Analysis of the impact of the decline in crude oil imports on the Japanese economy

by
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Abstract

This study analyzes the impact of the decrease in crude oil imports on the Japanese economy. In Japan, the use of crude oil depends almost exclusively on imports. Thus, guaranteeing crude oil imports is an important issue.

The impact of the decrease in crude oil imports is analyzed by considering two features of crude oil, namely as a factor of production and as feedstock. In order to do so, this study uses the GTAP and GTAP-E models, respectively, following the same methodologies and applying the same exogenous values. Furthermore, this study uses both a static analysis and an analysis incorporating the capital accumulation effects.

The difference between the simulation results of the GTAP and GTAP-E models in terms of Japan's real GDP is relatively small. However, the simulation results by industry and by commodity show different tendencies.

In general, the energy structure of the GTAP-E model makes it suitable for analyzing energy goods. However, when energy goods are used mainly as feedstock, as is the case of crude oil in petroleum and coal products, the GTAP model results are more realistic when energy goods are treated as intermediate inputs. Thus, it is better to use the GTAP model to analyze the impact of the decrease in crude oil imports on the Japanese economy, while referring to the results of the GTAP-E model, which treats energy goods as factors of production.

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1. Introduction

This study analyzes the impact of the decrease in crude oil imports on the Japanese economy using the GTAP and GTAP-E models. In Japan, the use of crude oil depends almost exclusively on imports, and is used in two sectors: mainly as feedstock in the petroleum and coal products sector (94%), and as a factor of production in the electricity sector (6%). Considering that petroleum and coal products and electricity are used as factors of production in all Japanese industries, and because it will take time to change the structure of the industrial use of energy goods, guaranteeing crude oil imports is an important issue in Japan. This study analyzes the impact of the decrease in crude oil imports by considering two features of crude oil, namely as a factor of production and as feedstock, using the GTAP and GTAP-E models, respectively.

Section 2 analyzes data on the import and structure of energy goods used in Japanese industries. The data are taken from the GTAP 9 database. This data analysis determines the main characteristics of energy imports and the industrial use of energy goods in Japan.

Section 3 discusses the difference between the treatment of energy goods in the GTAP and GTAP-E models. In the GTAP model, energy goods are treated as intermediate inputs. This structure is suitable for analyzing crude oil imports when they are used as intermediate inputs (i.e., as feedstock) in which the chemical content is transformed to become part of the output commodity. In the GTAP-E model, which incorporates an energy substitution structure into the GTAP model, energy goods are taken from the intermediate input nest and placed into the value-added nest, forming capital-energy sub-production. Capital-energy sub-production is classified as energy sub-production, which includes electricity, coal, crude oil, gas, and petroleum and coal products. This structure of substitution between capital and energy goods and between energy goods themselves is suitable for the analysis of crude oil imports when they are used as factors of production. By clarifying the difference in the treatment of energy goods between the GTAP and GTAP-E models, Section 3 shows the merit of using both models to analyze the impact of the decrease in crude oil imports on the Japanese economy.

Section 4 addresses the methodology for analyzing the economic impact of the decrease in crude oil imports in Japan. In order to assign the exogenous values in the models, the basic closure is changed in the first simulation by setting “ams” (the import-augmenting technical change) as endogenous, and “qxs” (export sales) as exogenous. Here, we consider a scenario in which Japan’s crude oil imports from the

Middle East are reduced. In terms of setting the exogenous values, we assume that this reduction in crude oil imports from the Middle East is the result of a failure in transportation, and we consider the possibility of Japan increasing its crude oil supply from other regions. Considering these conditions, the exogenous values are set to -25%. By applying the exogenous values to "qxs," we obtain the rate of change in "ams." The second simulation uses the basic closure. Using the rates at which "ams" decreased (taken from the first simulation) as the exogenous values, we estimate the impact of a 25% decrease in Japanese crude oil imports from the Middle East.

Section 4 also provides a brief survey of GTAP Technical Paper No.7, which explains the capital accumulation effects in the GTAP and GTAP-E models.

Section 5 discusses the simulation results of the GTAP and GTAP-E models with regard to the decrease in crude oil imports from the Middle East to Japan using a static analysis. The simulation result for the percentage change in Japan's real GDP is -0.53% for the GTAP model and -0.59% for the GTAP-E model. Although the difference between the two results is relatively small, the simulation results by industry and by commodity, especially concerning energy goods, show different tendencies. The reason for the latter differences can be attributed to the difference in the production structures of these two models. When crude oil imports from the Middle East are reduced, Japan would import additional crude oil from other regions. However, the amount of this increase in the GTAP-E model is less than that in the GTAP model, because the GTAP-E model has a production structure in which crude oil can be substituted by other energy goods.

Section 6 describes the simulations of the GTAP and GTAP-E models following the same methodology and applying the same exogenous values as in Section 5, but now incorporating capital accumulation effects. Here, we find that the resulting impacts in both models increase.

Section 7 concludes the paper. In general, the GTAP-E model is suitable for analyzing energy goods, given its production structure. However, when energy goods are used mainly as feedstock, the simulation using the GTAP model provides results that are more realistic. Because 94% of crude oil is used in petroleum and coal products in Japan, it would be better to use the GTAP model to analyze the impact of the decrease in crude oil imports on the Japanese economy, while referring to the results of the GTAP-E model, which treats energy goods as factors of production.

2. Analysis of data on the import and structure of crude oil in Japan

2.1 Japanese data from the GTAP 9 database on the import of crude oil

Table 2-1 shows the Japanese imports, at market prices, of energy goods (coal, oil, gas, and petroleum and coal products) taken from the GTAP 9 database. Table 2-2 shows the sources of Japanese imports of energy goods. The data in Table 2-2 show that almost 89% of crude oil is imported from the Middle East, along with 23.6% of imported gas and 53.1% of imported petroleum and coal products. In total, 61.7% of energy goods are imported from the Middle East. The "Strategic Energy Plan (2014)" points out this Japanese dependence on a limited number of areas supplying energy resources, as well as the importance of increasing diversity in the procurement of energy resources.

The data taken from the UN Comtrade database show that, in Japan, 82.7% of crude oil was imported from the Middle East in 2012, followed by 83.1% in both 2013 and 2014. Thus, until recently, the Middle East has been the main supplier of crude oil to Japan.

Table 2-1 Japanese import data for energy goods (millions, USD)

	Oceania	China	Korea	ASEAN Net Energy Exporters	Other ASEAN countries	Other Asian countries	India	United States
Coal	14,683	545	0	4,815	0	5	0	928
Oil	483	13	0	5,215	4	14	0	0
Gas	6,519	7	0	15,126	5	9	0	124
Petroleum and coal products	1,568	2,093	7,076	1,143	1,403	372	2,820	1,856
Total	23,253	2,658	7,076	26,299	1,412	400	2,820	2,908

	Latin America	EU28	Eastern Europe and FSU	Middle East	Africa	Rest of World	Total
Coal	74	1	2,181	0	101	1,457	24,789
Oil	172	28	5,667	118,231	3,382	30	133,238
Gas	411	14	10,674	10,550	1,244	59	44,743
Petroleum and coal products	145	339	1,389	23,504	373	154	44,233
Total	802	382	19,911	152,285	5,100	1,700	247,003

Source: GTAP 9 database.

Table 2-2 Sources of Japanese imports of energy goods (percentage)

	Oceania	China	Korea	ASEAN Net Energy Exporters	Other ASEAN countries	Other Asian countries	India	United States
Coal	59.2%	2.2%	0.0%	19.4%	0.0%	0.0%	0.0%	3.7%
Oil	0.4%	0.0%	0.0%	3.9%	0.0%	0.0%	0.0%	0.0%
Gas	14.6%	0.0%	0.0%	33.8%	0.0%	0.0%	0.0%	0.3%
Petroleum and coal products	3.5%	4.7%	16.0%	2.6%	3.2%	0.8%	6.4%	4.2%
Total	9.4%	1.1%	2.9%	10.6%	0.6%	0.2%	1.1%	1.2%

	Latin America	EU28	Eastern Europe and FSU	Middle East	Africa	Rest of World	Total
Coal	0.3%	0.0%	8.8%	0.0%	0.4%	5.9%	100.0%
Oil	0.1%	0.0%	4.3%	88.7%	2.5%	0.0%	100.0%
Gas	0.9%	0.0%	23.9%	23.6%	2.8%	0.1%	100.0%
Petroleum and coal products	0.3%	0.8%	3.1%	53.1%	0.8%	0.3%	100.0%
Total	0.3%	0.2%	8.1%	61.7%	2.1%	0.7%	100.0%

Source: GTAP 9 database.

2.2 Japanese data from the GTAP 9 database on the industrial use of crude oil

Table 2-3 shows the data on Japanese firms' domestic purchases, taken from the GTAP 9 database, illustrating that little domestic coal, crude oil, and gas are used in Japanese industries.

Table 2-3 Japanese firms' domestic purchases data (millions, USD)

	Agriculture	Coal	Oil	Gas	Petroleum and coal products	Electricity	Manufacturing sectors
Agriculture	12,086	1	0	0	1	1	64,049
Coal	0	0	0	0	3	26	71
Oil	0	0	0	0	469	58	6
Gas	0	0	0	0	0	0	12
Petroleum and coal products	5,839	0	0	6	49,168	26,889	51,392
Electricity	214	1	0	4	3,099	8,574	61,602
Manufacturing goods	22,524	9	33	70	4,998	2,478	1,289,128
Services	20,190	39	189	1,061	8,356	49,303	672,979
TOTAL	60,853	49	223	1,141	66,094	87,330	2,139,238

	Services sectors	TOTAL
Agriculture	13,950	90,088
Coal	6	107
Oil	0	533
Gas	89	101
Petroleum and coal products	91,127	224,421
Electricity	80,875	154,368
Manufacturing goods	598,009	1,917,249
Services	2,057,743	2,809,859
TOTAL	2,841,798	5,196,726

Source: GTAP 9 database.

Table 2-4 shows the data on Japanese firms' imports, taken from the GTAP 9 database. As shown, imports of crude oil are considerably larger than those of other energy goods. The value of crude oil imports is almost USD 133 billion, while the value of domestic crude oil remains USD 533 million, as shown in Table 2-3. This shows that Japan depends significantly on crude oil imports. The values of imported petroleum and coal products are much less than those of domestic petroleum and coal products, which shows that they are produced mainly in Japan. Then, a comparison of Table 2-3 and Table 2-4 shows that electricity is produced exclusively in Japan. Petroleum and coal products and electricity are used primarily within the manufacturing and service sectors.

Table 2-5 shows the shares of Japanese firms' imports, calculated from the GTAP 9 database. With regard to crude oil, 94.1% is used in the petroleum and coal products sector, and 5.9% is used in electricity sector.

Table 2-4 Japanese firms' import data (millions, USD)

	Agriculture	Coal	Oil	Gas	Petroleum and coal products	Electricity	Manufacturing sectors
Agriculture	1,812	0	0	0	8	0	22,483
Coal	0	0	0	0	10,329	12,279	2,062
Oil	0	0	0	4	125,379	7,842	11
Gas	0	0	0	49	4,781	28,030	3,696
Petroleum and coal products	161	0	0	5	4,151	2,432	25,184
Electricity	0	0	0	0	0	0	1
Manufacturing goods	2,000	0	1	4	135	452	263,659
Services	620	1	10	13	146	751	14,900
TOTAL	4,594	1	11	75	144,930	51,787	331,997

	Services sectors	TOTAL
Agriculture	2,707	27,011
Coal	116	24,787
Oil	1	133,238
Gas	7,376	43,933
Petroleum and coal products	8,916	40,849
Electricity	1	2
Manufacturing goods	84,891	351,143
Services	75,932	92,373
TOTAL	179,940	713,334

Source: GTAP 9 database.

