Soaring Oil Prices Induce Other Energy Product Price Increases And Further Economic Impact in Japan and Korea

M. Ichihashi,* S. Kaneko,* and H. Kim*
Hiroshima University

Abstract

This paper analyzes how much of an impact soaring crude oil prices have upon the economies of Japan and Korea from a supply side viewpoint and with an eye toward the demand side. First, using the 2000 Asian Input-Output table, we calculated to what extent the crude oil price shock beyond Asia raises other prices in Asia and the United States. Second, we compared the effect of crude oil price increases in Asia and the U.S. Third, we estimated demand functions in the energy sectors and measured the amount of demand decrease effects caused by price shock originating in the crude oil market.

According to our results, the effects of price increases in Japan are relatively less than in Korea, although the demand for petroleum and electricity in Japan is more sensitive to triggers as those prices rise. Alternatively, many prices in Korea are affected by the increase in crude oil prices, while the demand for petroleum and electricity has a weaker sensitivity than in Japan. As a result, the relative magnitudes of the effects induced by final demand decreases in both countries were almost the same when price elasticity and the complement and substitution effects of goods were taken into consideration.

Key Words: *energy prices, induced effect, price model, input-output analysis, demand function, Japan and Korea.*

1. Introduction

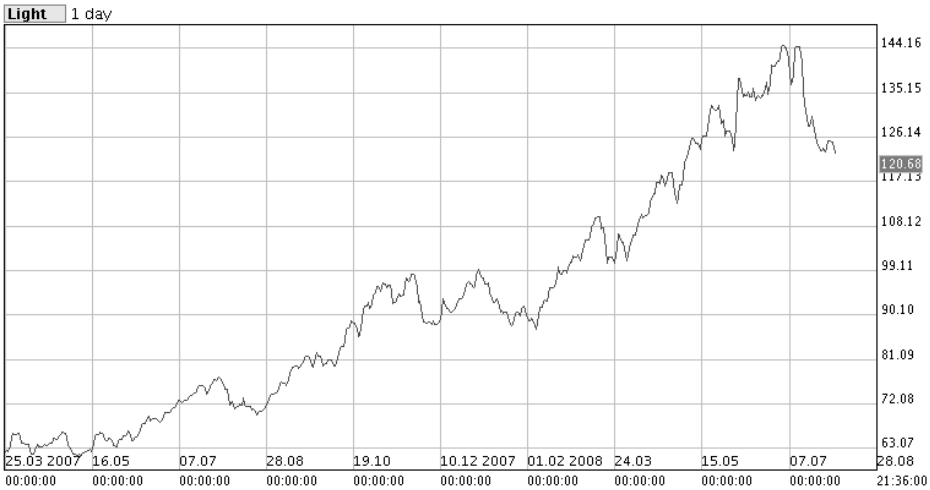
Crude oil prices in the futures market have been rising constantly since 2000, and prices finally exceeded US$100 a barrel near the end of 2007 (see Fig. 1). This price increase appears to be generated by a substitution of assets holding resulting from the subprime loan problem and concern about economic growth rate. Though this increase cannot necessarily reflect the real demand for oil in the economy, the resulting price increases can nonetheless seriously affect the

* International Development and Cooperation (IDEC), Hiroshima University, 1-5-1 Kagamiyama Higashi, Hiroshima, JAPAN.

global economy.

Eastern Asian countries, such as Japan, Korea, Taiwan, and China, have especially been developing and industrializing largely through the import of crude oil from outside Asia, including the Middle East. Further, these Asian countries have been strengthening their mutual dependency through the international trading and production network based on the division of labor. These nations must be threatened by recent soaring oil prices.

Fig. 1. Transition of Crude Oil Prices in the Futures Market.



Source: http://chartpark.com/wti.html

Moreover, any rapid price increase of a specific commodity within a particular region will affect other regions widely, and that price increase influence will become more complicated. As a fundamental energy good, the price change of crude oil must necessarily affect petroleum and electricity prices, and those price increases in turn have successive and wide effects upon individual production.

For instance, the Japanese Cabinet Office (2004) reported that a 10% increase in crude oil prices could push petroleum prices up by 0.17% and chemical goods prices up by 0.03%. In his simulation, Ono (2008) predicted that a 44.8% price increase in crude oil would result in a price increase of non-metals by 16.2% and in electricity by 13%.[1] The effect of the demand decrease

[1] However, the price increases of energy-related goods, such as petroleum and basic chemicals, were not high in his estimation.

was estimated to be -0.64% of the Japanese GDP. Also, Iwamoto (2004) pointed out that the influence of price increases from US$40 a barrel to US$52 in 2004 could account for -0.2% of that year's GDP.

Simply comparing these results is insufficient. Previous studies have employed different types of price increases during different periods, and the prices of petroleum, electricity, and basic chemicals commonly have a greater economic influence beyond crude oil price shock. It is also understood that the GDP often will experience little negative effect in response to oil prices.

