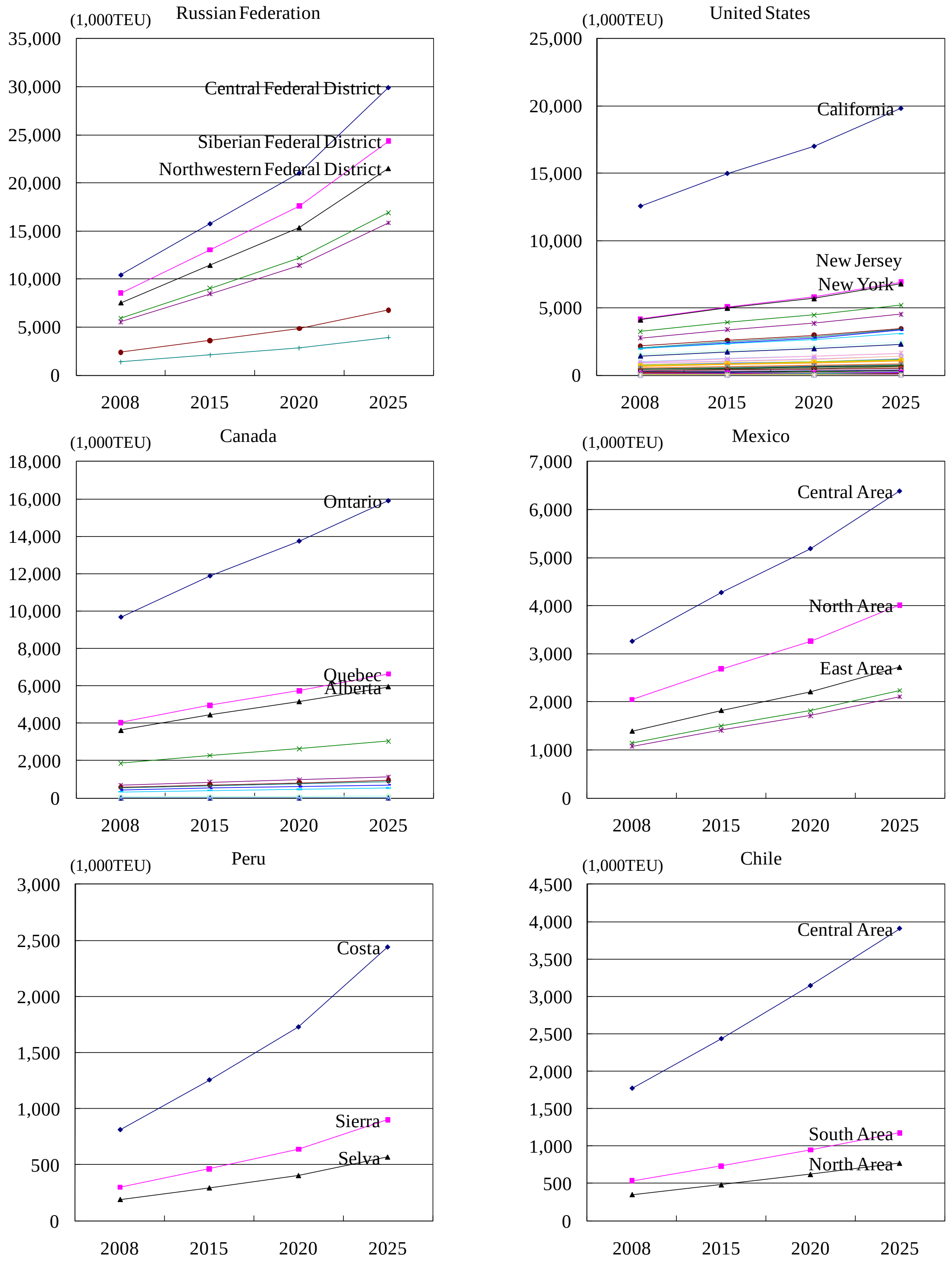


Figure B4 Estimated results of international maritime container cargo shipping demand (total of exports and imports) by multiple zones for each economy in middle case scenario (3/4)

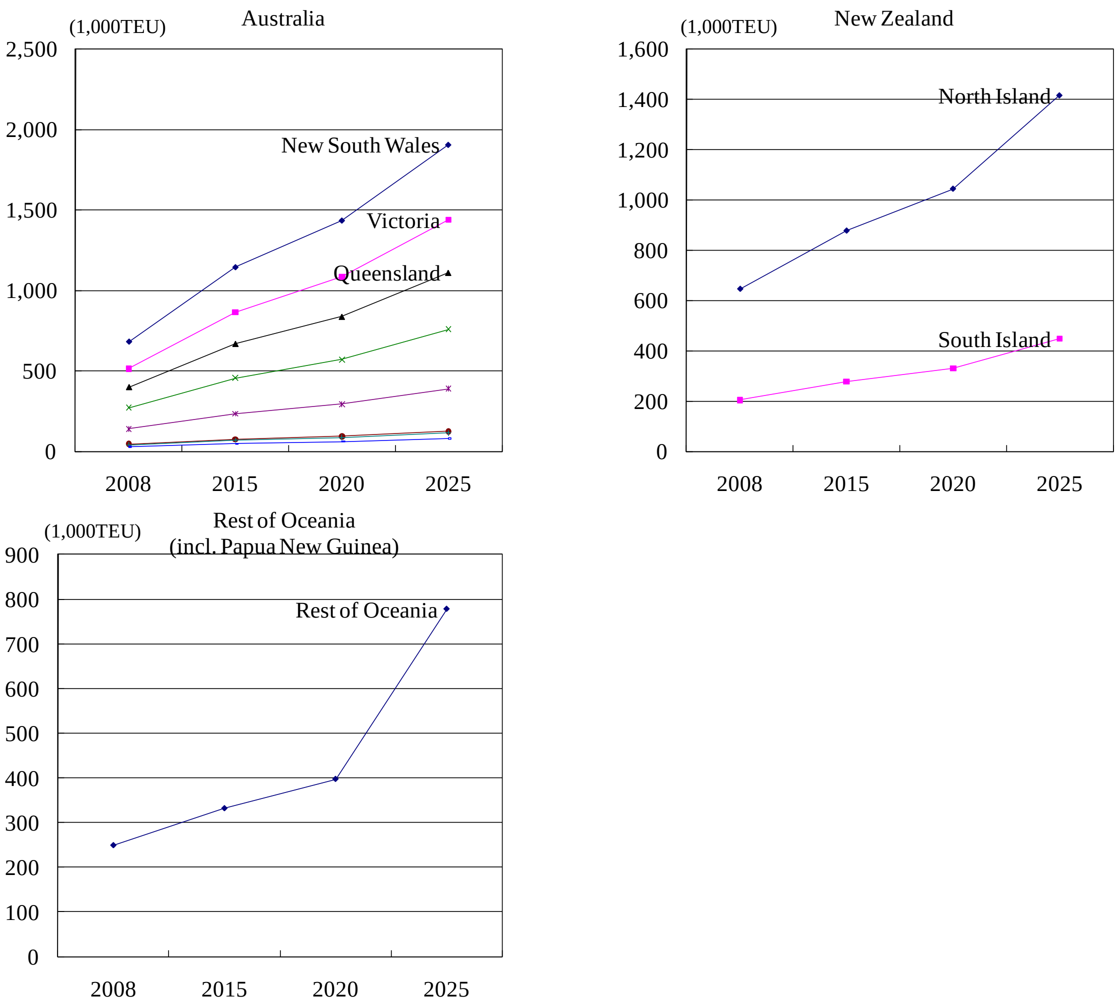


Figure B4 Estimated results of international maritime container cargo shipping demand (total of exports and imports) by multiple zones for each economy in middle case scenario (4/4)

ANNEX C. DETAILS OF INTERNATIONAL CARGO FLOW MODEL AND RESULTS

C1. Model Structure

C1.1 General Outline

The model outputs transportation patterns of container cargo on maritime and land networks, given a regional cargo transport demand (OD cargo volume), the service level at each port (e.g., the number of berths by water depth and port charges), and information related to the transportation network (transportation costs and time, etc.). The outputs can be also tabulated for each port to calculate the handling volume and transshipment cargo volume by port.

The model focuses on the behavior of "shippers" and "ocean-going carrier groups," which are the principal actors in the international container cargo shipping market. Referring to the freight charges and shipping time by route indicated by each ocean-going carrier group, a "shipper" selects a carrier group for maritime transport, the ports to be used for import/export, and the land transport route and mode for each cargo. Shippers determine their selections so as to minimize "recognized generalized costs," including not only shipping cost and time, but also factors which cannot be observed by the model developer. In this model, the selection process is divided into two steps, the choice of a carrier group and others, which includes ports and land routes/transport mode.

"Ocean-going carrier groups," for which cargo shipping demand is given as an input, is assumed to behave so as to maximize profit for each alliance (ocean-going carrier group). Each group determines freight charges by port pair (combination of ports for export and import) and a maritime transportation pattern (ports of call, transshipment ports, and vessel sizes) as well, so that the profit (= income – costs) of that group is maximized, considering the behavior of other groups, i.e., the freight charges, shipping times, and transportation pattern of competing groups. An ocean-going carrier assumingly behaves to maximize its own income in the short term under the condition that its cost is fixed, considering the shipper's behavior only in selecting a carrier. However, the carrier cannot predict the mid-term behavior of shippers, such as selection or change of ports used for export and import. In other words, each carrier group is assumed to have only a short-term strategy to compete with other carrier groups and depriving them of cargo under the fixed cost, and not any mid-term strategy to encourage shippers to change import/export ports. This assumption reflects the actual situation of an international maritime container shipping market in which changes in freight charges and the entry/exit of carriers are frequent, and carriers often determine shipping routes through trial and error.

Taking the above discussion into account, in this paper, the authors developed two models as described below. The first is a short-term model, in which maritime cargo shipping demand and shipping cost by port pair is unchanging for each carrier group, so that each carrier group determines its freight charges by port pair so as to maximize its own income, reflecting the behavior of other carrier groups and the shipper's choice of carrier group. The second model is a mid-term model, in which shipping demand by port pair can be changed, reflecting the shipper's unrestricted choice of ports used for export/import, but shipping demand by regional pair (i.e., demand from a 'true' origin to a 'true' destination) is fixed. In the mid-term model, shippers and carrier groups are countervailing forces, and neither has the power to control the international maritime container shipping market. Therefore, the authors assume that a Nash equilibrium is reached, in which all shippers and all ocean-going shipping companies cannot improve their own objective function so long as the behavior of the other party does not change.

The following sections explain a short-term model (income maximization model of ocean-going carriers, reflecting the shippers' choice of carrier groups) and a mid-term model (equilibrium model between ocean-going carriers and shippers, including the shippers' choice of ports used for export/import) separately.

C1.2 Short-term Model – Income Maximization Model of Ocean-going Carriers Reflecting Shippers' Choice of Carrier Group

C1.2.1 Formulation

Ocean-going carrier groups determine freight charges by port pair in order to maximize their own income, under the condition that cargo shipping demand is given and shipping cost is fixed by port pairs for each group. Herein, each carrier group assumingly considers not only the freight charges of other groups, but also other factors of them. Reflecting this, not all shipping demand is assigned to the group with the lowest freight charge or shortest shipping time between a given port pair, but rather, some part of demand is assigned to groups with relatively higher freight charges or longer shipping time.

The profit maximization behavior of each carrier group is formulated as

$$\max_{p} I_g , \quad \forall g \in G , \tag{C1}$$

$$s.t. \;\; I_g = \sum_{a \in A} \left\{ p_{ag} \cdot q_{ag} \left(p_{a1}, \cdots, p_{ag}, \cdots, p_{a|G|} \right) \right\}. \tag{C2}$$

The constraint condition (C2) means that income I_g (USD/year) for each carrier group g is defined as the total revenue of the group. Here, p_{ag}: freight charge (USD/TEU) indicated by a carrier group g for a port pair a, q_{ag}: shipping volume (TEU/year) of carrier group g for port pair a, A: set of port pairs, G: set of carrier groups, and $|G|$: number of carrier group. Each carrier group g determines the freight charge p_{ag} for a port pair a so as to maximize its income, referring to the freight charges $p_{ag'}$ of other groups g' ($\forall g' \in G, g' \neq g$) for the same port pair and the carrier group selection behavior of shippers, given total demand d_a (TEU/year) and shipping cost c_{ag} (USD/TEU) for each port pair. The shipping volume q_{ag} of carrier group g for port pair a is assumed to be formulated as the following stochastic choice behavior of shippers, taking into account factors which cannot be observed by the model developer

$$q_{ag} = d_a \cdot prob_{ag} , \tag{C3}$$

$$s.t. \;\; prob_{ag} = \frac{\exp\left(-\theta \cdot GM_{ag}\right)}{\exp\left(-\theta \cdot GM_{ag}\right) + \sum_{g' \in G} \exp\left(-\theta \cdot GM_{ag'}\right)} , \tag{C4}$$

where $prob_{ag}$: probability of selection of carrier group g for a port pair a, θ: variance parameter (USD^{-1}), and GM_{ag}: generalized cost (USD/TEU) of maritime shipping when using a carrier group g for a port pair a. The shipper makes a selection based on the service levels provided by each group (freight charges, frequency, shipping time, etc.) and does not consider shipping details such as the actual route or the size of the vessel used, which are determined by the carrier groups. The generalized cost of maritime shipping GM_{ag} is formulated as

$$GM_{ag} = p_{ag} + vt_{shpr} \cdot TM_{ag} \;, \tag{C5}$$

where vt_{shpr}: value of time for shipper (USD/TEU/hour), and TM_{ag}: total time (hour) of maritime shipping (also including waiting time etc.) for carrier group g for a port pair a.