Table 2-5 Shares of Japanese firms' imports (percentage)

	Agriculture	Coal	Oil	Gas	Petroleum and coal products	Electricity	Manufacturing sectors
Agriculture	6.7%	0.0%	0.0%	0.0%	0.0%	0.0%	83.2%
Coal	0.0%	0.0%	0.0%	0.0%	41.7%	49.5%	8.3%
Oil	0.0%	0.0%	0.0%	0.0%	94.1%	5.9%	0.0%
Gas	0.0%	0.0%	0.0%	0.1%	10.9%	63.8%	8.4%
Petroleum and coal products	0.4%	0.0%	0.0%	0.0%	10.2%	6.0%	61.7%
Electricity	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	37.5%
Manufacturing goods	0.6%	0.0%	0.0%	0.0%	0.0%	0.1%	75.1%
Services	0.7%	0.0%	0.0%	0.0%	0.2%	0.8%	16.1%
TOTAL	0.6%	0.0%	0.0%	0.0%	20.3%	7.3%	46.5%

	Services sectors	TOTAL
Agriculture	10.0%	100.0%
Coal	0.5%	100.0%
Oil	0.0%	100.0%
Gas	16.8%	100.0%
Petroleum and coal products	21.8%	100.0%
Electricity	56.3%	100.0%
Manufacturing goods	24.2%	100.0%
Services	82.2%	100.0%
TOTAL	25.2%	100.0%

Source: GTAP 9 database.

Table 2-6 shows Japanese firms' total intermediate goods, calculated from the GTAP 9 database. Petroleum and coal products have the largest values among the energy goods, and are used in many sectors as a factor of production. Table 2-7 shows the shares of Japanese firms' total intermediate goods used in the industrial sectors, calculated from the GTAP 9 database. Because the use of crude oil depends on imports, the shares of crude oil in Japanese firms' total intermediate goods are the same as those of imports. As much as 94.1% of crude oil is used in the petroleum and coal products sector, mostly as feedstock, and 5.9% is used in the electricity sector as a factor of production.

This data analysis shows that the Japanese industrial use of primary energy goods depends almost completely on imports. Therefore, Japan is vulnerable to changes in the international energy situation.

To overcome this vulnerability, the Japanese third strategic energy plan, published in 2010, set as a major objective enhancing energy self-sufficiency. However, after the Great East Japan Earthquake in 2011, Japan was again forced to make significant adjustments to its energy policy. The fourth strategic energy plan, published in April 2014, set four major objectives: energy security, economic efficiency, the environment, and safety.

Table 2-6 Japanese firms' total intermediate goods data (millions, USD)

	Agriculture	Coal	Oil	Gas	Petroleum and coal	Electricity
Agriculture	13,898	1	0	0	9	2
Coal	0	0	0	0	10,332	12,306
Oil	0	0	0	4	125,848	7,900
Gas	0	0	0	49	4,781	28,030
Petroleum and coal products	6,000	0	0	11	53,319	29,321
Electricity	214	1	0	4	3,099	8,574
Manufacturing goods	24,525	9	34	74	5,133	2,930
Services	20,811	40	199	1,074	8,502	50,054
TOTAL	65,448	50	234	1,216	211,023	139,117

	Manufacturing sectors	Services sectors	TOTAL
Agriculture	86,532	16,656	117,099
Coal	2,134	122	24,893
Oil	17	1	133,771
Gas	3,709	7,464	44,034
Petroleum and coal products	76,576	100,043	265,270
Electricity	61,602	80,876	154,370
Manufacturing goods	1,552,787	682,900	2,268,392
Services	687,878	2,133,675	2,902,232
TOTAL	2,471,235	3,021,738	5,910,061

Source: GTAP 9 database.

Table 2-7 Shares of Japanese firms' total intermediate goods used in the industrial sectors (percentage)

	Agriculture	Coal	Oil	Gas	Petroleum and coal	Electricity
Agriculture	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Coal	0.0%	0.0%	0.0%	0.0%	41.5%	49.4%
Oil	0.0%	0.0%	0.0%	0.0%	94.1%	5.9%
Gas	0.0%	0.0%	0.0%	0.1%	10.9%	63.7%
Petroleum and coal products	2.3%	0.0%	0.0%	0.0%	20.1%	11.1%
Electricity	0.1%	0.0%	0.0%	0.0%	2.0%	5.6%
Manufacturing goods	1.1%	0.0%	0.0%	0.0%	0.2%	0.1%
Services	0.7%	0.0%	0.0%	0.0%	0.3%	1.7%
TOTAL	1.1%	0.0%	0.0%	0.0%	3.6%	2.4%

	Manufacturing sectors	Services sectors	TOTAL
Agriculture	73.9%	14.2%	100.0%
Coal	8.6%	0.5%	100.0%
Oil	0.0%	0.0%	100.0%
Gas	8.4%	17.0%	100.0%
Petroleum and coal products	28.9%	37.7%	100.0%
Electricity	39.9%	52.4%	100.0%
Manufacturing goods	68.5%	30.1%	100.0%
Services	23.7%	73.5%	100.0%
TOTAL	41.8%	51.1%	100.0%

Source: GTAP 9 database.

3. Difference in the treatment of energy goods between the GTAP model and the GTAP-E model

3.1. Difference in the production structure between the GTAP model and the GTAP-E model

In CGE model analyses in the energy and environment domains, the structures of the substitutions between capital and energy goods and between energy goods themselves are usually incorporated in the model. Such CGE models are often used in economic analyses of crises or disasters, in which lifeline disruptions or supply shortages of energy goods occur (e.g., see Rose and Guha (2004), Guha (2005), Rose and Liao (2005), and Ishikura and Ishikawa (2011)). The decrease in crude oil imports, which would cause a supply shortage, could be considered a crisis.

The GTAP-E model, an extended energy-environment version of the GTAP model, was developed in 2002 to incorporate an energy substitution structure in the GTAP model. As Higashi-Shiraishi (2014) mentions, a comparison of the simulation results of these two models has the merit of indicating the effect of energy substitution.

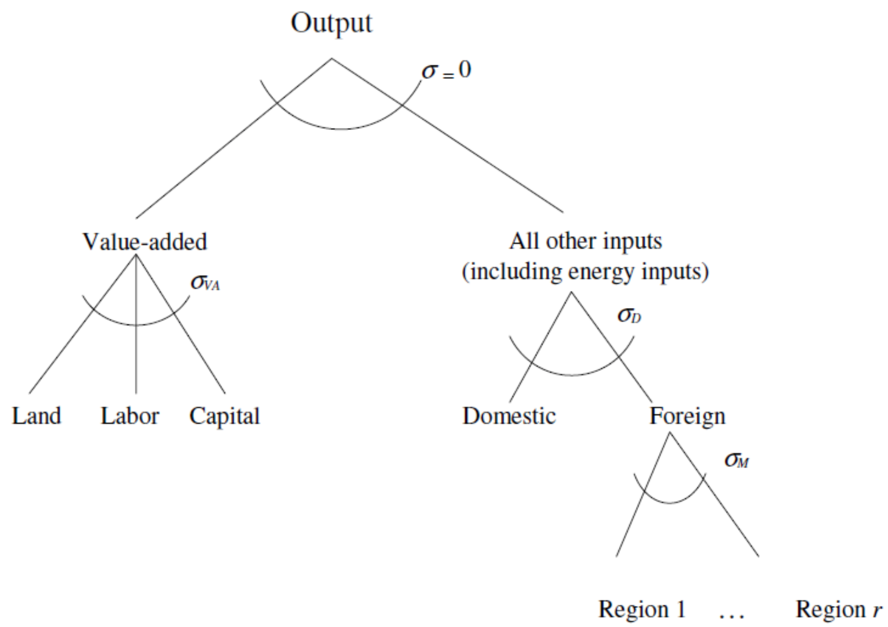
Compared with the standard GTAP model, the structure of which is explained in Hertel (1997), the main feature of the GTAP-E model is its production structure with energy substitution, namely, inter-fuel substitution and fuel-factor substitution. In the GTAP-E model, energy goods are taken from the intermediate input nest and placed in the value-added nest, forming capital-energy sub-production. Capital-energy sub-production is classified as follows: energy sub-production, which includes electricity and non-electricity energy goods; non-electricity energy sub-production, which includes coal and non-coal energy goods; and non-coal energy sub-production, which includes crude oil, gas, and petroleum and coal products.

This structure of substitution between capital and energy goods and between the energy goods themselves is suitable for analyzing crude oil imports when they are used as factors of production, that is, when used in the electricity sector. In the GTAP model, energy goods are treated as intermediate inputs only. This would be suitable for analyzing crude oil imports when they are used as intermediate inputs (i.e., as feedstock), in which the chemical content is transformed to become part of the output commodity, as described in Burniaux and Truong (2002). Burniaux and Truong (2002) note that among energy goods, coal, gas, and crude oil could be referred to as primary energy. These goods can be used as inputs for various industrial and household activities (e.g., natural gas, to provide the energy source for electricity production; and coal, as an energy source for steel making) and as "feedstock." As examples of energy goods used as feedstock, Burniaux and Truong (2002) include natural gas used as feedstock in fertilizer, crude oil used as feedstock in the petroleum refinery industry, and coke used as feedstock in steel production. In addition, Fujikawa (1999) states that coke used in steel production, and crude oil used in gasoline production are examples of energy goods that should be analyzed with fixed coefficients.

When energy goods are used as factors of production, as in the case of electricity, the effect of the substitution between capital and energy goods becomes important. This is illustrated in Higashi (2016), who analyzes the effect of the electricity supply shortage in Japan caused by the Great East Japan Earthquake. On the other hand, when energy goods are used as feedstock, as in the case of crude oil used in petroleum and coal products, we should consider that its chemical content is mainly transformed to become part of the output commodity.

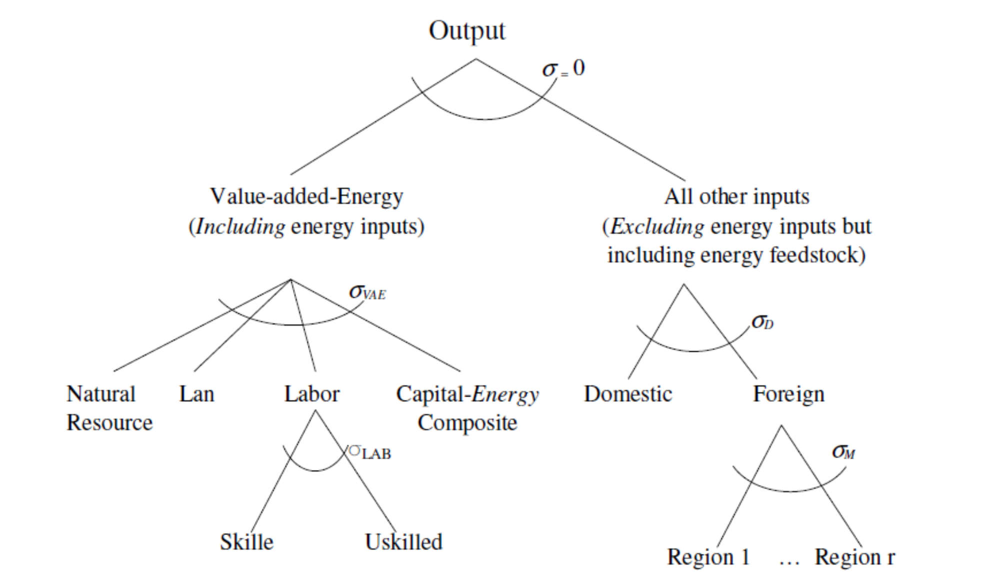
The production structure of the GTAP model is illustrated in Figure 3-1, while Figure 3-2 provides the GTAP-E production structure, and Figure 3-3 shows the GTAP-E capital-energy composite structure.