C1.2.2 Solution

As shown in Equations (C3)-(C5), the shipping volume q_{ag} does not depend on the freight charges $p_{a'g}$ for any other port pairs a' ($\forall a' \in A, a' \neq a$) than that in question. Therefore, Equations (C1) and (C2) are rewritten as the following profit maximization *by port pair*

$$\max_{p} I_{ag}, \quad \forall a \in A, \forall g \in G \;, \tag{C6}$$

$$s.t. \;\; I_{ag} = p_{ag} \cdot q_{ag}\left(p_{a1}, \cdots, p_{ag}, \cdots, p_{a|G|}\right), \tag{C7}$$

When the freight charges of other groups are fixed ($\bar{p}_{ag'}, \forall g' \neq g$), the first-order condition of Equation (C7) for each group g is written as

$$\frac{\partial \left\{ p_{ag} \cdot q_{ag}\left(\bar{p}_{a1}, \cdots, p_{ag}, \cdots, \bar{p}_{a|G|}\right) \right\}}{\partial p_{ag}} = 0 \,. \tag{C8}$$

Substituting Equation (C3)-(C5) into Equation (C8) and assuming $prob_{ag} \neq 0$, the result is

$$prob_{ag} + \frac{1}{\theta \cdot p_{ag}} - 1 = 0 \,. \tag{C9}$$

Equation (C9) can be solved by using a quasi-Newton method.

C1.3 Midterm Model – Equilibrium Model of Ocean-going Carriers and Shippers Considering Shippers' Choice of Port

C1.3.1 Outline

In this model, carriers and shippers are assumed to reach a Nash equilibrium condition in which one party cannot improve its objective function any further as far as the other party's behavior is not changed. Concretely, each shipper chooses a shipping route including the ports to be used for import/export, in order to minimize its "perceived" shipping cost, referring to the factors such as the generalized maritime cost GM_{ag} shown in Equation (C5) indicated by each ocean-going carrier group. On the other hand, each ocean-going carrier group determines the freight charges for each port pair and transportation pattern, in order to maximize its net profit, given the cargo shipping demand d_a for port pair a, which is acquired from the results of shippers' behaviors, as shown in the following sections.

C1.3.2 Carrier Model: Formulation and Solution

In this mid-term model, the profit maximization behavior of each carrier group is formulated as

$$\max_{p,x} \pi_g\ ,\ \ \forall g \in G\ , \tag{C10}$$

$$s.t.\ \ \pi_g = \sum_{a\in A} p_{ag} \cdot q_{ag}\left(p_{a1},\cdots,p_{ag},\cdots,p_{aG}\right) - \sum_{v\in V} x_{vg} \cdot t_{vg}\left(x_{11},\cdots,x_{vg},\cdots,x_{VG}\right), \tag{C11}$$

$$p_{ag} - c_{ag} \geq 0\ ,\ \ \forall a \in A\ , \tag{C12}$$

$$\sum_{k\in K_{ag}} f_{akg} - q_{ag} = 0\ ,\ \ \forall a \in A\ , \tag{C13}$$

$$x_{vg} = \sum_{k\in K_{ag}} \sum_{a\in A} \delta^{v}_{agk} \cdot f_{akg}\ ,\ \ \forall v \in V\ ,\ \text{and} \tag{C14}$$

$$f_{akg} \geq 0, x_{vg} \geq 0\ , \tag{C15}$$

where x_{vg}: container flow (TEU/hour) of link v for carrier group g, $t_{vg}\left(x_{,1},\cdots,x_{vg},\cdots,x_{|V||G|}\right)$: shipping cost (USD/TEU) of link v for carrier group g, V: set of links in the carriers' cost minimization model, $|V|$: number of links, f_{akg}: shipping volume of containers on a path k in shipping demand of group g for a port pair a, δ^{v}_{akg}: Kronecker delta (δ^{v}_{akg} =1 when a link v is included in path k; δ^{v}_{akg} = 0 when not included), and K_{ag}: path choice set of group g for a port pair a. Also, c_{ag} is shipping cost (USD/TEU) of group g or a port pair a, defined as the total monetary cost of the shortest path.

The difference from the short-term model shown in Equations (C1) and (C2) is that each shipping cost t_{vg} in the constraint condition (C11) depends on container flow x_{vg}, and a condition that a freight charge for each port pair should not be lower than its monetary shipping cost is added in the constraint condition (C12). Note that the cost t_{vg} is defined as generalized cost including shipping time; in other words, by considering shipping time, the preference of shippers is indirectly reflected in the cost minimization model of carriers. The other constraint conditions (C13) and (C14) on cargo shipping demand q_{ag} and shipping amount x_{vg} guarantee that all cargos are transported. Also, constraints (C15) are non-negative condition.

Since Equation (C10) cannot be solved by $\delta\pi_g/\delta x = 0$ nor $\delta\pi_g/\delta p = 0$ due to the difficulty of differentiation, the above problem is solved by the following stepwise procedure: First, focusing on minimization of total shipping costs expressed by the second term; and second, income maximization as shown in C1.2 when the shipping cost for each port pair is fixed. Namely,

Step 0. $n = 0$; the maritime shipping demand d_a by port pair and current link flow $\left\{x^{(0)}_{vg}\right\}$ are given. Also, current maritime shipping demand $\left\{q^{(0)}_{ag}\right\}$ and freight charge $\left\{p^{(0)}_{ag}\right\}$ by port pair for each carrier group are given, by initially calculating the short-term model described in C1.2.

Step 1. $n = n + 1$.

Step 2. The cost minimization problem is solved under fixed shipping demand $\left\{q^{(n-1)}_{ag}\right\}$ and freight charge $\left\{p^{(n-1)}_{ag}\right\}$ for a previous period. Namely,

$$\max_{p,x} \pi_g$$

$$s.t.\ \ \pi_g = \sum_{a\in A} \overline{p}^{(n-1)}_{ag} \cdot q^{(n-1)}_{ag}\left(\overline{p}^{(n-1)}_{a1},\cdots,\overline{p}^{(n-1)}_{ag},\cdots,\overline{p}^{(n-1)}_{a|G|}\right) - \sum_{v\in V} x^{(n)}_{vg} \cdot t^{(n)}_{vg}\left(x^{(n)}_{11},\cdots,x^{(n)}_{vg},\cdots,x^{(n)}_{|V||G|}\right)$$

$$\Leftrightarrow \min_{x} \left\{ \sum_{v \in V} x_{vg}^{(n)} \cdot t_{vg}^{(n)} \left(x_{11}^{(n)}, \cdots, x_{vg}^{(n)}, \cdots, x_{|V||G|}^{(n)} \right) \right\}, \ \forall g \in G \tag{C16}$$

Detail solution is explained afterward.

Step 3. The income maximization problem is solved as shown in C1.2, by fixing the link costs $\{t_{vg}^{(n)}\}$ and cargo flow $\{x_{vg}^{(n)}\}$ calculated in Step 2.

$$\max_{p,x} \pi_g$$

$$s.t. \ \pi_g = \sum_{a \in A} p_{ag}^{(n)} \cdot q_{ag}^{(n)} \left(p_{a1}^{(n)}, \cdots, p_{ag}^{(n)}, \cdots, p_{a|G|}^{(n)} \right) - \sum_{v \in V} \bar{x}_{vg}^{(n)} \cdot t_{vg}^{(n)} \left(\bar{x}_{11}^{(n)}, \cdots, \bar{x}_{vg}^{(n)}, \cdots, \bar{x}_{|V||G|}^{(n)} \right)$$

$$\Leftrightarrow \max_{p} \left\{ p_{ag}^{(n)} \cdot q_{ag}^{(n)} \left(p_{a1}^{(n)}, \cdots, p_{ag}^{(n)}, \cdots, p_{a|G|}^{(n)} \right) \right\}, \ \forall a \in A, \forall g \in G \tag{C17}$$

Step 4. If the cargo demand $\{q_{ag}^{(n)}\}$ acquired in Step 3 is converged for all carrier groups in comparison with the demand $\{q_{ag}^{(n-1)}\}$ for a previous period, or the repeat count n reaches an upper limit, the calculation is completed. If not, the procedure returns to Step 1. The fact of convergence that cost minimization and income maximization are simultaneously realized for every carrier group means at least that their profits are locally maximized.

In the above calculation procedure, the cost minimization problem stated in Step 2 is described as a problem to determine the cargo flow of each link on the international maritime container shipping network as shown in Figure C1. Since each link is set for vessel size as shown in the figure, in a decision problem of link flow there are embedded both the decision problem of the amount of containers handled at ports and the decision problem of the size of vessels entering the ports. The above problem corresponds to a "group-based" system optimum equilibrium assignment (in other words, "Cournot-Nash player" equilibrium assignment) on a flow-dependent transport network with interference from other links and other carriers.

In the following parts of this section, cost functions are formulated by type of links, and the solution of the problem is shown.

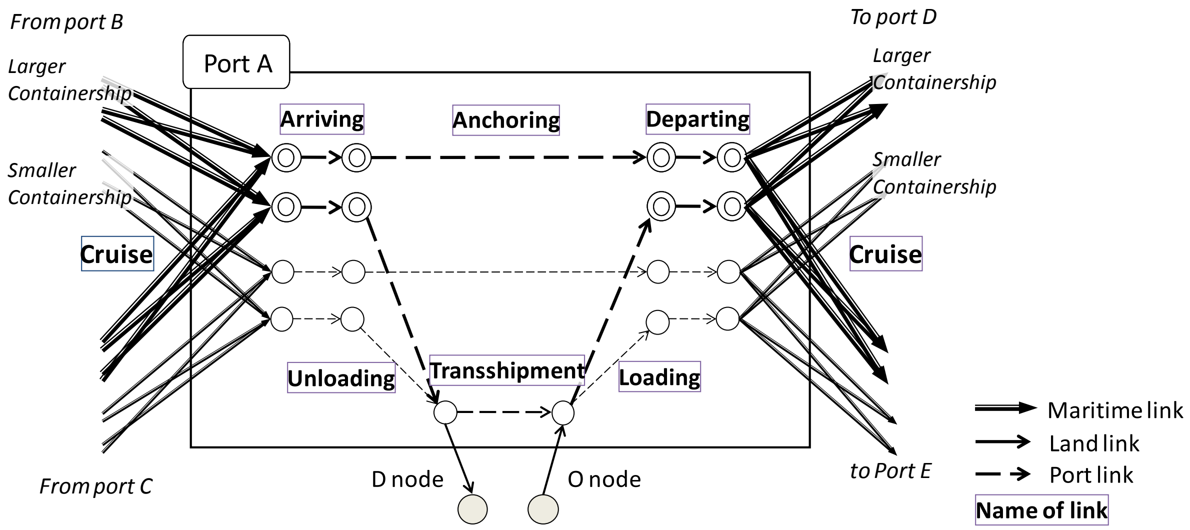


Figure C1 Network structure of carrier's cost minimization model

(1) Cost Functions by Link Type

a) Cruise Link

This link connects a port with another port by vessel size. The link consists from the following four types according to whether cargo is loaded at a previous port and whether it is unloaded at a subsequent port.

1. Passing–cruising-passing link: This link is set for cargo passing through while remaining on a vessel. It has not been loaded at a previous port, nor will it be unloaded at a subsequent port.
2. Loading-cruising-unloading link: This link is set for cargo that has been loaded at a previous port and that will be unloaded at a subsequent port.
3. Passing-cruising-unloading link: This link is set for cargo that has not been loaded at a previous port (i.e., it was loaded before the previous port) but that will be unloaded at a subsequent port.
4. Loading-cruising-passing link: This link is set for cargo that has been loaded at a previous port but that will not be unloaded at a subsequent port (i.e., it will be unloaded after the subsequent port).

The difference between loading/unloading at a previous/subsequent port and not loading/unloading relates to whether or not the frequency of service is considered in the corresponding link. When loading or unloading cargo at a given port, the expected waiting time expressed is considered in addition to the shipping time. Conversely, when cargo remains onboard at a given port due to the shipping company's vessel scheduling, because a vessel departs from the port immediately after the completion of handling, waiting time until port departure is not considered.

$$GCR_{zvg} = \frac{CCR_{wg}}{lf_{vg} \cdot cap_w} \cdot \frac{l_{ij}}{vl_w} + vt_g \cdot \left\{ \frac{l_{ij}}{vl_w} + \beta_z \cdot \frac{lf_{vg} \cdot cap_w}{2 \cdot \sum_z XC_{zvg}} \right\} \tag{C18}$$

where z: type of cruise link (z=1,⋯,4) which corresponds to the links explained above; w: vessel size ($w \in W$, W is set of vessel sizes); i, j: departing and destination ports ($i, j \in P$, P is set of ports); GCR_{zvg}: generalized cost (USD/TEU) of cruise link v (=ijw) of type z, carrier g; CCR_{wg}: monetary shipping cost (USD/hour/vessel) of carrier g when a vessel of vessel size w is cruising; lf_{vg}: load factor (space usage rate) of link v, carrier g; cap_w: capacity of a vessel (TEU/vessel) of vessel size w; vt_g: monetary time conversion coefficient (time value for shipping company) (USD/hour/TEU); l_{ij}: distance (nautical miles) between ports ij; vl_w: vessel speed (knots) for vessel size w; β_z: parameter set by link type z: β_1 = 0 (passing-cruising-passing link): β_2 = 1 (loading-cruising-unloading link): β_3 = β_4 = 1/2 (passing-cruising-unloading link and loading-cruising-passing link); and XC_{kvs}: flow (TEU/hour) of cruise link v, type k, carrier s.