Figure 3-1 Standard GTAP production structure



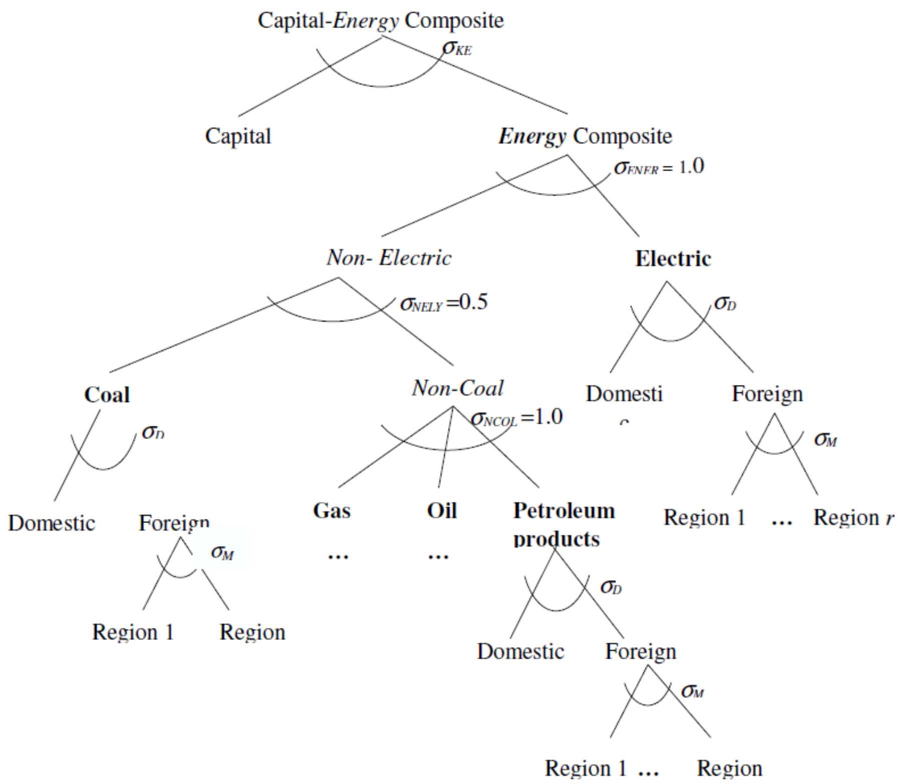
Source: Burniaux and Truong (2002), Figure 15, p.30.

Figure 3-2 GTAP-E production structure



Source: Burniaux and Truong (2002), Figure 16, p.31.

Figure 3-3 GTAP-E capital-energy composite structure



Source: Burniaux and Truong (2002), Figure 17, p.31.

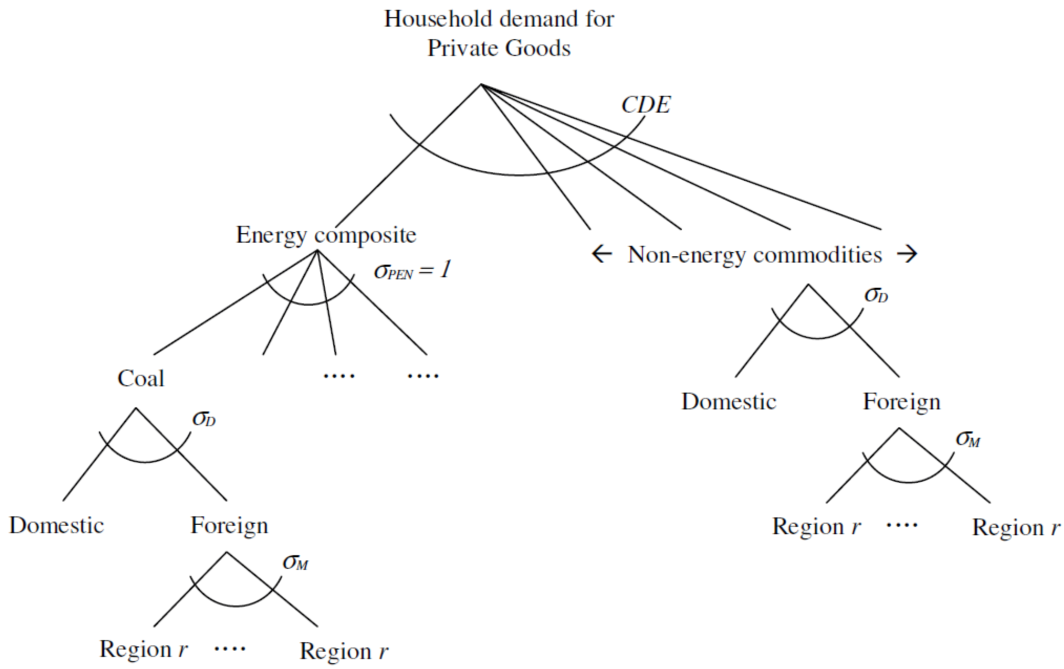
3.2. Difference in the consumption structure between the GTAP model and the GTAP-E model

Private household consumption is structured according to the constant difference of elasticities (CDE) functional form in the GTAP model. In the GTAP-E model, the main feature of private consumption is that commodities are divided into two groups: energy goods and non-energy goods. The energy commodities are aggregated into a single composite, which remains in the CDE structure and with the same CDE parameter values. To allow for flexible substitution between the individual energy commodities, the energy composite is specified as a CES sub-structure with a substitution elasticity value of 1.

Government consumption is assumed to be a Cobb–Douglas structure in the GTAP model, with a substitution elasticity value of 1 for all commodities. The main feature of government consumption in the GTAP-E model is that commodities are again divided into two groups: an energy-goods composite and a non-energy-goods composite, with a substitution elasticity value of 1 in both cases. At the top of the government consumption nest in the GTAP-E model, the substitution elasticity takes a value of 0.5.

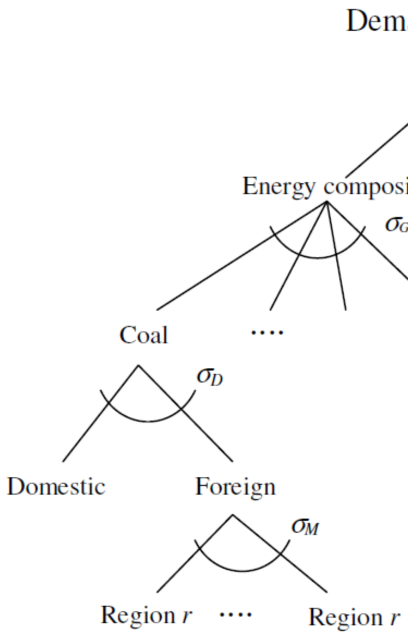
The private consumption structure of the GTAP-E model is provided in Figure 3-4, while Figure 3-5 provides the GTAP-E government consumption structure.

Figure 3-4 Private consumption structure of the GTAP-E model



Source: Burniaux and Truong (2002), Figure 19, p.38.

Figure 3-5 Government consumption structure of the GTAP-E model



Source: Burniaux and Truong (2002), Figure 18, p.37.

4. Methodology for analyzing the economic impact of the decrease in crude oil imports in Japan

4.1. Methodology for analyzing the economic impacts of the decrease in crude oil imports using the GTAP model and the GTAP-E model

This study analyzes the economic impact of the decrease in crude oil imports from the Middle East on the Japanese economy. To assign the exogenous values in this scenario, two simulations are needed. The basic closure is changed in the first simulation by setting "ams" (the import-augmenting technical change)[2]for Japan's crude oil imports from the Middle East, which is exogenous in the basic closure, as endogenous, and "qxs" (export sales) of crude oil from the Middle East to Japan, which is endogenous in the basic closure, as exogenous.

This scenario considers that crude oil imports from the Middle East are reduced owing to some failure in transportation, and that there is a possibility of Japan increasing its crude oil supply from other regions. Considering these conditions, the exogenous values are set to -25%. To concentrate on the analysis of the impact in

[2] The theory of using "ams" is described in detail in Hertel et al. (2001). Changes in the technical coefficient, "ams," capture the impact of non-tariff measures on the price of imports from a particular exporter. Thus, a change in "ams" ensures a change in the effective domestic price of good *i* exported from *r* to *s*. To maintain the trade balance, the product of the observed price and the quantity is adjusted to be equal to the product of the effective price and the quantity.

Japan, the exogenous values are applied only to Japanese crude oil imports from the Middle East. Japan also imports petroleum and coal products and gas from the Middle East, but here we focus on the decrease of imports of crude oil only.

By applying the exogenous values to “qxs” in the first simulation, we can obtain the rate of change in “ams.” In the second simulation, which uses the basic closure, by using the rates at which “ams” decreased (taken from the first simulation) as the exogenous values, we can estimate the impact of a 25% decrease in Japanese crude oil imports from the Middle East on the Japanese economy.

With regard to the investment allocation in the simulation, two options are possible in the GTAP and GTAP-E models. When RORDELTA (the binary coefficient used to switch the mechanism of allocating investment funds) = 1, investment funds are allocated across regions to equate the changes in the expected rates of return. When RORDELTA = 0, investment funds are allocated across regions to maintain the existing composition of capital stocks. Considering that the analysis period of this study is more medium or long term than it is short-term, we adopt the option that investment funds are allocated across regions to equate the changes in the expected rates of return (RORDELTA = 1).

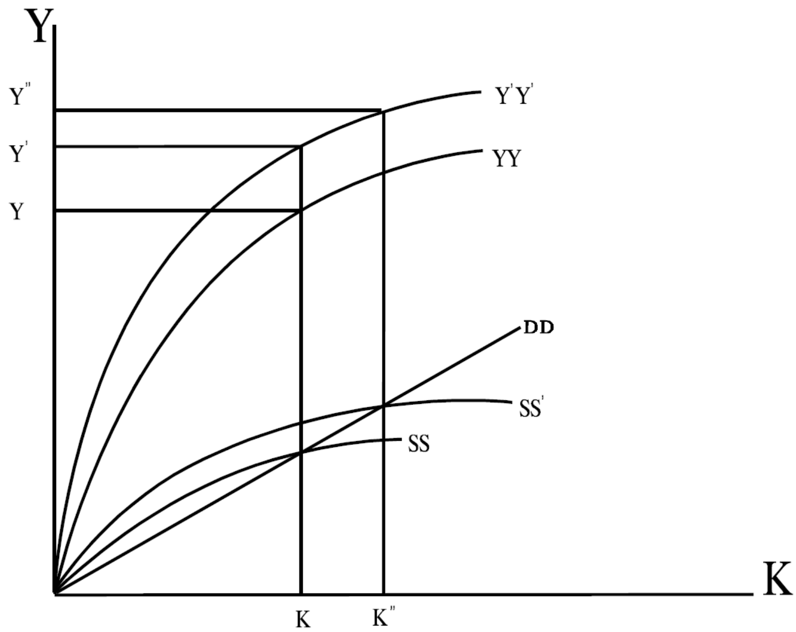
4.2. Methodology for incorporating the capital accumulation effects

The GTAP and the GTAP-E models, which were originally developed for static analyses, do not analyze the dynamic process in which new investments use savings from the increase in income, or that in which an additional increase in income is achieved by the accumulated capital. However, they have the option to use an analysis that implements the effect of capital accumulation explained in GTAP Technical Paper No.7.