The first term on the right side of Equation (C18) expresses monetary cost per TEU of maritime shipping. This cost decreases as vessel size increases. The second term expresses time cost (multiplying the summation of maritime shipping time and expected waiting time related to frequency by the monetary time conversion coefficient). The expected waiting time is expressed as a function of interval time on a service (dividing the number of containers loaded per vessel by shipping demand per unit time; note that shipping demand per unit time is defined as the total flow over the four types of cruise links). From the definition, it follows that expected waiting time decreases as link flow increases because interval time is shortened, and that expected waiting time increases as vessel size increases when link flow is constant.

b) Arriving Link and Departing Link

These links express port arrival and departure of vessels at each port. In the same manner as the cruising link, they are set for vessel size. Based on the same approach as the categorization of the cruising link into four types, these links consist from the following two types respectively depending on whether or not handling occurs at a port: 1. Arriving-passing link and 2. Arriving-unloading link for arrival link, and 3. Passing-departing link and 4. Loading-departing link for departing link. However, the cost functions of link 1 and link 2 are the same as well as those of link 3 and link 4. Furthermore, the costs associated with arriving at and departing from ports are reflected in the arriving and departing flow of other shipping companies because it is assumed that all of berths are for public use, not exclusive use. The following equation is an example of a cost function of an arrival link.

$$GAR_{vg} = \frac{CAD_{iw}/2 + CPA_{wg} \cdot TWA_{iw}}{\overline{lfa}_{iwg} \cdot cap_w} + vt_g \cdot TWA_{iw} \qquad \text{(C19)}$$

where GAR_{vg}: generalized cost (USD/TEU) of arrival link v (=iw) , carrier g; CAD_{iw}: charge for port (USD/vessel) when a vessel of vessel size w is arriving at and departing from port i; CPA_{wg}: monetary shipping cost (USD/hour/vessel) of carrier g when a vessel of vessel size w is berthing; $\overline{lfa}_{iws}$: average (weighted by link flow) of the load factor of a vessel of vessel size w arriving at port i, carrier g; and TWA_{iw}: average time for waiting (hours) due to vessel congestion when a vessel of vessel size w is arriving at port i.

The first term on the right-most side of Equation (C19) expresses the monetary cost for an arriving vessel, which is the sum of the port charges and shipping costs when the vessel is berthing. Although the average arrival waiting time due to vessel congestion TWA_{iw} could be defined using a rigorous solution from queuing theory, the calculation is simplified by approximating with a power function, as shown in the following equation.

$$TWA_{iw} = \gamma_1 \cdot \left\{\varphi\left(NVA_{iw}, TU_{iw}, NB_{iu}^{-1}\right)\right\}^{\gamma_2} \qquad \text{(C20)}$$

where γ_1, γ_2: parameter related to the arrival waiting time function (γ_1 and γ_2 are set at 120.0 and 5.0, respectively, based on trial calculation results); NVA_{iw}: number of vessels (vessels/hour) of vessel size w that arrive at port i. per unit time; TU_{iw}: time for unloading handling (hours/vessel) per vessel of vessel size w arriving at port i; NB_{iu}: number of berths of berth water-depth category u, port i; and $\varphi(.)$: function on berth throughput capacity.

The number of arriving vessels NVA_{iw} per unit time is expressed as follows.

$$NVA_{iw} = \sum_{g \in G}\left(\frac{XAP_{iwg} + XAU_{iwg}}{\overline{lfa}_{iwg} \cdot cap_w}\right) \qquad \text{(C21)}$$

where XAP_{iwg}, XAU_{iwg}: flow of arriving-passing link and arrival-unloading link (TEU/hour) for carrier g.

As shown above, NVA_{iw} is defined as the total amount for all carriers' flow based on the assumption of this study that all berths in all ports are designated for public use.

The handling time per vessel TU_{iw} is expressed by the following equation.

$$TU_{iw} = TAR_{iw} + \frac{\overline{lfag_{iw}} \cdot cap_w}{prod_i \cdot NC_{iw}} \cdot \frac{\sum_g XAU_{iwg}}{\sum_g XAU_{iwg} + \sum_g XAP_{iwg}} \qquad \text{(C22)}$$

where TAR_{iw}: minimum required time (hours) when a vessel of vessel size w arrives at port i; $\overline{lfas_{iw}}$: weighted average of load factors of a vessel of vessel size w that arrive at port i; $prod_i$: productivity for handling (TEU/hour) per crane at port i; and NC_{iw}: number of cranes used for handling of vessels of vessel size w at port i.

Equation (C22) indicates that handling time per vessel is expressed as the sum of minimum required time for piloting and berthing during arrival and the handling operation time, which is proportional to the amount of handling. The handling operation time is obtained by dividing the average number of unloading cargos per vessel by the handling capacity per unit time.

In Equation (C20), the reason why the function related to berth throughput capacity is not explicit is that its form changes depending on the situation. More precisely, vessels can arrive at deeper berths irrespective of vessel size, but only small vessels can arrive at shallower berths. Therefore, when large berths are relatively congested, large vessels arrive at large berths and small vessels arrive at small berths, and the degrees of congestion for the two kinds of berths are different. On the other hand, when small berths are relatively congested, congestion for the two kinds of berths would be equalized, adjusted by some proportion of small vessels using large berths. As a result, the congestion waiting time for both kinds of berths would become equal. The detailed programming algorithm that considers this relationship is omitted from this paper due to space limitations.

For the departing links, the cost function is similarly defined with respect to departing link flow XDP_{iwg} and XDL_{iwg} (TEU/hour, flow of passing-departing link and loading-departing link), although a detailed explanation is omitted.

c) Berthing Link

This link connects an arriving-passing link and a passing-departing link, considering shipping costs and time costs when a vessel is berthing for port handling. Handling time is the sum of the time required for unloading and the time required for loading.

$$GPA_{vg} = \left(\frac{TUG_{iwg}}{\overline{\overline{lfa_{iwg}}} \cdot cap_w} + \frac{TLG_{iwg}}{\overline{\overline{lfd_{iwg}}} \cdot cap_w} \right) \cdot CPA_{wg} + vt_g \cdot \left(TUG_{iwg} + TLG_{iwg} \right) \qquad \text{(C23)}$$

where GPA_{vg}: generalized cost (USD/TEU) of berthing link v (=iw), carrier g; $\overline{lfd_{iws}}$: average of load factors of a vessel of vessel size w that depart from port i, carrier g; TUG_{iwg}: time for unloading handling (hours/vessel) by carrier g; and TLG_{iwg}: time for loading handling (hours/vessel) by carrier g.

TUG_{iwg} and TLG_{iwg} are defined respectively as follows.

$$TUG_{iwg} = TAR_{iw} + \frac{\overline{lfa}_{iwg} \cdot cap_w}{prod_i \cdot NC_{iw}} \cdot \frac{XAU_{iwg}}{XAU_{iwg} + XAP_{iwg}} \tag{C24}$$

$$TLG_{iwg} = TDE_{iw} + \frac{\overline{lfd}_{iwg} \cdot cap_w}{prod_i \cdot NC_{iw}} \cdot \frac{XDL_{iwg}}{XDL_{iwg} + XDP_{iwg}} \tag{C25}$$

where TDE_{iw}: minimum required time (hours) when a vessel of vessel size w departs from port i.

d) Unloading and Loading Link

The unloading link connects the arriving-unloading link for each size and the transshipment link or D-link. The loading link connects the transshipment link or O-link and the loading-departing link. Both are set for vessel size. In addition to costs related to the time required for unloading (or loading), this link considers costs associated with the use of terminals.

$$GUL_{vg} = \left(\frac{\sum_u NB_{iu} \cdot CTE_i}{XT_i} + \frac{CPA_{wg}}{\overline{lfa}_{iwg} \cdot cap_w} \cdot TUG_{iwg} \right) \tag{C26}$$

where GUL_{vg}: generalized cost (USD/TEU) of unloading link v (=iw), carrier g; CTE_i: charge for terminal (USD/hour/berth) per unit time of port i; and XT_i: total handled volume (TEU/hour) of port i defined as below.

$$XT_i = \sum_g \sum_w XAU_{iwg} + \sum_g \sum_w XDL_{iwg} \tag{C27}$$

In this link, fixed facility use charge CTE_i, which is predetermined irrespective of the handled volume, is defined as terminal costs. This charge is differentiated from the port charges imposed for each vessel CAD_i (see Equation (C19)) and from handling costs incurred from handling a piece of cargo CHA_i (see Equation (C28) and (C29)). Since each cost function is defined as a cost per TEU in this model, terminal costs per TEU display economies of scale in that they decrease as the handled volume increases.

The cost function of the loading link is also similarly defined.

e) Transshipment Link

This link connects an unloading link and a loading link, set one link for each port.

$$GTR_{vg} = 1.5 \cdot CHA_i + vt_g \cdot TTR_i \tag{C28}$$

where GTR_{vg}: generalized cost (USD/TEU) of transshipment link v (=i), carrier g; CHA_i: charge for handling (USD/TEU) per TEU dispatched or received cargo at port i; TTR_i: time for transshipment operation (hours) at port i. The charge for handling of transshipment cargo is assumed 1.5 times as that of dispatched or received cargo for discounting, although transshipped containers are handled twice.

f) D-Link and O-Link

The D-link connects the unloading link and the D node, a destination of cargo. The O-link connects the O node, an origin of a cargo, and the loading link.

$$GO_{vg} = GD_{vg} = CHA_i \qquad \text{(C29)}$$

where GO_{vg}: generalized cost (USD/TEU) of O-link v (=i), carrier g; and GD_{vg}: generalized cost (USD/TEU) of D-link v (=i), carrier g.

(2) Model Solution

The problem described above is defined as the equilibrium assignment problem with Cournot-Nash players. Also, since interference from other links' flows is included, the problem should be solved using a relaxation method. The calculation process is as follows.

Step 0. n = 0 and initial link cost $\left\{t_{vg}^{(0)}\right\}$ is calculated based on the initial flow $\left\{x_{vg}^{(0)}\right\}$ as input.

Step 1. $n = n + 1$

Step 2. The flow $\left\{x_{vg'}^{(n-1)}\right\}$ for a previous period of each carrier g' ($g, g' \in G$, $g \neq g'$) other than carrier in question g is fixed and the cost minimization problem for the carrier is solved. In other words,

$$\min_x \left\{ \sum_{v \in V} x_{vg}^{(n)} \cdot t_{vg}^{(n)} \left(x_{11}^{(n-1)}, \cdots, x_{|V|1}^{(n-1)}, \cdots, x_{1g}^{(n)}, \cdots, x_{vg}^{(n)}, \cdots, x_{|V|g}^{(n)}, \cdots, x_{1|G|}^{(n-1)}, \cdots, x_{|V||G|}^{(n-1)} \right) \right\}, \quad \forall g \in G \qquad \text{(C30)}$$

This is repeated for all groups.

Step 3. The flow $\left\{x_{vg}^{(n-1)}\right\}$ for a previous period and flow $\left\{x_{vg}^{(n)}\right\}$ from Step 2 are checked for convergence ($\Delta^{(n)} = \dfrac{\sqrt{\sum_g \sum_v \left\{x_{vg}^{(n)} - x_{vg}^{(n-1)}\right\}^2}}{\sum_g \sum_v x_{vg}^{(n)}} < \varepsilon_C$, ε_C being an infinitesimally small positive value acting as a convergence criterion), or if the repeat count n approaches an upper limit, the process is terminated; if it does not converge, the process returns to Step 1.

Because there are links, such as the cruising link, the loading link, and the unloading link, in which link cost inversely related to flow, convexity in network equilibrium assignment calculations is not guaranteed and the results are local solutions rather than optimizations. Consequently, in this model, a local optimization is obtained when using the current conditions as a starting point (i.e., when current link flow is used as an initial value).

C1.3.3 Shipper Model: Formulation and Solution

In this model, cargos are assigned on a network as shown in Figure C2. The maritime transportation link is defined herein as the direct linkage between an export port and an import port, irrespective of the actual maritime transportation route, which are considered in the carrier model. A stochastic (but not equilibrium) network assignment model is also applied in this model, taking into account factors which cannot be observed by the model developer. Widely, a logit model is applied for this type of problem as is adopted in the short-term model in C1.2; however, the authors do not apply because to deal with the large number of choices is computationally difficult in the logit model.

A shipper chooses a route (including the mode of hinterland transport and the ports to be used for export/import) so as to minimize expected generalized shipping costs, given the freight charges for maritime and land transport, and shipping time. When K_{rs} is the path choice set of regional cargo transport demand Q_{rs} (TEU) on a regional OD pair (hereinafter, called "regional pair") rs ($rs \in \Omega$; Ω is the set of the regional pair), a path k is chosen for a cargo m so as to maximize utility U_{rskm}, including an error term ε_{rskm}, that is,

$$U_{rskm} > U_{rsk'm}\,, \quad \forall k \in K_{rs}, \forall k' \in K_{rs}, k \neq k', \forall rs \in \Omega\,, \tag{C31}$$

$$s.t.\, U_{rskm} = -G_{rsk} + \varepsilon_{rskm}\,, \tag{C32}$$

where G_{rsk}: shipping cost (USD/TEU) of path k between a regional pair rs. If the error term ε_{rskm} follows Gumbel distribution, the choice of shipper is formulated as

$$F_{rsk} = Q_{rs} \cdot \frac{\exp\left(-\theta \cdot G_{rsk}\right)}{\exp\left(-\theta \cdot G_{rsk}\right) + \sum_{k' \in K_{rs}} \exp\left(-\theta \cdot G_{rsk'}\right)}, \tag{C33}$$

where F_{rsk}: cargo volume on a path k between regional pair rs. The shipping cost G_{rsk} for each path is expressed by the equation below.

$$G_{rsk} = \sum_{a \in k} \Lambda_a + \sum_{b \in k} GL_b + \sum_{i \in k} \left(GPX_i + GPM_i + GPT_i\right), \tag{C34}$$

where Λ_a: minimum expected cost (composite cost) for maritime link a included in a path k, which is a log-sum variable reflecting the selection result of the carrier group as shown in Equations (C3)-(C5) in section C1.2. More precisely,

$$\Lambda_a = -\frac{1}{\theta} \cdot \ln \sum_{g \in G} \exp\left(-\theta \cdot GM_{ag}\right) + \zeta\,, \tag{C35}$$

where ζ: adjustment parameter to avoid the log-sum variable (i.e. maritime link cost) being negative. GL_b in Equation (C34) is the generalized shipping cost on land link b included in the path k, expressed as

$$GL_b = CL_b + vt_{shpr} \cdot TL_b\,, \tag{C36}$$

where CL_b: freight on land link b (USD/TEU), and TL_b: shipping time (hours) on land link b. Additionally, GPX_i, GPM_i, GPT_i in Equation (C34) are the cost of a port link i included in the path k. Figure C3 shows the network structure in each port, which is omitted from Figure C2. As shown in Figure C3, a receipt (of export cargo) and a dispatch (of import cargo) link are respectively set in order to consider the lead time in each port. In addition, an inter-carrier transshipment link is also considered for each port taking into account the transshipment determined by the shipper. These link costs are defined as

$$GPX_i = vt_{shpr} \cdot TPX_i\,, \tag{C37}$$

$$GPM_i = vt_{shpr} \cdot TPM_i\,, \text{ and} \tag{C38}$$

$$GPT_i = CPT_i + vt_{shpr} \cdot TPT_i , \quad \text{(C39)}$$

where, TPX_i: lead time when exporting in port *i* (hours), TPM_i: lead time when importing in port *i* (hours), CPT_i: freight when transshipped between carrier groups (USD/TEU), and TPT_i: shipping time when transshipped between carrier groups (hours).

In addition, the relationship between the path flow F_{rsk} and the shipping demand d_a for each port pair is expressed as

$$d_a = \sum_{rs \in \Omega} \sum_{k \in K_{rs}} \delta'^{a}_{rsk} \cdot F_{rsk} , \ \forall a \in A , \quad \text{(C40)}$$

where δ'^{a}_{rsk}: Kronecker delta (δ'^{a}_{rsk} =1 when a link *a* is included in path *k* for regional pair *rs*; δ'^{a}_{rsk} = 0 when not included).

As shown above, a stochastic network assignment model with no flow-independent link is applied in this model. The cargo flow for each link is calculated using the Dial algorithm.

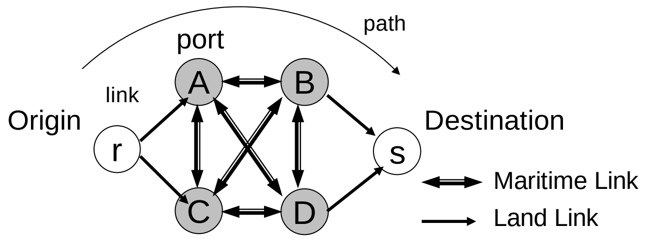


Figure C2 Schematic view of network structure of shipper model

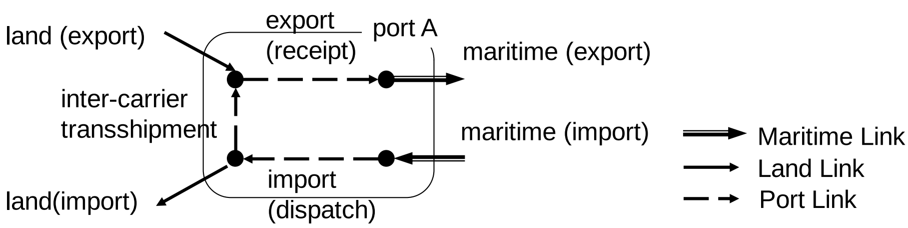


Figure C3 Network structure in port of shipper model

C1.3.4 Procedure of Calculation to Acquire Nash Equilibrium Solution

Inputting the initial conditions as a starting point and alternately repeating both the shipper and carrier model calculations, a local optimum solution is obtained according to following steps.

Step 0. [Setting initial condition] N = 0 and generalized cost of maritime shipping $\{GM_{ag}^{(0)}\}$ is acquired from an initial calculation of the carrier model described in section C1.3.2.
Step 1. $N = N + 1$.
Step 2. [Shipper model calculation] Based on the generalized cost of maritime shipping $\{GM_{ag}^{(N-1)}\}$ by port pair for the carrier group calculated in the last step, calculation of the shipper model as shown in C1.3.3 is performed. Shipping demand $\{d_a^{(N)}\}$ by port pair for the overall carrier group is then calculated.

Step 3. [Carrier model calculation] The carrier model is calculated according to the solution method described in section C1.3.2, by inputting the shipping demand $\left\{d_{ag}^{(N)}\right\}$ calculated in Step 2 as well as freight charge $\left\{p_{ag}^{(N-1)}\right\}$, shipping time $\left\{TM_{ag}^{(N-1)}\right\}$, and link cost in the network of the cost minimization model for carriers $\left\{t_{vg}^{(N-1)}\right\}$ calculated in the carrier model with previous iteration. The link flow $\left\{x_{vg}^{(N)}\right\}$ in the network of the cost minimization model for each carrier group and generalized cost of maritime shipping $\left\{GM_{ag}^{(N)}\right\}$ can be obtained.

Step 4. [Convergence test] The sum $\left\{XC_{ijsg}^{(N)}\right\}$ of the four types of cruising link flows in the network of the cost minimization model for carrier groups calculated in Step 4 is compared with the sum $\left\{XC_{ijsg}^{(N-1)}\right\}$ of the previously existing link flow and checked for convergence. If convergence is reached or the repeat count N approaches an upper limit, the process is terminated, and if not, the process returns to Step 1.

Although a detailed description is omitted due to space limitations, the authors confirmed that the above calculation process converges in most cases in which the input data and several parameters are reasonably set. Also, the solution acquired is robust in that the solution changes slightly as input data and/or parameters are changed slightly.

C2. Data Preparation

C2.1 Value of Time

The value of time for shipper vt_{shpr} included in the shipper model is set as a common value for all cargo at 10.8 (USD/TEU/hour) based on the description in a manual on port project evaluation in Japan.

The value of time for carrier vt_g included in the carrier model will be estimated to fit best for calculation results of the model with the actual conditions as described in next chapter, due to scarce reasoning in setting such a value.

C2.2 Maritime Shipping Network and Port Data

The ports covered by the model and the data for each port required as input are shown in Table C1. The maritime shipping network is prepared to connect between all major ports (defined as shown in Table C1 according to actual container cargo throughput, same below), between major ports and adjacent regional/local ports, between adjacent regional ports, and between all ports in the same region. In total, this maritime container cargo shipping network comprises 9514 combinations of ports. Distance data are also required for each combination of ports (not shown in this paper due to space limitations). These data are organized using a distance chart and software that can be freely downloaded.

The vessel sizes considered in this model are the five divisions (W = 5) shown in Table C2. Berth water depth categories relative to size are also defined as shown in Table C2. In addition, in this model, it is assumed that ocean-going carriers minimize their shipping costs by operation groups such as alliances, and the number of groups is 8 (G = 8), as shown in Table C3.

Table C1 Parameter settings of each container port in the international cargo flow model (1/4)

No	Area	Category	Port Name		Handl-ing Charge (USD/ TEU)*	Port Charge** (thousand USD/vessel)						Terminal Charge (million USD/ year/ berth)**	lead time for cargo handling (hours)		
						< 1000 TEU	1000 | 2500 TEU	2500 | 4000 TEU	4000 | 6000 TEU	6000 | 8000 TEU	8000 TEU <		export cargo*	import cargo*	Trans-ship-ped cargo**
1	East/ Southeast/ South Asia	L	Japan	Tomakomai	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
2		L	Japan	Sendai-Shiogama	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
3		M	Japan	Tokyo	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
4		M	Japan	Yokohama	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
5		L	Japan	Niigata	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
6		L	Japan	Shimizu	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
7		M	Japan	Nagoya	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
8		L	Japan	Yokkaichi	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
9		R	Japan	Osaka	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
10		M	Japan	Kobe	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
11		L	Japan	Mizushima	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
12		L	Japan	Hiroshima	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
13		L	Japan	Tokuyama-Kudamatsu	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
14		L	Japan	Hakata	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
15		L	Japan	Kitakyushu	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
16		L	Japan	Shibushi	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
17		L	Japan	Naha	165	15.0	18.1	21.9	26.3	31.3	36.3	9.0	48	48	48
18		M	Republic of Korea	Busan	183	5.4	8.5	12.3	16.7	21.7	26.7	5.8	72	48	24
19		R	Republic of Korea	Kwangyang	183	5.4	8.5	12.3	16.7	21.7	26.7	5.8	72	48	24
20		R	Republic of Korea	Incheon	183	5.4	8.5	12.3	16.7	21.7	26.7	5.8	72	48	48
21		L	DPR Korea	Najin	487	5.4	8.5	12.3	16.7	21.7	26.7	4.2	240	240	72
22		L	Russian Federation	Vostochniy	244	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	48	72
23		M	China	Dalian	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
24		M	China	Tianjin (Hsinkang)	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
25		M	China	Qingdao	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
26		L	China	Lianyungang	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
27		M	China	Shanghai	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
28		M	China	Ningbo	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
29		L	China	Fuzhou	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
30		M	China	Xiamen	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
31		M	China	Shenzhen	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
32		M	China	Guangzhou	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
33		R	China	Zhongshan	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
34		L	China	Nanjing	68	5.6	8.8	12.5	16.9	21.9	26.9	4.2	48	48	72
35		M	Hong Kong, China	Hong Kong	251	13.3	16.5	20.2	24.6	29.6	34.6	37.7	48	24	12
36		R	Chinese Taipei	Keelung	158	10.0	13.1	16.9	21.3	26.3	31.3	7.3	48	48	48
37		R	Chinese Taipei	Taichung	158	10.0	13.1	16.9	21.3	26.3	31.3	7.3	48	48	48
38		M	Chinese Taipei	Kaohsiung	158	10.0	13.1	16.9	21.3	26.3	31.3	7.3	48	48	24
39		M	Philippines	Manila	198	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	96	72
40		L	Vietnam	Haiphong	381	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	96	72
41		R	Vietnam	Ho Chi Minh City	381	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	96	72
42		L	Cambodia	Sihanoukville	157	4.8	8.0	11.7	16.1	21.1	26.1	2.1	72	120	72
43		M	Thailand	Laem Chabang	117	6.1	9.2	13.0	17.3	22.3	27.3	1.3	72	48	48
44		R	Thailand	Bangkok	117	6.1	9.2	13.0	17.3	22.3	27.3	1.3	72	48	72
45		L	Malaysia	Pasir Gudang	123	7.9	11.0	14.8	19.2	24.2	29.2	4.2	72	48	48
46		M	Malaysia	Tanjung Pelepas	123	7.9	11.0	14.8	19.2	24.2	29.2	4.2	72	48	12
47		M	Malaysia	Port Klang	123	7.9	11.0	14.8	19.2	24.2	29.2	4.2	72	48	24
48		L	Malaysia	Penang	123	7.9	11.0	14.8	19.2	24.2	29.2	4.2	72	48	48
49		L	Malaysia	Kuching	123	7.9	11.0	14.8	19.2	24.2	29.2	4.2	72	48	48
50		M	Singapore	Singapore	168	8.3	11.5	15.2	19.6	24.6	29.6	5.2	24	24	12
51		L	Myanmar	Thilawa	348	5.4	8.5	12.3	16.7	21.7	26.7	4.2	168	168	72
52		R	Indonesia	Surabaya (Tanjung Perak)	148	6.4	9.5	13.3	17.7	22.7	27.7	4.2	48	144	72
53		M	Indonesia	Jakarta (Tanjung Priok)	148	6.4	9.5	13.3	17.7	22.7	27.7	4.2	48	144	72
54		L	Indonesia	Belawan	148	6.4	9.5	13.3	17.7	22.7	27.7	4.2	48	144	72
55		L	Indonesia	Balikpapan	148	6.4	9.5	13.3	17.7	22.7	27.7	4.2	48	144	72
56		L	Indonesia	Ujyung Pandang	148	6.4	9.5	13.3	17.7	22.7	27.7	4.2	48	144	72
57		L	Brunei Darussalam	Muara	233	5.4	8.5	12.3	16.7	21.7	26.7	4.2	48	24	48
58		L	Bangladesh	Chittagong	529	5.4	8.5	12.3	16.7	21.7	26.7	4.2	120	96	72
59		L	India	Chennai	178	6.3	9.4	13.1	17.5	22.5	27.5	2.9	72	144	72
60		M	India	Jawaharlal Nehru	178	6.3	9.4	13.1	17.5	22.5	27.5	2.9	72	144	72
61		M	Sri Lanka	Colombo	132	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	72	24
62		L	Pakistan	Port Qasim	114	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	72	72
63		L	Pakistan	Karachi	114	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	72	72
64	##	L	Russian Federation	St Petersburg	244	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	48	72
65	West Coast of North America	L	USA	Anchorage	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
66		R	Canada	Vancouver	537	13.8	16.9	20.6	25.0	30.0	35.0	12.5	24	48	48
67		R	USA	Seattle	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
68		R	USA	Tacoma	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
69		R	USA	Oakland	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
70		M	USA	Los Angeles	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
71		M	USA	Long Beach	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
72		R	USA	Honolulu	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
73		L	Mexico	Manzanillo	225	6.3	9.4	13.1	17.5	22.5	27.5	4.2	48	72	72