As shown in Figure 4-1, when a change (in this case, positive) occurs, the production function YY and the savings function SS shift upward. In the short-term analysis, the capital used remains the same, and production increases to Y'. However, in the long term, part of the income increase is directed to savings. Capital stock increases to K'' by investment, and production increases to Y''. The analysis incorporating the capital accumulation effects tries to implement this movement of change in capital stock in the GTAP and GTAP-E models.

In this study, in which a decrease in income occurs, both the static analysis and the analysis incorporating the capital accumulation effects (with the fixed savings rate) are used.

Figure 4-1 Short-term and long-term effects of an income shock



Source: Francois et al. (1996), Figure 1, p.3.

4.3. Aggregation of regions and sectors

Considering the structure of Japanese crude oil imports, the regional aggregation in this study is set to 15 regions, as shown in Table 4-1. With regard to the sectoral aggregation, we attempt a rather large sectoral aggregation of 28 sectors, as shown in Table 4-2.

Table 4-1 Regional disaggregation

No.	Code	Region Description	Comprising GTAP 9 Countries/Regions
1	ANZ	Oceania	Australia, New Zealand, Rest of Oceania
2	JPN	Japan	Japan
3	CHN	China	China, Hong Kong
4	KOR	Korea	Korea
5	AEEx	ASEAN Net Energy Exporters	Brunei Darusslam, Indonesia, Malaysia, Viet Nam
6	OASN	Other ASEAN countries	Cambodia, Lao People's Democratic Republic, Philippines, Singapore, Thailand, Rest of Southeast Asia
7	ASA	Other Asian countries	Mongolia, Taiwan, Rest of East Asia, Bangladesh, Nepal, Pakistan, Sri Lanka, Rest of South Asia
8	IND	India	India
9	USA	United States	United States of America
10	LTN	Latin America	Mexico, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean
11	EU28	EU28	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Bulgaria, Croatia, Romania
12	EEFSU	Eastern Europe and FSU	Albania, Belarus, Russian Federation, Ukraine, Rest of Eastern Europe, Rest of Europe, Kazakhstan, Kyrgyzstan, Rest of the FSU, Armenia, Azerbaijan, Georgia
13	MEC	Middle East	Bahrain, Islamic Republic of Iran, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Rest of Western Asia
14	AFR	Africa	Egypt, Morocco, Tunisia, Rest of North Africa, Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa, Botswana, Namibia, South Africa, Rest of South African Customs Union
15	ROW	Rest of the World	Canada, Rest of North America, Switzerland, Norway, Turkey, Rest of EFTA, Rest of the World

Source: Author.

Table 4-2 Sectoral disaggregation

No.	Code	Sector Description	Comprising GTAP 9 Sectors
1	AGR	Agriculture	Paddy rice, wheat, cereal grains nec*, vegetables, fruit, nuts, oil seeds, sugarcane, sugar beet, plant-based fibers, crops nec, bovine cattle, sheep and goats, horses, animal products nec, raw milk, wool, silk-worm cocoons, forestry, fishing
2	Coal	Coal	Coal
3	Oil	Oil	Oil
4	Gas	Natural gas extraction	Gas, gas manufacture, distribution
5	Oil_Pcts	Petroleum, coal products	Petroleum, coal products
6	Electricity	Electricity	Electricity
7	OMN	Minerals nec	Minerals nec
8	PFD	Food processing	Bovine meat products, meat products nec, vegetable oils and fats, dairy products, processed rice, sugar, food products nec, beverages and tobacco products
9	TXL	Textiles	Textiles, wearing apparel
10	CRP	Chemical, rubber, plastic products	Chemical, rubber, plastic products
11	NMM	Mineral products nec	Mineral products nec
12	I_S	Ferrous metals	Ferrous metals
13	NFM	Metals nec	Metals nec
14	FMP	Metal products	Metal products
15	MVH	Motor vehicles and parts	Motor vehicles and parts
16	OTN	Transport equipment nec	Transport equipment nec
17	ELE	Electronic equipment	Electronic equipment
18	OME	Machinery and equipment nec	Machinery and equipment nec
19	OMF	Manufactures nec	Leather products, wood products, paper products, publishing, manufactures nec
20	CNS	Construction	Construction
21	TRD	Trade	Trade
22	OTP	Transport nec	Transport nec
23	WTP	Water transport	Water transport
24	ATP	Air transport	Air transport
25	CMN	Communication	Communication
26	OFR	Financial services	Financial services nec, insurance
27	OSP	Other services	Water, business services nec, recreational and other services, dwellings
28	OSG	Public services	Public administration, defense, education, health

Source: Author.
Note: * not elsewhere classified

5. Economic impact of the decrease in Japan's crude oil imports by static analysis

5.1. Static analysis of macroeconomic changes

Section 5 discusses the simulation results of the GTAP and GTAP-E models, given a decrease in crude oil imports by 25% from the Middle East to Japan, based on a static analysis. Table 5-1 and Table 5-2 show the simulation results of the macroeconomic changes,[3] in percentages and in million USD, respectively.

The simulation results for the percentage change in Japan's real GDP are -0.53% for the GTAP model and -0.59% for the GTAP-E model. The results of the percentage change in Japan's exports are +5.04% for the GTAP model and +4.43% for the GTAP-E model.[4] Although the difference between these results for real GDP is relatively small, the simulation results by industry and by commodity, especially with regard to energy goods, show different tendencies, as described in the following sections.

The reason for the differences in the results by industry and by commodity could be attributed to the difference in the production structure of these two models. When crude oil imports from the Middle East are reduced, Japan will increase its imports of crude oil from other regions. However, the amount of this increase in the GTAP-E model is less than that in the GTAP model. This is because the GTAP-E model has a production structure in which crude oil can be substituted by other energy goods. The decrease in crude oil use reduces the production of petroleum and coal products, an important factor of production in Japan. As a result, in the GTAP-E model, the reduction in production becomes more serious than in the GTAP model, which does not have a structure for substitution between energy goods. In addition, the reduction in production will affect exports.

With regard to the simulation results for the percentage change in real GDP in

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[3] The simulation results for the percentage change in Japan's "qiwreg" (index for macro-level imports) are 0.0% for the GTAP model and -1.25% for the GTAP-E model. "Qiwreg" is based on the cost, insurance, and freight (CIF) price, which does not reflect the change caused by the change in "ams." On the other hand, the simulation results of "qim" (imports by industry) described in Section 5.6 are based on the market price, which does reflect the change caused by the change in "ams." Because the change in price caused by the change in "ams" is important in this study, and the "qiw" simulation results by industry are not shown in the values, the results of imports will be analyzed in Section 5.6. Apart from crude oil, the results of the Japanese "piw" (world price of composite imports) and "pim" (market price of composite imports) are the same.

[4] With regard to exports, "qxw" (aggregate exports, FOB weights) is used for both the macro-level and industry analyses. The sums of the Japanese "qxw" and "qxwreg" are almost the same.

other regions, real GDP increases slightly in regions that include energy exporters, such as AEEX (ASEAN Net Energy Exporters) and EEFSU (Eastern Europe and FSU).

Table 5-1 Macroeconomic changes, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)

	Change in GDP		Change in Export	
	GTAP model	GTAP-E model	GTAP model	GTAP-E model
ANZ	0.00	0.00	-0.12	-0.30
JPN	-0.53	-0.59	5.04	4.43
CHN	0.01	0.01	0.00	-0.12
KOR	0.00	0.01	0.28	0.07
AEEx	0.03	0.03	-0.06	-0.33
OASN	0.01	0.01	0.09	-0.02
ASA	0.00	0.00	0.02	-0.09
IND	0.01	0.01	0.17	-0.04
USA	0.00	0.00	-0.32	-0.41
LTN	0.01	0.01	-0.36	-0.30
EU28	-0.01	-0.01	-0.11	-0.17
EEFSU	0.05	0.03	-0.52	-0.27
MEC	0.01	0.00	-0.18	-0.02
AFR	0.01	0.01	-0.31	-0.13
ROW	0.00	0.00	-0.24	-0.18

Source: Author

Table 5-2 Macroeconomic changes, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

	Change in GDP		Change in Export		Change in EV	
	GTAP model	GTAP-E model	GTAP model	GTAP-E model	GTAP model	GTAP-E model
ANZ	-27	57	-415	-1,053	-445	186
JPN	-31,575	-34,713	47,520	41,784	-40,663	-41,262
CHN	883	972	1	-2,549	-743	1,177
KOR	-51	106	1,733	419	-921	12
AEEx	363	407	-353	-1,829	2,118	2,235
OASN	78	104	572	-149	-213	302
ASA	-22	23	80	-444	-466	204
IND	125	250	621	-160	-656	523
USA	-157	161	-6,098	-7,609	-1,872	1,734
LTN	473	381	-4,319	-3,619	2,015	1,149
EU28	-2,638	-918	-7,402	-11,616	-6,970	-858
EEFSU	1,303	704	-4,454	-2,279	7,639	2,923
MEC	330	-16	-2,264	-232	5,139	-2,494
AFR	281	140	-2,047	-817	4,194	1,520
ROW	-17	70	-2,853	-2,117	1,131	355

Source: Author.

5.2. Static analysis of changes in Japanese industrial output

Figures 5-1 and 5-2 show the impacts on Japan's industrial output of a 25% decrease in crude oil imports from the Middle East, simulated by the GTAP and GTAP-E models, shown in percentages and million USD, respectively. The results of both models show the same tendency, although the negative impacts are stronger in the GTAP-E model. Among all sectors, the reduction rate is especially large in Oil_Pcts (petroleum and coal products), attaining -7.3% in the GTAP model and -11.0% in the GTAP-E model.[5] The largest change in terms of millions USD is again observed in Oil_Pcts. The decrease in this sector attains USD 21.1 billion according to the GTAP model, and USD 31.7 billion according to the GTAP-E model. After Oil_Pcts, the construction sector is the most severely affected by the decrease in crude oil imports in Japan. The industrial output of the construction sector decreases by 2.6% according to the GTAP model, and by 3.3% according to the GTAP-E model.

Because the capital stock in Japan is not damaged in this scenario, Japanese industrial sectors would try to use their production capacity. As a result, industrial outputs increase in some sectors. Because of the crude oil supply shortage, the use of other primary energy goods, such as coal and gas, would increase. In non-energy-intensive industries, such as OTN (transport equipment nec), ELE (electronic equipment), and OME (machinery and equipment nec), the positive percentage change is relatively high. When the changes are evaluated in terms of millions USD, the greatest increases are shown in OME, which attains USD 26 billion according to the GTAP model, and USD 20.5 billion according to the GTAP-E model.

With regard to the overall balance of industrial output, the simulation result of the GTAP model, in which the negative effect is less than that of the GTAP-E model, becomes slightly positive. On the other hand, in the simulation result of the GTAP-E model, the negative impacts surpass the positive impacts, and the overall balance of industrial output becomes negative.

Figures 5-1 and 5-2 also show the simulation results of the qo ("cgds", r), the output of the capital goods sector, which is equal to qcgds(r), a variable denoting gross investment. The negative effect in the simulation results of gross investment is noteworthy. It decreases by 3.3% according to the GTAP model, and by 4.1% according to the GTAP-E model, while the sign is positive in all other regions.

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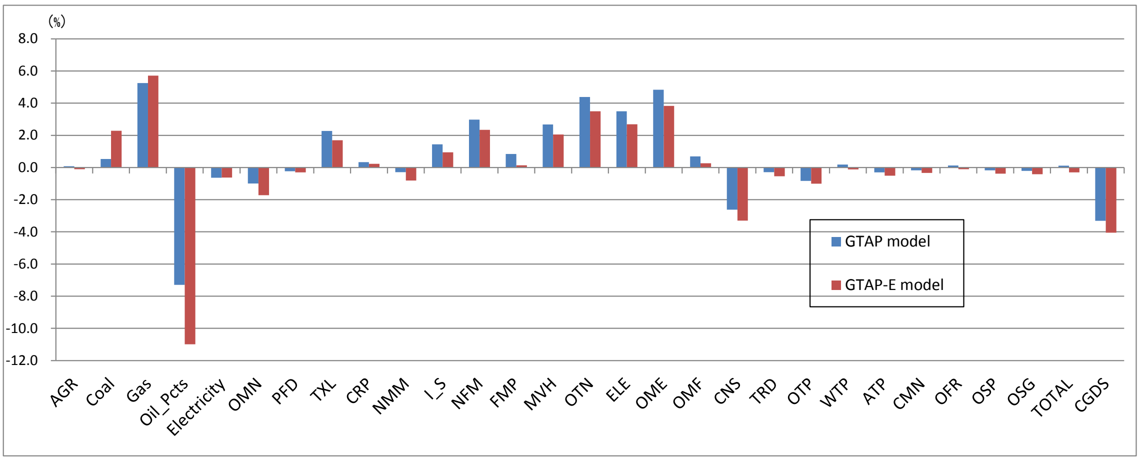
[5] In Figure 5-1, the results for the oil sector are not shown because it increases by more than by 30% in the GTAP-E model, even though its industrial output is small.

Figure 5-1 Impacts on Japan's industrial output, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 5-2 Impacts on Japan's industrial output, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

Source: Author.

5.3. Static analysis of changes in Japanese private consumption

Figures 5-3 and 5-4 show the impacts on Japan's private consumption owing to a 25% decrease in crude oil imports from the Middle East, simulated by the GTAP and GTAP-E models, in percentages and in million USD, respectively. The simulation results of both models show a similar tendency. Evaluated in terms of millions of USD, a large decrease is observed in the private consumption of Oil_Pcts (petroleum and coal products), PFD (food processing), and service commodities such as TRD (trade), OTP (transport nec), and OSP (other services). The largest percentage change is observed in crude oil, although private consumption in this case is almost zero.

In the simulation results of private consumption, negative impacts are slightly stronger in the GTAP model. Total private consumption decreases by 0.9% according to the GTAP model, and by 0.8% according to the GTAP-E model. The reason for this difference lies in the difference of the change in the price, as described in Section 5.4. Table 5.3 shows the simulation results for Japan's private consumption of energy goods and non-energy goods.

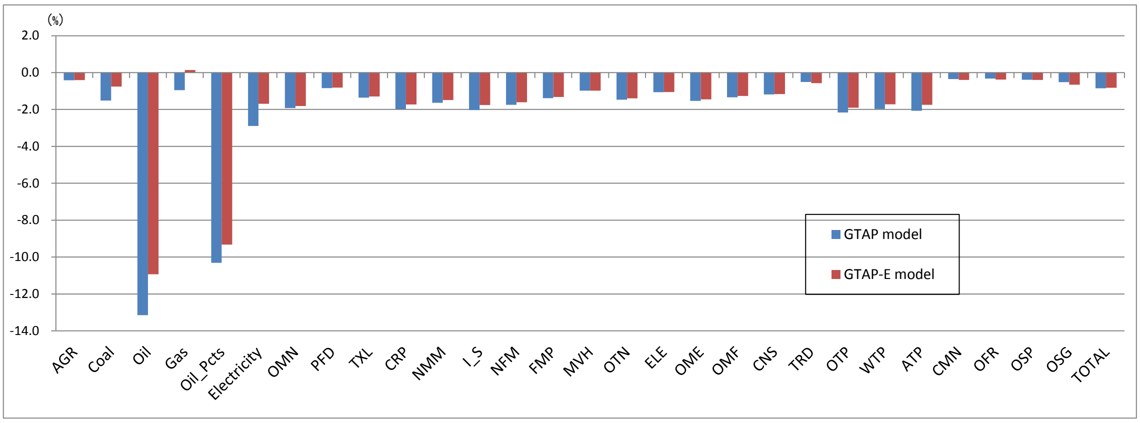
Table 5-3 Japan's private consumption changes in energy goods and non-energy goods, by static analysis, caused by a 25% decrease in crude oil imports from the Middle East (millions, USD)

	energy goods	non-energy goods	TOTAL
GTAP model	-7,323	-21,367	-28,689
GTAP-E model	-6,005	-21,730	-27,735

Source: Author.

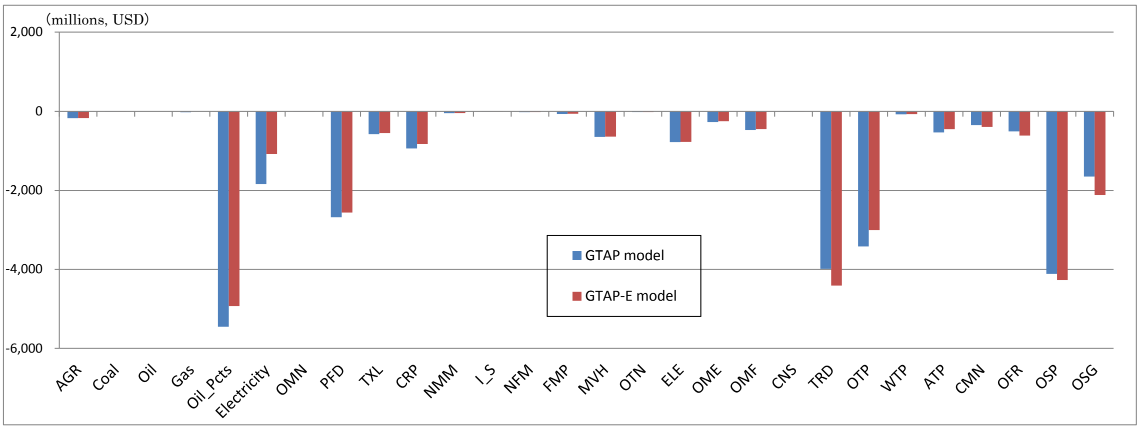
With regard to energy goods, the decrease in the GTAP-E model is less serious than that in the GTAP model, because the increase in the price of energy goods is higher in the GTAP model. Though there is little difference in the change in non-energy goods between the two models, the change in total private consumption becomes more negative in the GTAP model, owing to the decrease in energy commodities.

Figure 5-3 Impacts on Japan's private consumption, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 5-4 Impacts on Japan's private consumption, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

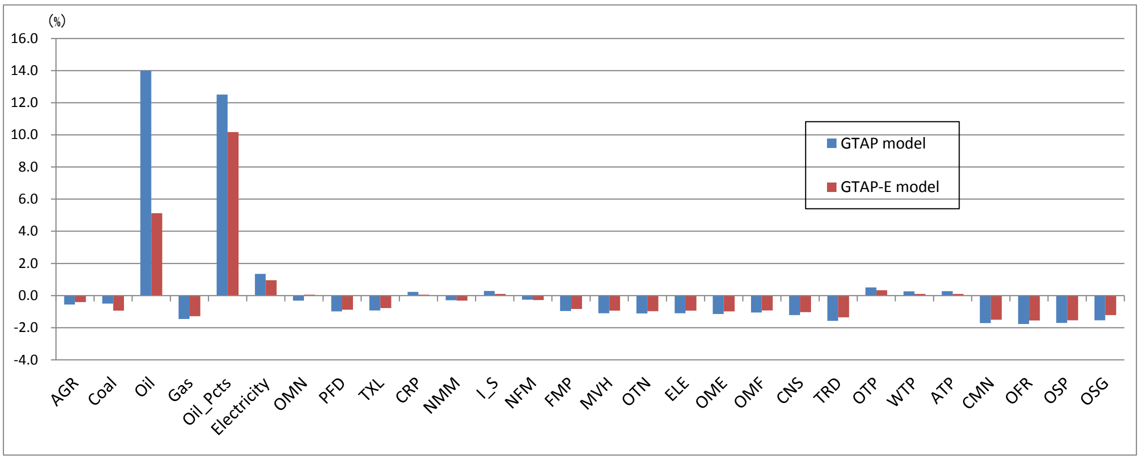


Source: Author.

5.4. Static analysis of changes in Japanese supply price

Figure 5-5 shows the simulation results of changes to Japan's supply price caused by a 25% decrease in crude oil imports from the Middle East, simulated by the GTAP and GTAP-E models (in percentages).

Figure 5-5 Impacts on Japan's supply price, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

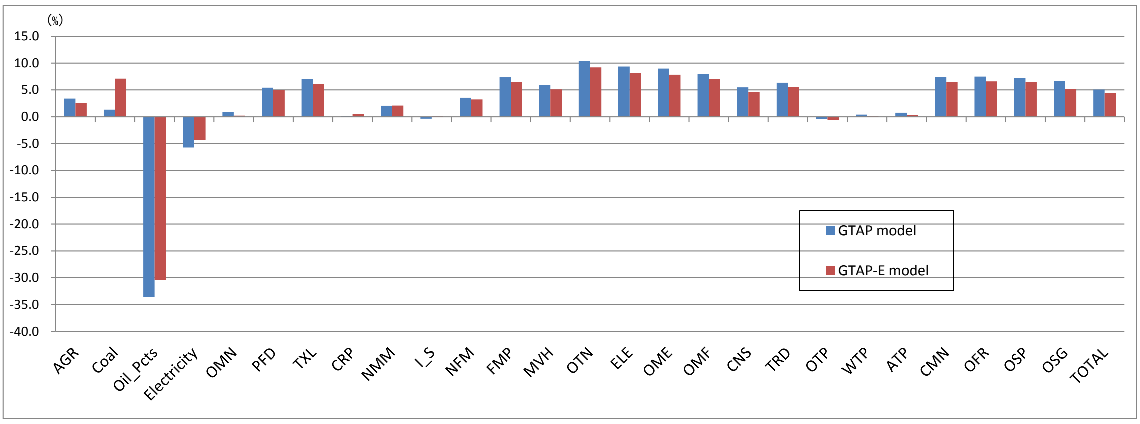
Though both models show similar results in terms of the supply price of non-energy goods, those concerning energy goods, especially crude oil, show a marked difference. The crude oil price increases by 14% according to the GTAP model. However, in the GTAP-E model, owing to the substitution structure in the capital-energy composite and in the energy composite, the increase is about 5%, which is less than that in the GTAP model. Furthermore, for petroleum and coal products, there is a clear difference in the supply price in the results of the two models.

5.5. Static analysis of changes in Japanese exports

Figure 5-6[6] shows the simulation results of changes in Japan's exports owing to a 25% decrease in crude oil imports from the Middle East for both models (in percentages). As we have already seen, the results of both models with regard to industrial output in each sector show similar tendencies, although the negative impacts are stronger in the GTAP-E model. With regard to exports, the results of both models are similar in almost all industries, although the positive change in the GTAP model is slightly larger than that in the GTAP-E model, with the exception of petroleum and coal products. Because industrial outputs decrease in the GTAP model by less than they do in the GTAP-E model, petroleum and coal products are used more domestically than they are in the GTAP-E model. Therefore, exports of petroleum and coal products would decrease by more in the GTAP model than they would in the GTAP-E model. In both models, exports increase in non-energy-intensive goods, such as MVH (motor vehicles and parts), ELE (electronic equipment), and OME (machinery and equipment nec), in which industrial output tends to increase.