Table C1 Parameter settings of each container port in the international cargo flow model (2/4)

No	Port Name		Number of berth(2008)***						Number of berth(2015)**					
			> -11 m	-11 | -13 m	-13 | -14 m	-14 | -15 m	-15 | -16 m	-16 m >	> -11 m	-11 | -13 m	-13 | -14 m	-14 | -15 m	-15 | -16 m	-16 m >
1	Japan	Tomakomai	0	0	0	1	0	0	0	0	0	**2**	0	0
2	Japan	Sendai-Shiogama	0	1	0	1	0	0	0	1	0	1	0	0
3	Japan	Tokyo	2	2	0	2	8	0	2	**3**	0	**0**	**11**	**2**
4	Japan	Yokohama	0	4	9	1	4	2	0	4	9	1	4	**4**
5	Japan	Niigata	1	1	0	0	0	0	1	**0**	0	**1**	0	0
6	Japan	Shimizu	0	3	0	0	1	0	0	**2**	0	0	**2**	0
7	Japan	Nagoya	3	5	0	2	2	2	3	5	0	2	2	2
8	Japan	Yokkaichi	0	0	1	1	0	0	0	0	1	1	0	0
9	Japan	Osaka	2	4	5	1	2	0	**1**	4	5	1	2	**1**
10	Japan	Kobe	2	4	2	4	6	0	2	4	2	4	6	0
11	Japan	Mizushima	4	0	0	0	0	0	4	**1**	0	0	0	0
12	Japan	Hiroshima	3	0	0	1	0	0	3	0	0	**2**	0	0
13	Japan	Tokuyama-Kudamatsu	0	1	0	0	0	0	0	**2**	0	0	0	0
14	Japan	Hakata	0	1	2	1	1	0	0	1	2	1	1	0
15	Japan	Kitakyushu	3	2	0	0	2	0	3	2	0	0	2	0
16	Japan	Shibushi	2	0	0	0	0	0	2	0	0	2	0	0
17	Japan	Naha	0	0	2	0	0	0	0	0	2	0	0	0
18	Republic of Korea	Busan	0	2	2	2	15	6	0	2	2	2	**14**	**18**
19	Republic of Korea	Kwangyang	0	2	0	0	3	11	0	2	0	0	3	11
20	Republic of Korea	Incheon	0	4	0	2	0	0	0	4	0	**8**	0	0
21	DPR Korea	Najin	1	0	0	0	0	0	1	0	0	0	0	0
22	Russian Federation	Vostochniy	0	2	2	0	0	0	0	2	**10**	0	0	0
23	China	Dalian	0	2	3	8	2	2	0	2	3	**9**	**1**	**7**
24	China	Tianjin (Hsinkang)	0	1	0	4	7	4	0	1	0	4	**12**	**13**
25	China	Qingdao	0	0	1	5	3	3	0	0	1	**7**	3	**10**
26	China	Lianyungang	0	2	0	0	0	0	0	2	0	0	0	**5**
27	China	Shanghai	9	12	6	4	0	9	9	12	**11**	4	0	**16**
28	China	Ningbo	0	0	6	0	4	4	0	0	6	0	4	**14**
29	China	Fuzhou	2	3	0	1	1	1	2	3	0	1	**2**	**2**
30	China	Xiamen	0	8	7	0	0	3	0	8	7	0	0	3
31	China	Shenzhen	0	2	0	3	15	12	0	2	0	**5**	**16**	**22**
32	China	Guangzhou	0	9	0	10	0	0	0	9	0	**4**	**6**	**6**
33	China	Zhongshan	4	0	0	0	0	0	**5**	**2**	0	0	0	0
34	China	Nanjing	5	0	0	0	0	0	**0**	**11**	0	0	0	0
35	Hong Kong, China	Hong Kong	0	0	0	1	23	0	0	0	0	1	23	0
36	Chinese Taipei	Keelung	2	6	5	0	0	0	2	6	5	**1**	**7**	0
37	Chinese Taipei	Taichung	0	0	0	6	0	0	0	0	0	6	0	0
38	Chinese Taipei	Kaohsiung	4	4	1	15	3	0	4	4	1	15	3	**4**
39	Philippines	Manila	29	7	2	1	0	0	29	7	2	1	0	0
40	Vietnam	Haiphong	3	0	0	0	0	0	3	0	0	**2**	0	0
41	Vietnam	Ho Chi Minh City	10	6	2	1	0	0	10	6	2	**8**	0	0
42	Cambodia	Sihanoukville	1	0	0	0	0	0	1	0	0	0	0	0
43	Thailand	Laem Chabang	0	0	0	8	0	5	0	0	0	**5**	0	**6**
44	Thailand	Bangkok	21	0	0	0	0	0	21	0	0	0	0	0
45	Malaysia	Pasir Gudang	0	0	0	0	3	0	0	0	0	0	3	0
46	Malaysia	Tanjung Pelepas	0	0	0	0	6	0	0	0	0	0	6	0
47	Malaysia	Port Klang	0	0	0	6	13	0	0	0	0	6	13	**1**
48	Malaysia	Penang	2	3	0	0	0	0	2	3	0	0	0	0
49	Malaysia	Kuching	6	6	0	0	0	0	6	6	0	0	0	0
50	Singapore	Singapore	6	15	4	4	11	20	6	15	4	4	11	**22**
51	Myanmar	Thilawa	2	3	0	0	0	0	2	3	0	0	0	0
52	Indonesia	Surabaya (Tanjung Perak)	11	0	0	0	0	0	11	0	0	**4**	0	0
53	Indonesia	Jakarta (Tanjung Priok)	2	4	0	6	0	0	**0**	4	0	6	0	0
54	Indonesia	Belawan	5	0	0	0	0	0	5	0	0	0	0	0
55	Indonesia	Balikpapan	0	2	0	0	0	0	0	2	0	0	0	0
56	Indonesia	Ujyung Pandang	0	2	0	0	0	0	0	2	0	0	0	0
57	Brunei Darussalam	Muara	0	2	0	0	0	0	0	2	0	0	0	0
58	Bangladesh	Chittagong	2	0	0	0	0	0	2	0	0	0	0	0
59	India	Chennai	0	0	4	0	0	0	0	0	4	0	0	**5**
60	India	Jawaharlal Nehru	3	5	2	0	0	0	3	5	**7**	0	0	0
61	Sri Lanka	Colombo	4	2	1	0	5	0	4	2	1	0	5	0
62	Pakistan	Port Qasim	0	3	0	0	0	0	0	3	0	0	0	**5**
63	Pakistan	Karachi	4	0	2	0	0	0	4	0	2	0	0	**4**
64	Russian Federation	St Petersburg	2	6	0	0	0	0	2	6	**1**	**2**	**2**	**2**
65	USA	Anchorage	3	0	0	0	0	0	3	0	0	0	0	0
66	Canada	Vancouver	0	1	0	0	8	1	0	1	0	0	**9**	1
67	USA	Seattle	0	0	0	0	11	0	0	0	0	0	11	0
68	USA	Tacoma	0	0	0	0	10	0	0	0	0	0	**12**	0
69	USA	Oakland	0	20	0	0	5	0	0	20	0	0	5	0
70	USA	Los Angeles	2	5	10	1	4	7	2	5	10	1	4	7
71	USA	Long Beach	0	3	7	5	14	1	0	3	7	5	14	1
72	USA	Honolulu	0	5	0	0	0	0	0	5	0	0	0	0
73	Mexico	Manzanillo	0	9	0	3	0	0	0	9	0	3	0	0

Table C1 Parameter settings of each container port in the international cargo flow model (3/4)

No	Area	Category	Port Name		Handling Charge (USD/TEU)*	Port Charge** (thousand USD/vessel) < 1000 TEU	1000 – 2500 TEU	2500 – 4000 TEU	4000 – 6000 TEU	6000 – 8000 TEU	8000 TEU <	Terminal Charge (million USD/year/berth)**	lead time for cargo handling (hours) export cargo*	import cargo*	Trans-shipped cargo**
74	East Coast of North America/ Central America#	R	Panama	Puerto Manzanillo	224	6.3	9.4	13.1	17.5	22.5	27.5	4.2	24	24	24
75		L	Costa Rica	Limon	243	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	48	72
76		R	Puerto Rico	San Juan	418	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	72	72
77		R	Jamaica	Kingston	327	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	48	24
78		L	Cuba	Havana	576	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	72	72
79		R	Bahamas	Freeport	408	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	48	24
80		R	USA	Houston	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
81		R	USA	Miami	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
82		L	USA	Port Everglades	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
83		L	USA	Jacksonville	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
84		R	USA	Savannah	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
85		R	USA	Charleston	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
86		R	USA	Virginia（Norfolk）	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
87		M	USA	New York/New Jersey	216	13.8	16.9	20.6	25.0	30.0	35.0	25.0	48	24	48
88		R	Canada	Montreal	537	13.8	16.9	20.6	25.0	30.0	35.0	12.5	24	48	48
89	South America	L	Ecuador	Guayaquil	229	6.3	9.4	13.1	17.5	22.5	27.5	4.2	48	96	72
90		L	Peru	Callao	235	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	120	72
91		L	Chile	Valparaiso	184	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	96	72
92		R	Chile	San Antonio	184	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	96	72
93	#	L	Colombia	Cartagena	152	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	48	72
94		L	Venezuela	Puerto Cabello	414	6.3	9.4	13.1	17.5	22.5	27.5	4.2	168	168	72
95	South America	R	Brazil	Santos	178	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	72	72
96		L	Uruguay	Montevideo	297	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	96	72
97		R	Argentina	Buenos Aires	471	6.3	9.4	13.1	17.5	22.5	27.5	4.2	48	72	72
98	Middle East	R	Iran	Bandar Abbas	203	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	120	72
99		L	Saudi Arabia	Dammam	94	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	96	72
100		M	UAE	Dubai	128	6.3	9.4	13.1	17.5	22.5	27.5	4.2	24	24	24
101		R	UAE	Khor Fakkan	128	6.3	9.4	13.1	17.5	22.5	27.5	4.2	24	24	72
102		M	Oman	Salalah (Mina Raysut)	183	6.3	9.4	13.1	17.5	22.5	27.5	4.2	72	96	24
103		M	Saudi Arabia	Jeddah	94	6.3	9.4	13.1	17.5	22.5	27.5	4.2	96	96	24
104	Mediterra-nean	R	Israel	Haifa	238	10.8	14.0	17.7	22.1	27.1	32.1	4.2	72	72	48
105		L	Cyprus	Limassol	143	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	24
106		R	Turkey	Ambarli (Istanbul)	193	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	72
107		R	Greece	Piraeus	285	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	120	24
108		R	Malta	Marsaxlokk	298	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	24
109		M	Italy	Gioia Tauro	308	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	24
110		R	Italy	La Spezia	308	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	24
111		R	Italy	Genoa	308	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	24
112		L	France	Marseilles	232	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	48
113		R	Spain	Barcelona	179	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	48	24
114		M	Spain	Valencia	179	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	48	24
115		M	Spain	Algeciras	179	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	48	24
116		R	Egypt	Damietta	174	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	24
117		L	Algeria	Algiers (El Djazair)	374	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	120	72
118	North Europe##	L	UK	London (Tilbury)	165	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	48
119		R	UK	Southampton	165	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	48
120		M	UK	Felixstowe	165	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	48
121		R	France	Le Havre	232	10.8	14.0	17.7	22.1	27.1	32.1	8.3	72	72	48
122		R	Belgium	Zeebrugge	266	10.8	14.0	17.7	22.1	27.1	32.1	8.3	24	24	48
123		M	Belgium	Antwerp	266	10.8	14.0	17.7	22.1	27.1	32.1	8.3	24	24	48
124		M	Holland	Rotterdam	186	10.8	14.0	17.7	22.1	27.1	32.1	8.3	24	24	24
125		M	Germany	Bremen/Bremerhaven	207	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	48
126		M	Germany	Hamburg	207	10.8	14.0	17.7	22.1	27.1	32.1	8.3	48	24	48
127		L	Sweden	Gothenburg	136	10.8	14.0	17.7	22.1	27.1	32.1	8.3	24	48	72
128		L	Iceland	Raykajavik	172	10.8	14.0	17.7	22.1	27.1	32.1	4.2	168	48	72
129	Sub-Saharan Africa	L	Senegal	Dakar	488	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	72	48
130		R	Cote d'Ivoire	Abidjan	874	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	192	72
131		L	Nigeria	Lagos	390	5.4	8.5	12.3	16.7	21.7	26.7	4.2	96	120	72
132		L	Cameroon	Douala	346	5.4	8.5	12.3	16.7	21.7	26.7	4.2	72	120	72
133		L	Angola	Luanda	581	5.4	8.5	12.3	16.7	21.7	26.7	4.2	576	576	72
134		R	South Africa	Durban	311	5.4	8.5	12.3	16.7	21.7	26.7	4.2	216	336	72
135		L	Kenya	Mombasa	367	5.4	8.5	12.3	16.7	21.7	26.7	4.2	144	168	72
136		L	Djibouti	Djibouti	259	5.4	8.5	12.3	16.7	21.7	26.7	4.2	96	72	72
137	Oceania	L	Australia	Brisbane	251	7.5	10.6	14.4	18.8	23.8	28.8	8.3	24	48	48
138		R	Australia	Sydney	251	7.5	10.6	14.4	18.8	23.8	28.8	8.3	24	48	48
139		R	Australia	Melbourne	251	7.5	10.6	14.4	18.8	23.8	28.8	8.3	24	48	48
140		L	Australia	Fremantle	251	7.5	10.6	14.4	18.8	23.8	28.8	8.3	24	48	48
141		L	New Zealand	Auckland	213	7.5	10.6	14.4	18.8	23.8	28.8	8.3	48	24	48
142		L	New Zealand	Tauranga	213	7.5	10.6	14.4	18.8	23.8	28.8	8.3	48	24	48
143		L	Papua New Guinea	Port Moresby	183	7.5	10.6	14.4	18.8	23.8	28.8	8.3	72	96	72

Source: * World Bank: Doing Business. ** authors' estimation. *** Containerisation International Yearbook etc.

Table C1 Parameter settings of each container port in the international cargo flow model (4/4)

No	Port Name		Number of berth(2008)[***]						Number of berth(2015)[**]					
			> -11 m	-11 | -13 m	-13 | -14 m	-14 | -15 m	-15 | -16 m	-16 m >	> -11 m	-11 | -13 m	-13 | -14 m	-14 | -15 m	-15 | -16 m	-16 m >
74	Panama	Puerto Manzanillo	0	0	4	1	0	0	0	0	4	**2**	0	**4**
75	Costa Rica	Limon	2	0	0	0	0	0	**0**	**2**	0	0	0	0
76	Puerto Rico	San Juan	9	0	0	0	0	0	9	0	0	0	**1**	0
77	Jamaica	Kingston	7	2	3	0	0	0	**3**	**4**	**5**	0	0	0
78	Cuba	Havana	1	0	0	0	0	0	**2**	0	0	0	0	0
79	Bahamas	Freeport	0	0	0	0	0	3	0	0	0	0	0	3
80	USA	Houston	0	5	0	7	0	0	0	5	0	7	0	0
81	USA	Miami	0	4	0	0	5	0	0	4	0	0	5	0
82	USA	Port Everglades	1	6	4	0	0	0	1	6	4	0	0	0
83	USA	Jacksonville	0	18	0	0	0	0	0	**8**	0	**10**	0	0
84	USA	Savannah	0	14	0	4	0	0	0	14	0	**0**	**4**	0
85	USA	Charleston	0	6	7	0	0	0	0	6	7	0	**3**	0
86	USA	Virginia（Norfolk）	5	4	2	0	4	0	5	4	2	0	4	0
87	USA	New York/New Jersey	1	12	4	15	4	0	1	12	4	15	4	0
88	Canada	Montreal	16	0	0	0	0	0	16	0	0	0	0	0
89	Ecuador	Guayaquil	3	0	0	0	0	0	3	**2**	0	0	0	0
90	Peru	Callao	0	18	0	0	0	0	0	18	0	**2**	0	0
91	Chile	Valparaiso	2	3	0	0	0	0	2	3	0	0	0	0
92	Chile	San Antonio	2	3	0	0	0	0	2	3	0	0	0	0
93	Colombia	Cartagena	2	4	2	0	0	0	2	4	2	0	0	0
94	Venezuela	Puerto Cabello	0	13	0	0	0	0	0	13	0	0	0	0
95	Brazil	Santos	2	5	9	0	0	0	2	**2**	**10**	**1**	0	**5**
96	Uruguay	Montevideo	2	0	0	0	0	0	2	0	0	0	0	0
97	Argentina	Buenos Aires	21	0	0	0	0	0	21	0	0	0	0	0
98	Iran	Bandar Abbas	0	5	0	0	0	0	0	5	0	0	0	**4**
99	Saudi Arabia	Dammam	0	0	0	6	0	0	0	0	0	6	0	0
100	UAE	Dubai	0	5	5	3	3	11	0	5	5	3	3	11
101	UAE	Khor Fakkan	0	2	0	0	0	3	0	2	0	0	0	3
102	Oman	Salalah (Mina Raysut)	0	0	0	0	0	6	0	0	0	0	0	**8**
103	Saudi Arabia	Jeddah	0	1	0	0	4	4	0	1	0	0	4	**7**
104	Israel	Haifa	4	2	0	2	0	0	4	2	0	2	**3**	0
105	Cyprus	Limassol	0	3	0	0	0	2	0	3	0	0	0	2
106	Turkey	Ambarli (Istanbul)	6	4	3	7	0	0	6	4	3	7	0	0
107	Greece	Piraeus	0	2	2	2	1	2	0	2	2	2	1	2
108	Malta	Marsaxlokk	0	0	0	0	6	1	0	0	0	0	**0**	**7**
109	Italy	Gioia Tauro	0	0	5	0	5	0	0	0	5	0	5	0
110	Italy	La Spezia	0	0	1	3	0	0	0	0	**0**	**0**	**4**	0
111	Italy	Genoa	3	6	2	2	5	0	3	6	2	2	5	0
112	France	Marseilles	1	8	0	5	0	0	1	8	0	5	**2**	**2**
113	Spain	Barcelona	6	4	0	3	0	2	6	4	0	3	0	**4**
114	Spain	Valencia	0	2	0	0	2	8	0	2	0	0	2	8
115	Spain	Algeciras	4	0	0	2	0	3	4	0	0	2	0	**5**
116	Egypt	Damietta	0	0	0	4	0	0	**1**	0	0	**7**	0	**7**
117	Algeria	Algiers (El Djazair)	0	3	0	0	0	0	0	**6**	0	0	0	0
118	UK	London (Tilbury)	3	0	2	0	0	0	3	0	2	0	0	0
119	UK	Southampton	1	2	0	0	2	0	1	2	0	0	2	0
120	UK	Felixstowe	1	2	2	2	2	0	1	2	2	2	2	**2**
121	France	Le Havre	2	4	8	10	0	0	2	4	8	**12**	0	0
122	Belgium	Zeebrugge	0	0	0	0	6	9	0	0	0	0	6	9
123	Belgium	Antwerp	0	0	9	4	15	4	0	0	9	4	15	**7**
124	Holland	Rotterdam	5	17	4	8	0	20	**13**	17	4	8	0	**24**
125	Germany	Bremen/Bremerhaven	2	3	0	10	0	0	2	3	0	10	0	**2**
126	Germany	Hamburg	1	9	5	3	9	7	1	9	5	3	9	**10**
127	Sweden	Gothenburg	2	10	0	0	0	0	2	10	0	0	0	0
128	Iceland	Raykajavik	3	0	0	0	0	0	3	0	0	0	0	0
129	Senegal	Dakar	10	5	0	0	0	0	10	5	0	0	0	0
130	Cote d'Ivoire	Abidjan	0	5	0	0	0	0	0	5	0	0	0	0
131	Nigeria	Lagos	24	0	0	0	0	0	24	0	0	0	0	0
132	Cameroon	Douala	0	3	0	0	0	0	0	3	0	0	0	0
133	Angola	Luanda	6	0	0	0	0	0	6	0	0	0	0	0
134	South Africa	Durban	0	9	0	0	0	0	0	9	0	0	0	0
135	Kenya	Mombasa	0	5	0	0	0	0	0	**0**	0	0	**5**	0
136	Djibouti	Djibouti	1	1	0	0	0	0	1	1	0	0	0	0
137	Australia	Brisbane	0	0	0	10	0	0	0	0	0	**12**	0	0
138	Australia	Sydney	0	0	1	6	0	0	0	0	1	6	0	**2**
139	Australia	Melbourne	4	2	8	0	0	0	4	2	**0**	**8**	0	0
140	Australia	Fremantle	0	0	6	0	0	0	0	0	6	0	0	0
141	New Zealand	Auckland	0	4	0	0	0	0	0	4	0	0	0	0
142	New Zealand	Tauranga	3	2	3	0	0	0	3	2	3	0	0	0
143	Papua New Guinea	Port Moresby	3	0	0	0	0	0	3	0	0	0	0	0

Table C2 Settings by containership and berth size

- containership size

category	range of TEU capacity (TEU)	average of TEU capacity (TEU)	berth size category that containership can enter	maritime shipping cost (USD/TEU/hour)		vessel speed (knot)
				when vessel is sailing**	when vessel is anchoring**	
1	- 1000	500	all 1-6	27.4	25.3	16.5
2	1000 - 2500	1750	2,3,4,5,6	17.4	14.8	20.3
3	2500 - 4000	3250	3,4,5,6	14.1	11.2	22.5
4*	4000 - 6000	5000	4,5,6	12.1	9.0	24.2
5*	6000 - 8000	7000	5,6	10.7	7.4	25.6
6*	8000 -	9000	6	9.7	6.3	26.7

- berth size

category	depth (m)
1	under 11.0
2	11.0 - 13.0
3	13.0 - 14.0
4	14.0 - 15.0
5	15.0 - 16.0
6	over 16.0

*impossible to pass through the Panama Canal before expansion (possible after expansion)

**exemplified figures if load factor is assumed to be 80%

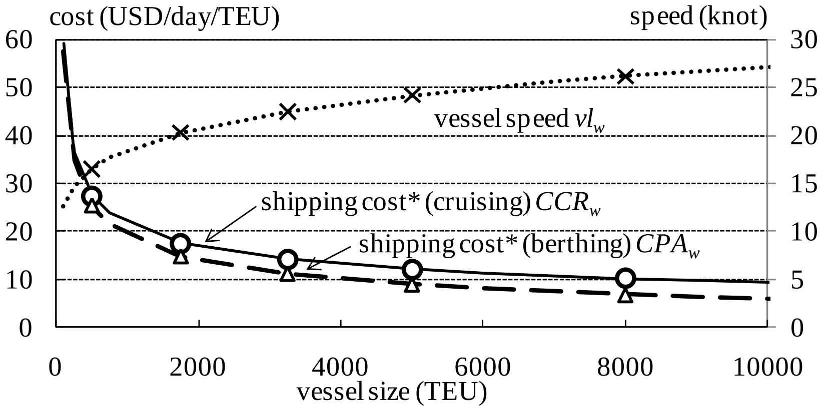
Table C3 Settings of container carrier group

group	alliance name	main shipping companies	share of container flow
A	-	Maersk	12%
B	-	Evergreen, LT	9%
C	-	MSC	6%
D	Grand Alliance	MOL, APL, Hyundai, NOL	12%
E	New World	HAPAG-LLOYD, MISC, NYK, OOCL, P&O	19%
F	CKYH	COSCO, KL, Yang Ming, Hanjing	18%
G	other carriers I (Asian carriers)	Cho Yang, CSAV, Heung-A, Namsung, UASC, Sinotrans, Wan Hai, etc.	11%
H	other carriers II (others)	CMA-CGM, PIL, ZIM, Wilhelmsen, etc.	13%

The data for each port are extracted and estimated from various statistics and the authors' own investigation. For example, the berth number NB_{iu} by category for each port is set based on the Containerisation International Yearbook and each port's website, as shown in Table C1. Various charges and transship time are estimated based on the Doing Business database provided by the World Bank and the authors' investigation, also shown in Table C1. Other port-related data are defined commonly irrespective of ports due to data availability; i.e., $TA_{iw} = TD_{iw} = 1$ (hour), $prod_i = 45$ (TEUs/hour), and $NC_{iw} = w + 1$.

C2.3 Maritime Shipping Cost

Maritime shipping costs CCR_{wg} (when a vessel is cruising) and CPA_{wg} (when a vessel is berthing) per TEU and unit time are set as shown in Figure C4 based on Kurokawa et al. (1999) and other research. In this simulation, these costs are assumed to be the same irrespective of the carrier g. As shown in the figure, these costs decrease as vessel size increases. Vessel speed vl_w is also defined by vessel size as shown in Figure C4 based on the above-mentioned research, and increases as vessel size increases.



*assuming load factor is 0.8

Figure C4 Maritime shipping cost and vessel speed by containership size assumed in model

C2.4 Current Maritime Shipping Link Flow

In the link with economies of scale for cargo flow (i.e., in the cruise, loading, and unloading links) of the carrier sub-model, actual flows are needed as initial input, in order to solve the local optimum of the problem as described in the previous chapter. The actual flow of cruise links (i.e., shipping volumes between ports for each carrier by vessel size) is estimated by multiplying vessel capacity per annum for each link by a load factor. The annual vessel capacity is estimated using sequence data for ports of call, frequency, and vessel size provided by MDS Transmodal database. The load factor, since actual data are not available, is set at 0.8 for all links. The actual flows of loading and unloading links are estimated by aggregating the shipping demand by export/import ports and adding the actual volume of transshipped containers from various sources such as Drewry Shipping Consultants.

C2.5 Land Network and Shipping Cost

This model also considers the land transport network, including roads and railways, in the APEC region (Northeast Asia & Russia, Southeast Asia, North America, South America, and Oceania). The authors utilized a database acquired from ADC WorldMap™; however, this database is very dense and, if the network is directly incorporated into the maritime shipping network, the problem of independence from irrelevant alternatives cannot neglected because a stochastic assignment methodology is applied in the model. Therefore, a shortest path search between zone representatives, and between zone representatives and ports for import/export was conducted in advance only on the land transport network. The land network used in the shortest path search and the routes selected as a result for each APEC region are shown in Figure C5. In addition, several routes of short sea shipping using ferry or RORO ship are included in the model for connection between continents and isolated islands, although these are not shown in the following figures.