Figure 5-7 shows the simulation results of changes in Japanese exports, evaluated in millions USD. In both models, the positive impacts in non-energy-intensive goods overcome the negative impacts in petroleum and coal products.

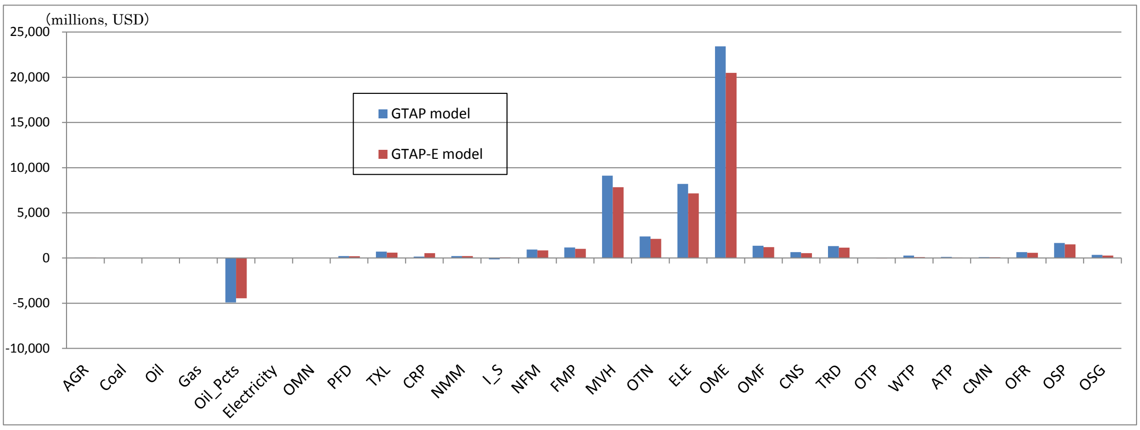
Figure 5-6 Impacts on Japan's exports, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author

[6] In Figure 5-6, the results of the crude oil and gas sectors are not shown because they show greater changes than the other sectors do: crude oil exports decrease by 67.6% according to the GTAP model, and by 36.6% according to the GTAP-E model. Gas exports increase by 77.5% according to the GTAP model, and by 61.7% according to the GTAP-E model. However, the values of crude oil and gas exports are nearly zero.

Figure 5-7 Impacts on Japan's exports by static analysis caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)



Source: Author.

5.6. Static analysis of changes in Japanese imports

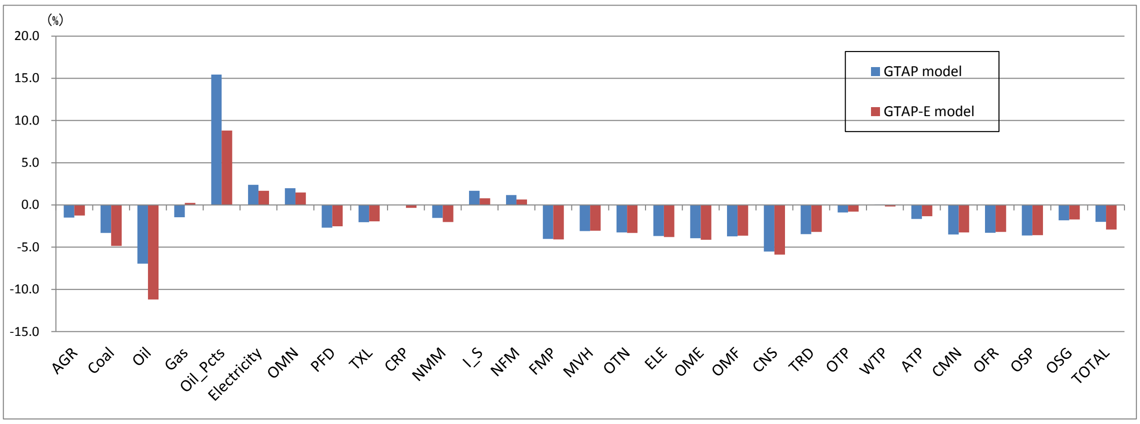
Figure 5-8 shows the simulation results of changes in Japan's imports (market price weights) caused by a 25% decrease in Japan's crude oil imports from the Middle East, simulated by the GTAP and the GTAP-E models (in percentages). The difference between the simulation results of the GTAP model and the GTAP-E model is clear for energy goods, especially crude oil. When crude oil imports from the Middle East decrease according to the GTAP model, which does not have a structure for substitution between energy goods, Japan would try to increase its crude oil imports from other regions in order to secure its crude oil supply. However, according to the GTAP-E model, in which energy goods are treated as factors of production and there is a structure for substitution between energy goods, the substitution effects between crude oil and other energy goods take effect. Reflecting this difference in the structure of energy goods, the imports of crude oil decrease by more in the GTAP-E model than they do in the GTAP model.

When crude oil imports from the Middle East decrease, Japan would also try to increase its imports of petroleum and coal products, which use crude oil as feedstock.[7] However, in the GTAP-E model, which incorporates a substitution structure in the capital-energy composite and in the energy composite, imports of petroleum and coal products would not increase by as much as they do in the GTAP model.

[7] An increase in the imports of petroleum and coal products includes those from the Middle East.

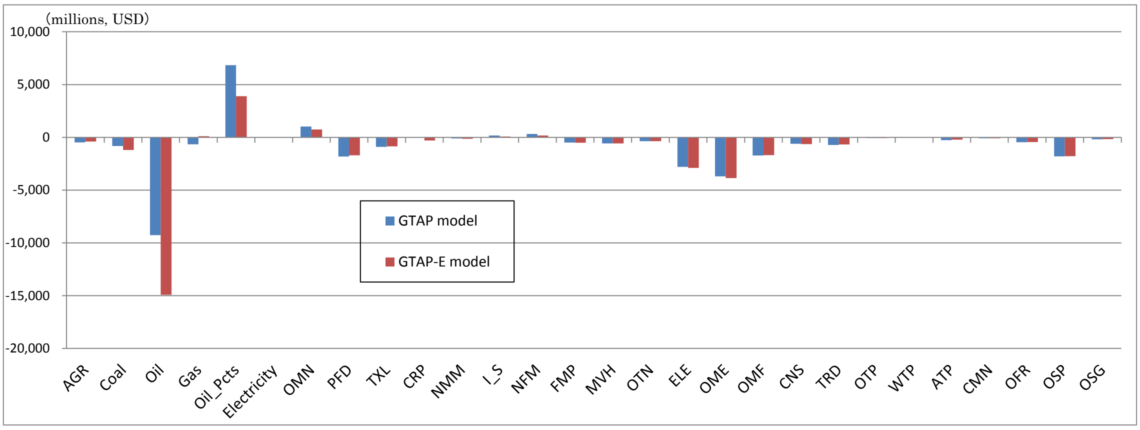
Figure 5-9 shows the simulation results for Japan's imports, evaluated in millions USD. Figures 5-8 and 5-9 show little difference in the change in imports between the two models for non-energy goods.

Figure 5-8 Impacts on Japan's imports, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 5-9 Impacts on Japan's imports, by static analysis, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)



Source: Author.

6. Economic impacts of the decrease in crude oil imports in Japan, incorporating capital accumulation effects

6.1. Macroeconomic changes with capital accumulation effects

Section 6 discusses the simulation results of the GTAP and GTAP-E models with regard to a 25% decrease in Japan's crude oil imports from the Middle East, incorporating capital accumulation effects. Tables 6-1 and 6-2 show the simulation results of macroeconomic changes, in percentages and in million USD, respectively.

The simulation results for the percentage changes in Japan's real GDP are -1.04%

for the GTAP model, and -1.19% for the GTAP-E model. The difference between these results is a little larger than that of the static analysis, and becomes clearer with regard to exports. The percentage change in Japan's exports is almost 0.9% for the GTAP model and -0.6% for the GTAP-E model.[8]

The simulation results for the percentage change in real GDP in other regions in the GTAP model are all positive, and increase by more than they do in other regions when energy exporters are included, such as AEEx (ASEAN Net Energy Exporters), EEFSU (Eastern Europe and FSU), MEC (Middle East), and AFR (Africa). In the results of the GTAP-E model, the negative effect on the Japanese real GDP increases, and in some regions, the sign of the percentage change of real GDP becomes negative because it is affected by the change in Japanese trade.

Table 6-1 Macroeconomic changes, including capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)

	Change in GDP		Change in Export	
	GTAP model	GTAP-E model	GTAP model	GTAP-E model
ANZ	0.01	-0.04	0.10	-0.10
JPN	-1.04	-1.19	0.86	-0.57
CHN	0.03	-0.01	0.03	-0.02
KOR	0.01	-0.01	0.28	0.11
AEEx	0.11	0.12	0.23	0.05
OASN	0.06	-0.01	0.25	0.09
ASA	0.06	0.01	0.14	0.01
IND	0.05	0.03	0.25	0.13
USA	0.02	0.00	0.05	0.00
LTN	0.09	0.01	0.00	-0.01
EU28	0.03	-0.01	0.05	-0.01
EEFSU	0.24	0.09	-0.03	0.04
MEC	0.25	-0.05	0.12	0.01
AFR	0.16	0.04	-0.03	0.04
ROW	0.07	0.01	-0.03	0.00

Source: Author.

[8] The simulation results for the percentage change in Japan's imports based on CIF weights are 0.6% for the GTAP model and -046% for the GTAP-E model.

Table 6-2 Macroeconomic changes, including capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

	Change in GDP		Change in Export		Change in EV	
	GTAP model	GTAP-E model	GTAP model	GTAP-E model	GTAP model	GTAP-E model
ANZ	101	-587	351	-363	-813	-712
JPN	-61,227	-70,185	8,159	-5,338	-50,674	-53,390
CHN	2,461	-465	724	-521	-502	-1,044
KOR	143	-135	1,734	708	-749	-286
AEEx	1,478	1,502	1,264	262	2,394	2,348
OASN	591	-50	1,644	630	-123	-146
ASA	593	81	676	61	-127	9
IND	903	522	924	501	20	565
USA	3,014	254	946	63	-1,522	-290
LTN	5,643	420	24	-118	4,740	261
EU28	4,746	-1,048	3,271	-723	-2,077	-1,736
EEFSU	6,210	2,244	-254	332	10,221	3,413
MEC	6,372	-1,340	1,564	68	8,639	-4,267
AFR	3,349	894	-167	279	5,937	1,637
ROW	2,541	264	-311	-46	2,624	214

Source: Author.

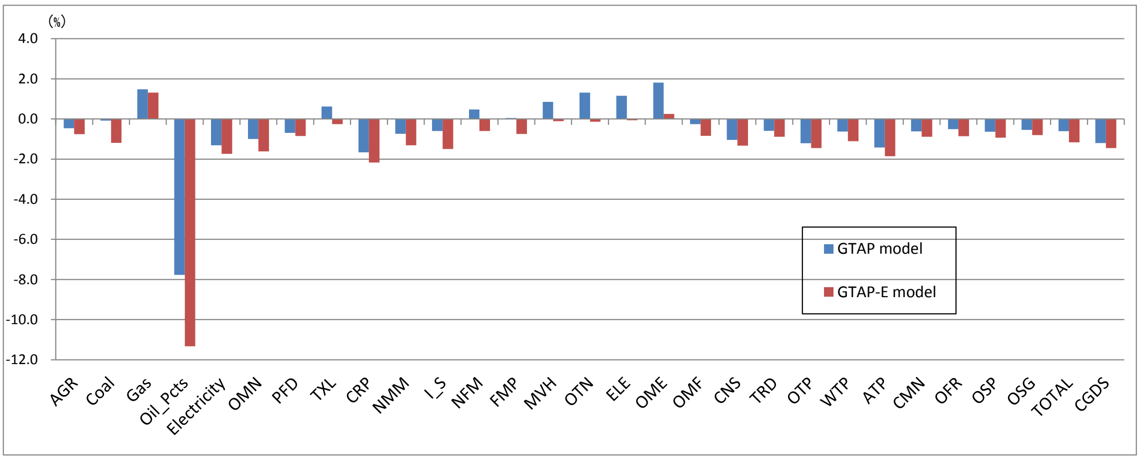
6.2. Changes in Japanese industrial output with capital accumulation effects

Figures 6-1 and 6-2 show the impacts on Japan's industrial output owing to a 25% decrease in crude oil imports from the Middle East, simulated by the GTAP and GTAP-E models, in percentages and in millions USD, respectively, and incorporating capital accumulation effects. The results show similar tendencies, although the negative impacts are stronger in the GTAP-E model.

Compared with the simulation results of the static analysis, the impact of the decrease in crude oil imports becomes more serious when capital accumulation effects are included. The reduction rate is especially large in the petroleum and coal products sector: -7.8% according to the GTAP model, and -11.3% according to the GTAP-E model.[9] Although these changes are almost as large as those in the static analysis are, the impacts become more negative for non-energy goods (i.e., agriculture, manufacturing, and service sectors). With regard to the total balance of industrial output, the results of the GTAP model, in which the negative effect is less than that in the GTAP-E model, show a decrease of about USD 71 billion. In the GTAP-E model, the decrease is about USD 135 billion.

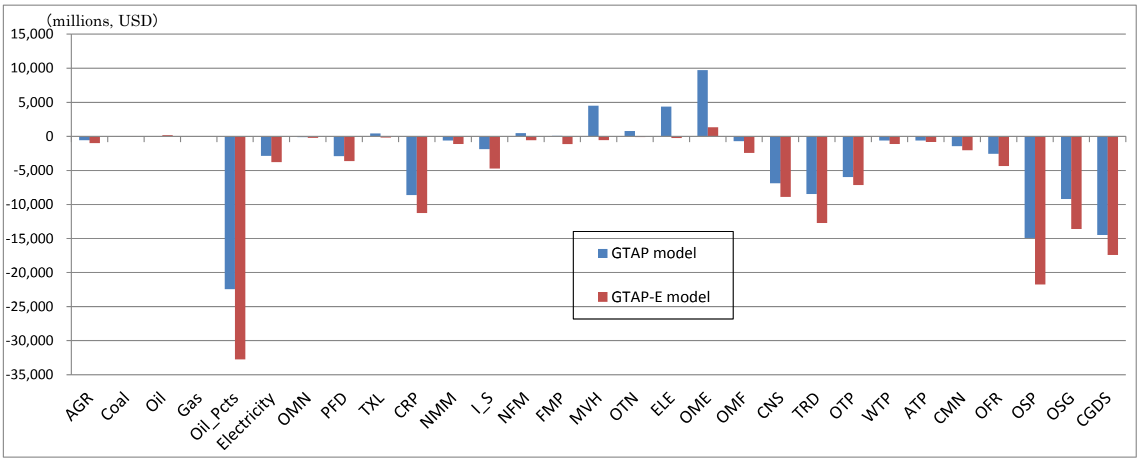
[9] In Figure 6-1, the result of the crude oil sector is not shown because it increases by more than 30% of the result of the GTAP-E model, although its industrial output is small.

Figure 6-1 Impacts on Japan's industrial output, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 6-2 Impacts on Japan's industrial output, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)



Source: Author.

6.3. Changes in Japanese private consumption with capital accumulation effects

Figures 6-3 and 6-4 show the impacts on Japan's private consumption caused by a 25% decrease in crude oil imports from the Middle East simulated by the GTAP and GTAP-E models, in percentages and millions USD, respectively, and incorporating capital accumulation effects. The simulation results of both models are similar. As we have already seen in the results of the static analysis, a large decrease (in million USD) is observed in the private consumption of Oil_Pcts (petroleum and coal products), PFD (food processing), and service commodities, such as TRD (trade), OTP (transport nec), and OSP (other services).

Total private consumption decreases by 1.1% in both models, and the negative impacts are slightly stronger in the GTAP-E model, in contrast to the results of the static analysis. Table 6-3 shows the simulation results for Japan's private consumption of energy goods and non-energy goods.

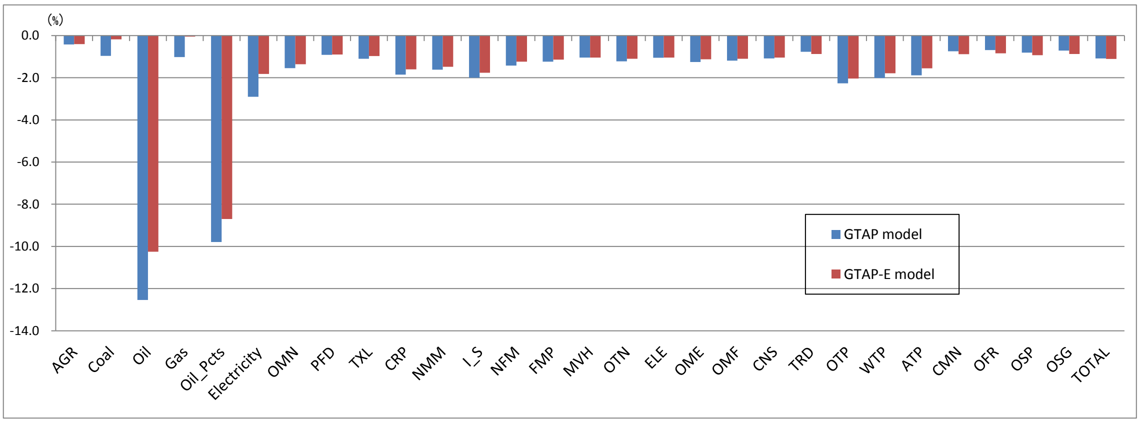
Table 6-3 Private consumption changes in energy goods and non-energy goods, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

	energy goods	non-energy goods	TOTAL
GTAP model	-7,053	-29,441	-36,494
GTAP-E model	-5,765	-31,646	-37,411

Source: the author.

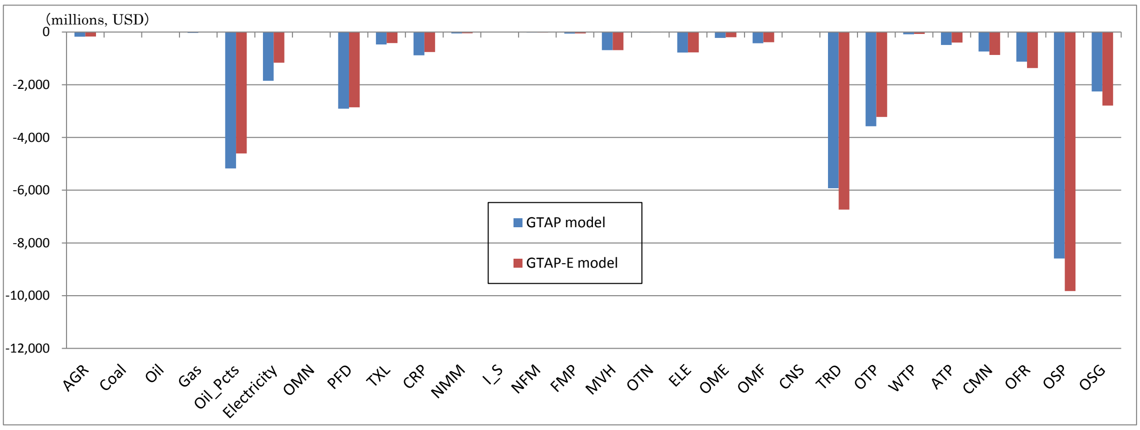
With regard to energy goods, the decrease in the simulation results of the GTAP-E model is less serious than that in the GTAP model, as in the case of the static analysis, because the price of energy goods increases by more in the GTAP model. However, the change in non-energy goods is more serious in the GTAP-E model than it is in the GTAP model. When capital accumulation effects are incorporated, the change in total private consumption becomes more negative in the GTAP-E model than it is in the GTAP model.

Figure 6-3 Impacts on Japan's private consumption, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 6-4 Impacts on Japan's private consumption, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)

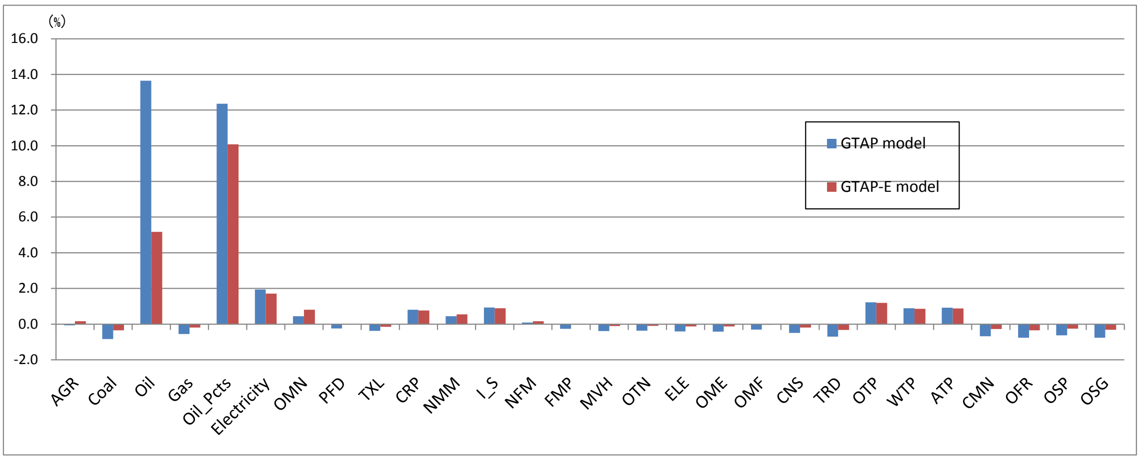


Source: Author.

6.4. Changes in Japanese supply price with capital accumulation effects

Figure 6-5 shows the simulation results of changes in Japan's supply price caused by a 25% decrease in crude oil imports from the Middle East, simulated by the GTAP and GTAP-E models and incorporating capital accumulation effects (in percentages).

Figure 6-5 Impacts on Japan's supply price, with the capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Though the results for the supply price of non-energy goods in both models are similar, the results for energy goods, especially crude oil, are rather different. The crude oil price increases by 13.7% in the GTAP model, which is almost the same percentage change shown in the static analysis. However, the crude oil price in the

GTAP-E model does not increase by as much, owing to the substitution structure in the capital-energy composite and in the energy composite, remaining at 5.2%, which is almost the same change shown in the static analysis. As in the case of the static analysis, the difference in the supply prices of petroleum and coal products in the two models is also clear. The price of petroleum and coal products increases by 12.4% in the GTAP model, and by 10.1% in the GTAP-E model.

6.5. Changes in Japanese exports with capital accumulation effects

Figure 6-6[10] shows the simulation results with regard to changes in Japanese exports, incorporating capital accumulation effects, and evaluated as percentages. As we have already seen in the results of the static analysis, the differences in the results for exports are relatively small in both models and in almost all industries, with the exception of petroleum and coal products. Because industrial outputs decrease by less in the GTAP model than they do in the GTAP-E model, and because petroleum and coal products are used more domestically in the GTAP model, exports in this sector decrease by more in the GTAP model than they do in the GTAP-E model.