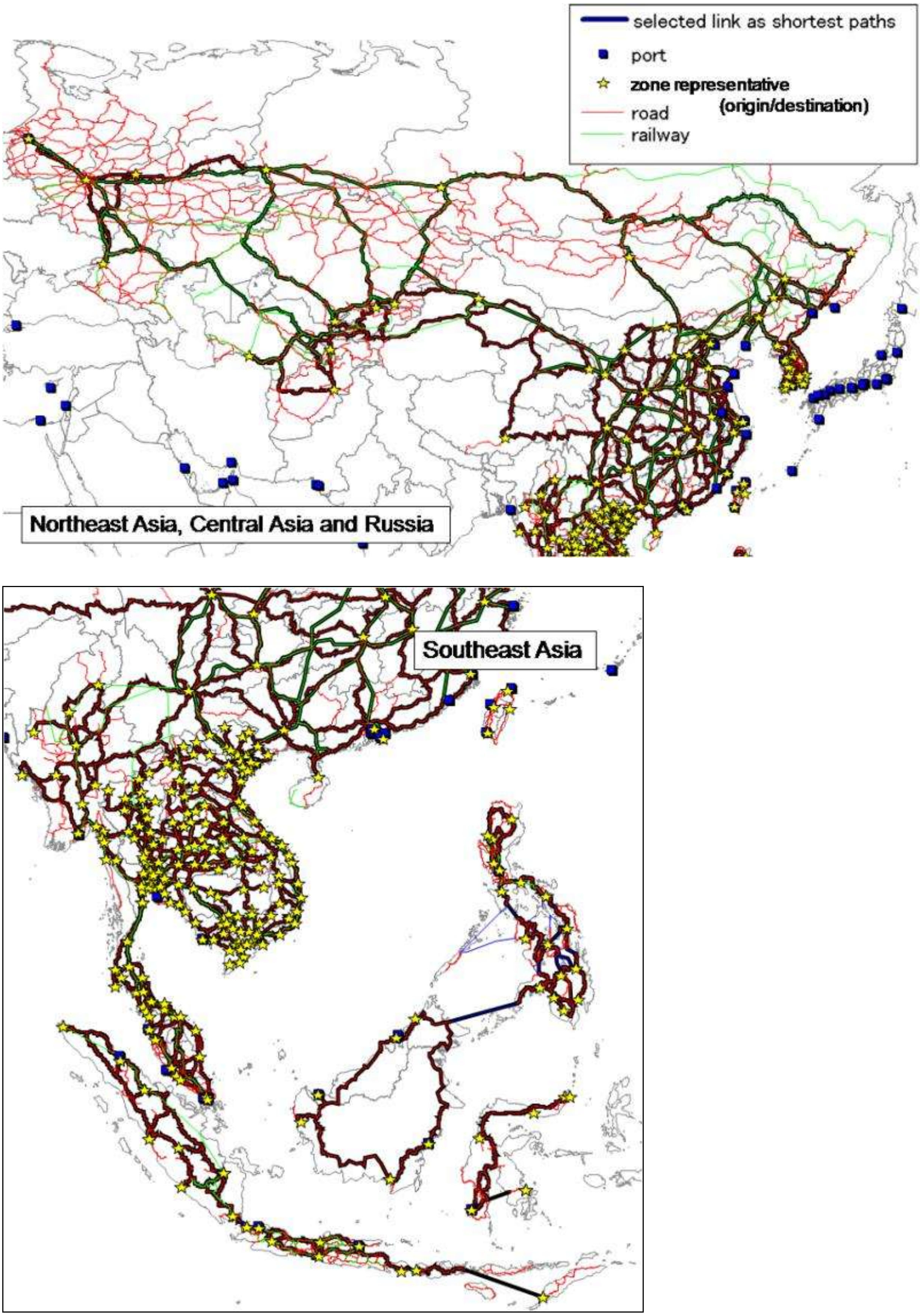
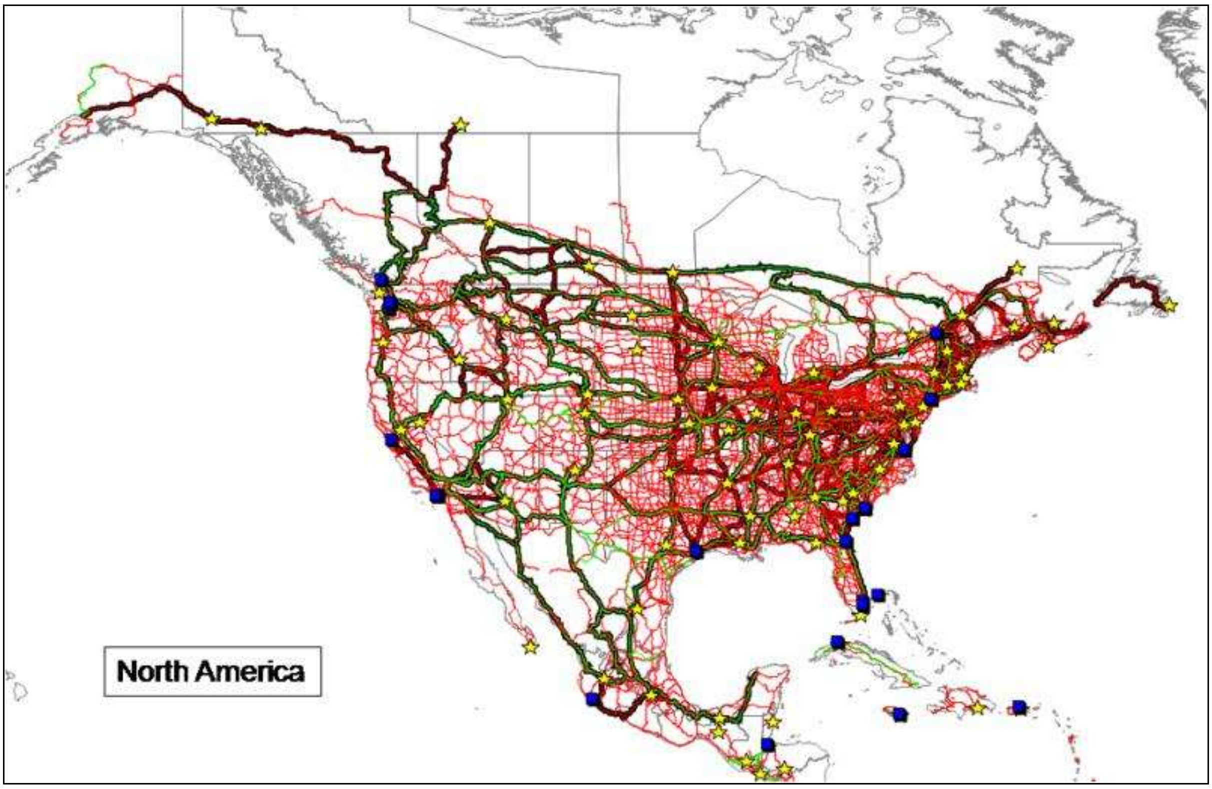


Figure C5 Land transport network in APEC region and neighboring region considered in model (1/3)



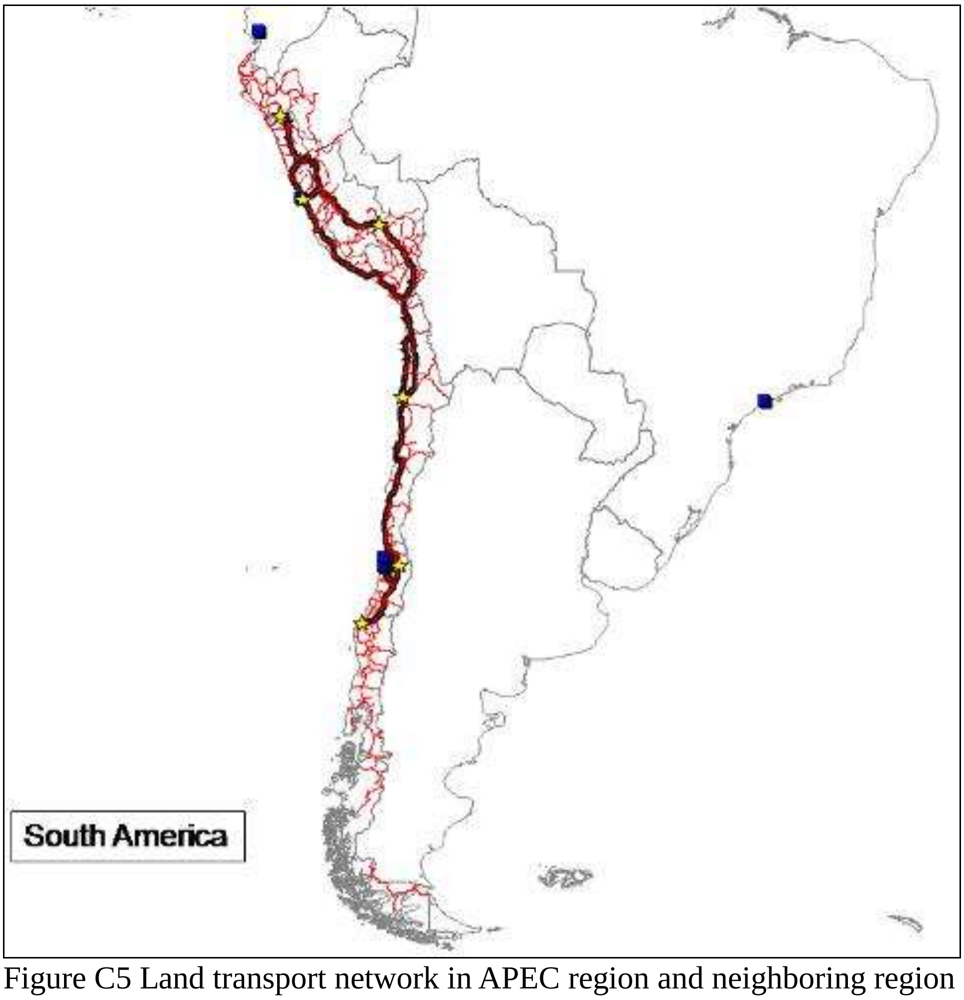


Figure C5 Land transport network in APEC region and neighboring region considered in model (2/3)

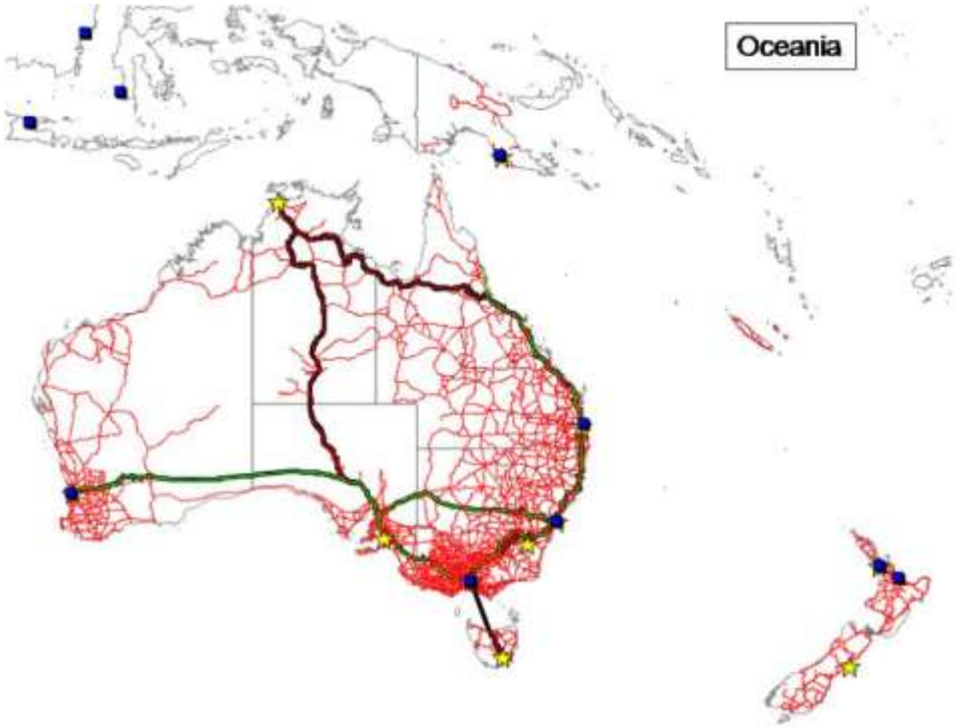


Figure C5 Land transport network in APEC region and neighboring region considered in model (3/3)

The transport costs when utilizing trucks, railways, and inland/short sea shipping (i.e. ferry and RORO ship) as generally defined in Equation (C36) in the previous chapter are assumed as shown below. Freight charges for land transport (CL_b in Eq. C36) are generally divided into the fixed cost *CLF* and operational cost *CLO* in proportion to the link distance l_b. The fixed cost for each transport should be imposed only once for one transport mode (however, when transiting from one mode to another mode, it should be imposed again), while the proportional cost is imposed for every link. Shipping time (TL_b in Eq. C36) is generally defined by dividing the link distance l_b by vehicle speed v_b (i.e., $TL_b = l_b / v_b$). For railways and short sea shipping, expected waiting time *TLW* depending on service frequency is also imposed.