In both models, exports increase in the non-energy-intensive sectors, such as MVH (motor vehicles and parts), ELE (electronic equipment), and OME (machinery and equipment nec). Because the negative impacts in other sectors are stronger in the analysis incorporating capital accumulation effects, the total percentage change is smaller than that in the static analysis in both models.

Figure 6-7 shows the simulation results of changes in Japanese exports (million USD). The positive impacts on non-energy-intensive goods and services surpasses the negative impacts on petroleum and coal products and energy-intensive goods. Thus, total exports becomes positive in the GTAP model. On the other hand, in the GTAP-E model, the decreases in petroleum and coal products and in energy-intensive goods are greater than the increase in non-energy-intensive goods and services. Thus, total exports becomes negative.

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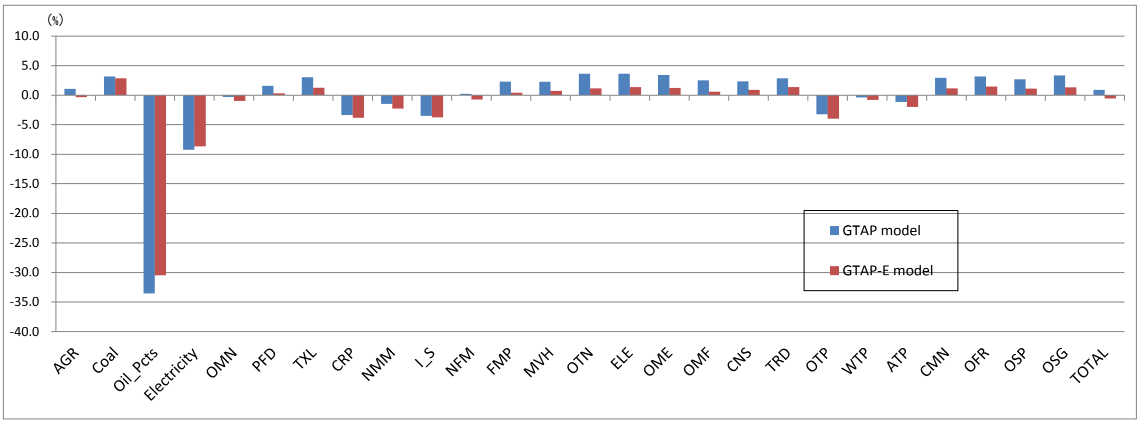
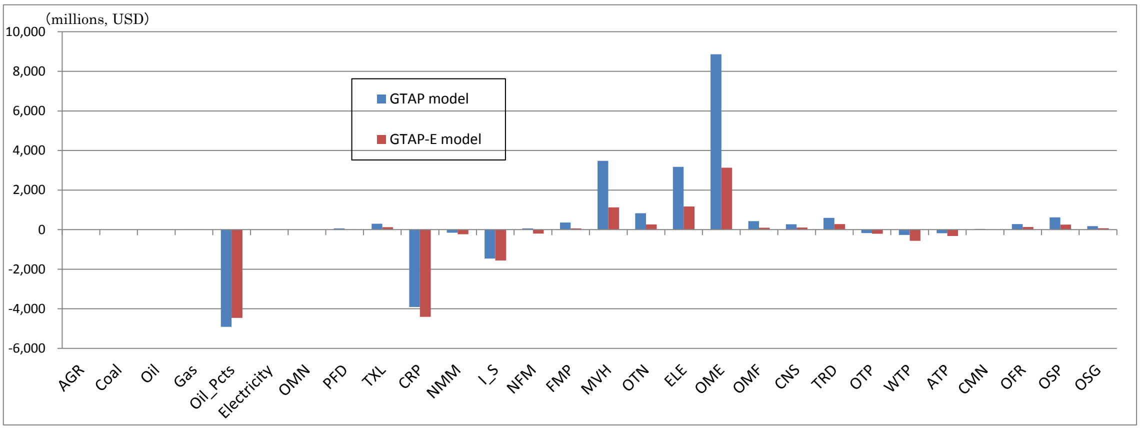
[10] In Figure 6-6, the results of the crude oil and gas sectors are not shown because they change significantly compared with the results in the other sectors. Crude oil exports decrease by 67.2% in the GTAP model, and by 37.8% in the GTAP-E model. The percentage change of gas exports is much less than that in the static analysis, increasing by 26.2% in the GTAP model, and by 10.2% in the GTAP-E model. However, the values of crude oil and gas exports are nearly zero.

Figure 6-6 Impacts on Japan's exports, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 6-7 Impacts on Japan's exports, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)



Source: Author.

6.6. Changes in Japanese imports with capital accumulation effects

Figure 6-8 shows the changes in Japan's imports (market price weights), incorporating capital accumulation effects, evaluated as percentages.

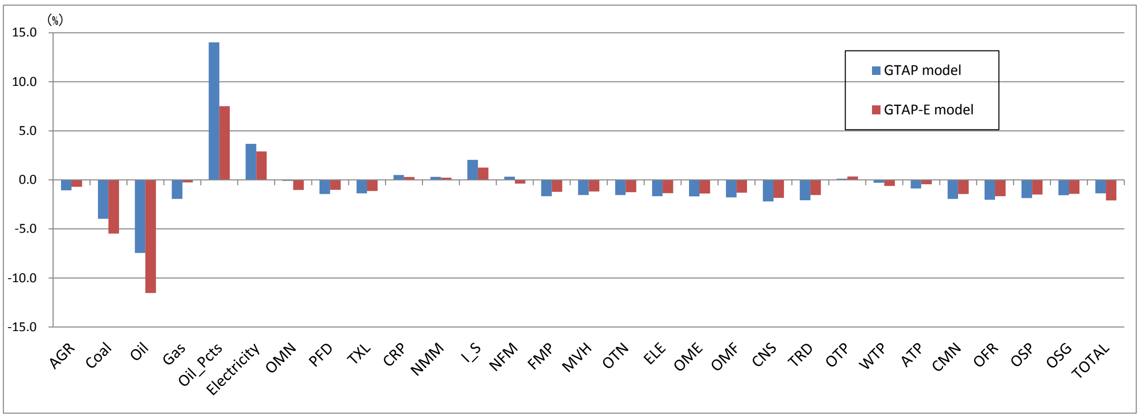
As in the case of the static analysis, the difference between the simulation results of the GTAP model and the GTAP-E model is shown clearly in energy goods. In the GTAP model, which does not have a structure for substitution between energy goods, Japan would try to increase its crude oil imports from other regions to secure its crude oil supply. In the GTAP-E model, which does have a structure for substitution between energy goods, the substitution between crude oil and other energy goods takes effect, and imports decrease by more than they do in the case of the GTAP model.

Reflecting this difference in the structure of energy goods, imports of energy goods decrease by far more in the GTAP-E model than they do in the GTAP model.

When crude oil imports decrease, Japan would try to increase its imports of petroleum and coal products, which use crude oil as feedstock, including petroleum and coal products from the Middle East. However, in the GTAP-E model, which incorporates the substitution structure in the capital-energy composite and in the energy composite, Japan would not try to increase its imports of petroleum and coal products by as much as it would in the GTAP model. When capital accumulation effects are incorporated, industrial outputs decrease by more than they do in the static model, as does the use of petroleum and coal products.

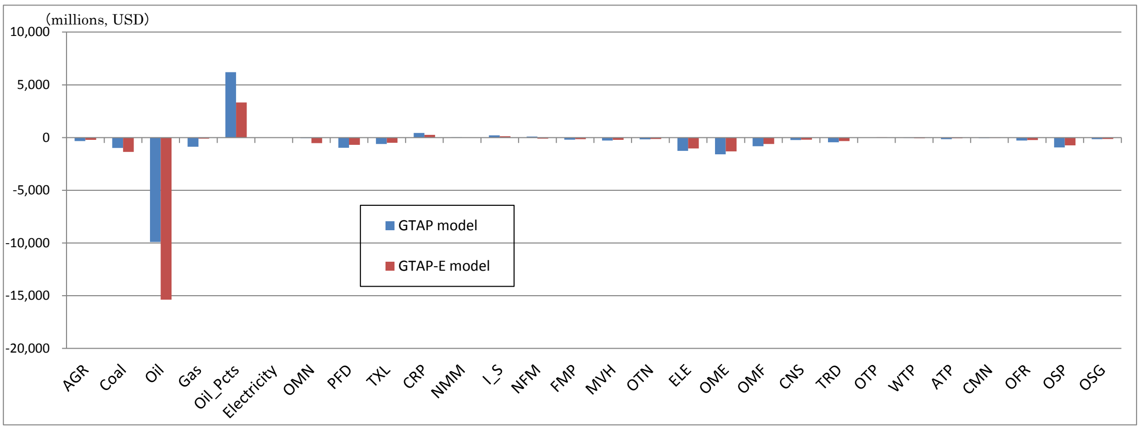
Figure 6-9 shows the simulation results of changes in Japan's imports, incorporating capital accumulation effects, and evaluated in millions USD. In both models, total imports decrease by a little less than they do in the static model. Because industrial outputs decrease by more than they do in the static model, Japan would depend more on imports.

Figure 6-8 Impacts on Japan's imports, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (percentage)



Source: Author.

Figure 6-9 Impacts on Japan's imports, with capital accumulation effects, caused by a 25% decrease in Japan's crude oil imports from the Middle East (millions, USD)



Source: Author.

7. Conclusion

This study analyzed the impact of a decrease in Japan's crude oil imports from the Middle East on the Japanese economy using the GTAP and GTAP-E models, as well as a static analysis and an analysis incorporating capital accumulation effects.

In the static analysis, the change in real GDP is -0.53% for the GTAP model and -0.59% for the GTAP-E model. The simulation results indicate that although the difference between the results of the two models in terms of real GDP is relatively small, the simulation results by industry and by commodity (especially for energy goods) show rather different tendencies.

The reason for this difference between the two models can be attributed to the difference in their production structures, where the GTAP-E model includes a structure for energy substitution. In the GTAP-E model, with its production structure in which crude oil can be substituted by other energy goods, when crude oil imports from the Middle East decrease, Japan would try to increase its crude oil imports from other regions, but by less than in the case of the GTAP model. Thus, the decrease in the production of petroleum and coal products, for which crude oil is important as feedstock, becomes more serious than in the GTAP model. This, in turn, causes a more serious decrease in industrial outputs than it does in the case of GTAP model.

The GTAP model, which does not have a structure for substitution between energy goods, treats energy goods as intermediate goods (i.e., as feedstock). Therefore, when the crude oil imports from the Middle East decrease, Japan will increase its imports of crude oil from other regions in the GTAP model, and the production of petroleum and coal products will decrease by less than it does in the GTAP-E model. The difference in the decrease of production of petroleum and coal products, which are important factors of production, affects the simulation results of both models.

When capital accumulation effects are incorporated, the difference between the results of the two models becomes a little larger and clearer than in the case of the static analysis. This difference is mainly because of the difference in the production structures of the two models.

In general, the GTAP-E model is suitable for analyzing energy goods because of its production structure of substitution between capital and energy goods and between energy goods themselves. However, when energy goods are used mainly as feedstock, the simulation results of the GTAP model, which treats energy goods as intermediate inputs only, present results that are more realistic. In Japan, 94% of crude oil is used in petroleum and coal products and 6% is used for electricity. Thus, it would be better to use the GTAP model to analyze the impact of a decrease in crude oil imports on the Japanese economy, while referring to the results of the GTAP-E model, which treats energy goods as factors of production.

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