C2.5.1 Road Transport

Freight charges for road transport are assumed as shown below according to sample data reported in JETRO (2008) for the Southeast Asian region. Expected waiting time is considered to be zero because trucks can essentially provide on-demand service.

$$CLF_{road} = 167 \text{ (USD/TEU)} \quad \text{(C41)}$$

$$CLO_{road} = 0.83 \cdot (2 \cdot l_b) \text{ (USD/TEU)} \quad \text{(C42)}$$

$$TLW_{road} = 0 \quad \text{(C43)}$$

In addition, the vehicle speed of trucks v_{road} varies from 60 (km/h) to 20 (km/h) depending on the rank of road as originally defined in the database (ADC WorldMap). The link distance l_b is doubled in Equation (C42) because many international marine container transport trucks make round trips for transportation between producing region and export port and between import ports and consuming region (i.e., no cargo is transported on the return trip).

C2.5.2 Railway Transport

Freight charges for railway transport are assumed as shown below considering the relative scale to truck costs by trial and error. Depending on the advancement of railway infrastructure and actual usage, two types of parameter settings are prepared by region.

1) Asia, Russia, and South America

$$CLF_{rail} = vt_{shpr} \cdot 24 \text{ (USD/TEU)} \quad \text{(C44a)}$$

$$CLO_{rail} = 0.42 \cdot l_b \text{ (USD/TEU)} \quad \text{(C45)}$$

$$TLW_{rail} = \frac{1}{2} \cdot (3.5 \cdot 24) \text{ (hour)} \quad \text{(C46a)}$$

2) North America and Oceania

$$CLF_{rail} = vt_{shpr} \cdot 4 \text{ (USD/TEU)} \quad \text{(C44b)}$$

$$CLO_{rail} = 0.42 \cdot l_b \text{ (USD/TEU)} \quad \text{(C45)}$$

$$TLW_{rail} = \frac{1}{2} \cdot 24 \text{ (hour)} \quad \text{(C46b)}$$

Railway speed v_{rail} also varies, being 20 (km/h) in Asia, Russia, and South America and 40 (km/h) in North America and Oceania. Equations (C44a) and (C44b) mean that the fixed cost for railway transport CLF_{rail} depends on handling time (4 hours for North America and Oceania, 24 hours for other regions) when transiting from truck to rail and vice versa. Equation (C45) means that the operational cost is common for all economies and that shippers do not pay for return transport when utilizing railways. Equations (C46a) and (C46b) mean the expected waiting time is assumed to be half of service frequency, which is assumed to be twice a week (i.e., 3.5 days) for Asia, Russia, and South America and daily for North America and Oceania. The service frequency and other parameters in the above formulations can be set differently for each railway link in order to reflect differences in the level of service on each link, if the data are available. The above parameters are temporal settings.

C2.5.3 Ferry/RORO Ship Transport

Freight charges for ferry (or RORO ship) transport are assumed as shown below according to the description in the Guideline for Evaluation of Port Investment in Japan (2004).

$$CLF_{ferry} = 2 \cdot (25 + vt_{shpr} \cdot 4) \text{ (USD/TEU)} \quad \text{(C47)}$$

$$CLO_{ferry} = 0.625 \cdot (2 \cdot l_b) \text{ (USD/TEU)} \quad \text{(C48)}$$

$$TLW_{ferry} = \frac{1}{2} \cdot (3.5 \cdot 24) \text{ (hour)} \quad \text{(C49)}$$

Vessel speed v_{ferry} is set at 20 (km/h) for all economies. The fixed cost for ferry transport CLF_{ferry} is the sum of the fixed part of freight charges for ferry transport and the cost related to handling time (4 hours for all economies). Since trucks are loaded onto a vessel without transit, the fixed part of freight charges for truck transport is not imposed, unlike transit between trucks and railways. Instead, however, as is also the case with road transport, trucks transported by ferry are assumed to carry no cargo when returning. Therefore, the cost for ferry transport is doubled for both the fixed and operational parts. For expected waiting time, the frequency of service is assumed to be twice a week for all economies. However, since time cost depends on the transport time of the cargo, time cost is considered for only one direction (i.e., is not imposed on the return trip without cargo).

C2.6 Cross-border Transport Cost

When crossing national borders in both the maritime container and land networks, additional costs (monetary cost and time) are assumed to be imposed, as shown in Table C4. It should be noted that these costs are imposed respectively for the export and import economies.

Table C4 Settings for each port in the shipper model (shown by economy)

economy	monetary cost (USD/TEU)		time (hours)		economy	monetary cost (USD/TEU)		time (hours)	
	export	import	export	import		export	import	export	import
Japan	258	316	144	168	Venezuela	940	1,168	936	1464
Republic of Korea	92	92	72	96	Argentina	730	810	192	264
DPR Korea	1,000	1,000	744	792	Brazil	500	400	192	264
Mongolia	271	194	384	408	Uruguay	625	690	264	360
China	320	330	384	456	Iran	326	496	336	600
Hong Kong, China	110	118	72	72	UAE	281	267	144	168
Chinese Taipei	303	315	216	192	Saudi Arabia	286	279	216	288
Philippines	376	374	264	264	Oman	391	607	408	360
Vietnam	207	159	384	384	Israel	240	180	144	144
Lao PDR	130	140	672	792	Turkey	420	480	216	264
Cambodia	482	475	408	528	Greece	465	405	384	432
Thailand	320	375	216	240	Italy	371	371	312	288
Malaysia	150	150	288	240	Spain	400	400	120	144
Singapore	136	119	48	48	Cyprus	265	445	72	72
Myanmar	532	565	648	696	Algeria	550	640	288	384
Indonesia	379	335	384	456	Egypt	267	273	240	288
Brunei Darussalam	240	222	552	408	Malta	265	445	72	72
East Timor	190	195	312	408	Belgium	619	600	96	168
Bangladesh	410	590	408	552	France	135	305	96	144
India	470	510	240	288	Germany	172	237	96	96
Sri Lanka	445	475	360	360	UK	280	360	120	120
Pakistan	296	330	336	312	Holland	220	312	96	96
Russian Federation	700	700	672	696	Sweden	157	195	72	72
USA	250	295	72	72	Iceland	292	434	264	264
Canada	260	260	96	120	Senegal	600	660	144	216
Mexico	400	800	216	288	Cote d'Ivoire	380	577	480	624
Costa Rica	450	450	192	264	Nigeria	633	690	408	744
Panama	200	350	120	168	Cameroon	601	1,361	384	456
Puerto Rico	525	525	240	264	Angola	1,350	1,590	720	768
Bahamas	430	430	240	240	Djibouti	416	491	312	312
Jamaica	1,050	720	336	432	Kenya	780	800	408	336
Cuba	1,075	1,070	336	432	South Africa	347	472	456	432
Peru	265	285	408	408	Australia	330	389	144	120
Chile	185	235	312	360	New Zealand	268	250	144	144
Ecuador	545	532	336	552	Papua New Guinea	276	275	408	552
Colombia	600	580	168	216					

Source: World Bank (sum of "document preparation" and "custom clearance" in doing business database)

C2.7 Container Shipping Demand

For initial calculation of the model, international maritime container cargo shipping demand between ports (i.e., demand only for maritime container shipping) for each carrier group must be prepared. This is obtained from the total international maritime container cargo shipping demand of all carrier groups, which is estimated in a similar manner to the estimation of international cargo shipping demand on a regional basis described in Annex B. The total shipping demand of international maritime container cargo is divided among carriers using a Fratar method. Import/export cargo handling volume by port and by carrier, which is a proportional distribution of the import/export port handling cargo volume (excluding transshipment volumes) using the carrier share of the import/export cargo flow aggregated by ports from the current link flow, is used as a control total.

C3. Unknown Parameter Estimation and Verifying Model Convergence

C3.1 Unknown Parameter Estimation

In the previous chapter, almost all data and parameters that need to be input into the model are explained. However, three unknown parameters, which are the value of time for carrier vt_g included in the carrier model, variance parameter θ in Equation (C4) and (C33) of the shipper model, and the adjustment parameter ζ to avoid the log-sum variable being negative in Equation (C35) of the shipper model, is difficult to decide due to scarce reasoning in setting such values.

Herein, the adjustment parameter ζ is tentatively set to ζ = 1,667 (USD) by trial and error calculation by making Λ_a approximately equal to actual costs on the route with the smallest value for Λ_a, while other two parameters vt_{carr} and θ are estimated so as to fit best for calculation results of the model with the actual conditions by grid search. Note that the calculation in this chapter is conducted on a basic shipping network including maritime shipping network consisting from 50 seaports of the world and land shipping network only in Japan. In addition, in the calculation of this chapter, upper limit of repeat count n and N in iterative calculation of the mid-term carrier model and the Nash equilibrium solution are set to n = 10 and N = 5, and convergence criteria are set to be 10^{-4} for each iterative calculation, by trial and error calculation.

The calculation result is shown in Figure C6. The objective value is the root sum of squares of error in the estimated link flow $\{\hat{x}_{vg}\}$ and the current link flow $\{x_{vg}\}$ in the cost minimization model for carriers. The link flows used for the purposes of comparison are summed up for all vessel sizes and limited to the link departing from or arriving into the Asia region, for reasonable estimation. Finally, the objective value is minimized when vt_g is $1.0*10^{-3}$ and θ is $1.2*10^{-5}$.

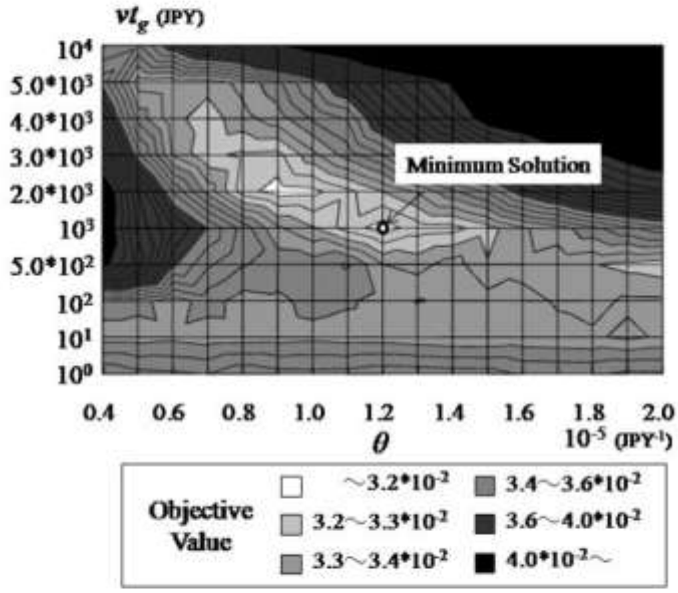
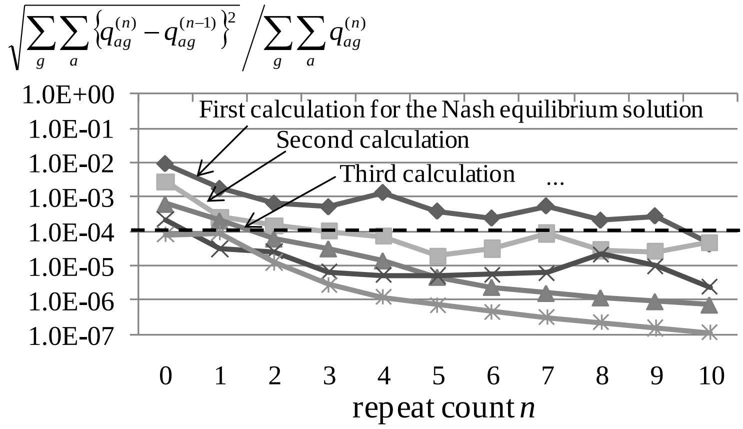


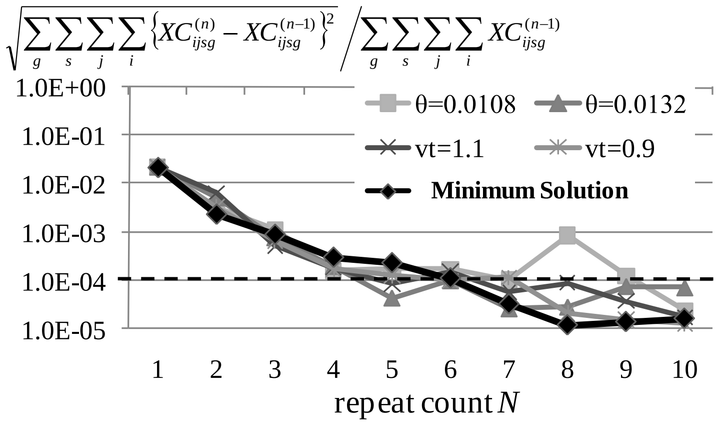
Figure C6 Objective values for each combination of vt_{carr} and θ and minimum solution

C3.2 Verifying Model Convergence

As the iterative model calculation is not guaranteed to converge, it should be confirmed whether the calculation actually converges. Figure C7 shows convergence status for the mid-term carrier model and the Nash equilibrium solution between shipper and carrier model. The error term becomes less than 10^{-4} with approximately 5-10 repetitions of the iterative calculation. In addition, it is confirmed that when the iterative calculation is repeated enough times, the change of link flow becomes sufficiently small. From these results, it is found that the model calculation converges sufficiently, at least within an applicative range.



(calculation for the mid-term carrier model)



(calculation for the Nash equilibrium solution between shipper and carrier model)

Figure C7 Convergence of calculation

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