This paper attempts to analyze how much crude oil price increases, both in Asia and beyond Asian borders, affect Asian economies, especially focusing on individual prices and market demands in Japan and Korea. We have tried to clarify how significant the repercussive effect of crude oil price shock was found to be through the 2000 Asian Input-Output Sector 76 model and upon individual demand functions in Japan and Korea by using SNA data in both instances.

In a previous paper,[2] we analyzed energy consumption and CO2 emissions in industrializing Korea through the lens of an export-oriented economic policy, one that might change domestic industrial structures and facilitate energy-saving technology. However, because that paper did not address the price effects induced by crude oil price shock, this paper analyzes this complementary problem.

Section 2 herein analyzes the price effect induced by crude oil, which is primarily imported, by examining price increases regions beyond Asia using an equilibrium price model Input-Output frame. Section 3 focuses upon those effects caused by crude oil price increases in Asia. In Section 4, we estimate the demand functions of petroleum and electricity individually within Japan and Korea and analyze the effect of a demand decrease with the price increase that we calculated in Sections 2 and Section 3. Section 5 demonstrates the amount of demand decrease using the data from an Asian IO table and the repercussive effects of that decrease. Finally, we address remaining problems and offer concluding remarks.

2. An Analysis of Energy Price Changes Using an Equilibrium Price Model

In this section, we will analyze how crude oil price increases outside Asia affect the Asian economy; to accomplish this we are using an equilibrium price model with an Input-Output table. The question at hand is, if the price of crude oil that Japan and Korea are primarily importing from outside Asia soars, how will it affect individual prices in Asian countries, including Japan and

[2] Kim, Kaneko, and Ichihashi (2008).

Korea?

We employed the 2000 Asian IO table, Sector 76, to conduct this analysis (see Table 1). The outline of this table is illustrated in Fig. 2 and is a typical interregional table of ten countries. These countries are nine Asian nations, Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Taiwan, Korea, and Japan, plus the United States. This table technically includes noncompetitive imports, since imports are excluded from the intermediate demand area. This results in ease of use because it does not require consideration of each sector's self-sufficiency rate when applying the Leontief inverse matrix.

Since most of the countries in Table 1 are primarily dependent upon imports from outside Asia (ROW), such as are Japan and Korea, we can analyze the price change utilizing an exogenous vector. That results in an equilibrium price model of IO where an equation (1) derived from the following balance provides the new balanced price.[3]

Table 1. Contents of Asian IO, Sector 76.

1	Paddy	39	Glass and glass products
2	Other grain	40	Other non-metallic mineral products
3	Food crops	41	Iron and steel
4	Non-food crops	42	Non-ferrous metal
5	Livestock and poultry	43	Metal products
6	Forestry	44	Boilers, Engines and turbines
7	Fishery	45	General machinery
8	Crude petroleum and natural gas	46	Metal working machinery
9	Iron ore	47	Specialized machinery
10	Other metallic ore	48	Heavy Electrical equipment
11	Non-metallic ore and quarrying	49	Television sets, radios audios and communication equipment
12	Milled grain and flour	50	Electronic computing equipment
13	Fish products	51	Semiconductors and integrated circuits
14	Slaughtering and meat and dairy products	52	Other electronics and electronic products
15	Other food products	53	Household electrical equipment
16	Beverage	54	Lighting fixtures, batteries, wiring and others
17	Tobacco	55	Motor vehicles
18	Spinning	56	Motor cycles
19	Weaving and dyeing	57	Shipbuilding
20	Knitting	58	Other transport equipment
21	Wearing apparel	59	Precision machines
22	Other made-up textile products	60	Other manufacturing products
23	Leather and leather products	61	Electricity and gas
24	Timber	62	Water supply
25	Wooden furniture	63	Building construction
26	Other wooden products	64	Other construction
27	Pulp and paper	65	Wholesales and retail trade
28	Printing and publishing	66	Transportation
29	Synthetic resins and fiber	67	Telephone and telecommunication
30	Basic industrial chemicals	68	Finance and insurance
31	Chemical fertilizers and pesticides	69	Real estate
32	Drugs and medicine	70	Education and research
33	Other chemical products	71	Medical and health service
34	Refined petroleum and its products	72	Restaurants
35	Plastic products	73	Hotel
36	Tires and tubes	74	Other service
37	Other rubber products	75	Public administration
38	Cement and cement products	76	Unclassified

[3] Hirose (1996) conducted analysis similar to our research; however, that data is outdated.

Figure 2. 2000 Asian IO Outline.

	code	Intermediate Demand (A)										Final Demand (F)										Export (L)				
		Indonesia (AI)	Malaysia (AM)	Philippines (AP)	Singapore (AS)	Thailand (AT)	China (AC)	Taiwan (AN)	Korea (AK)	Japan (AJ)	U.S.A. (AU)	Indonesia (FI)	Malaysia (FM)	Philippines (FP)	Singapore (FS)	Thailand (FT)	China (FC)	Taiwan (FN)	Korea (FK)	Japan (FJ)	U.S.A. (FU)	Export to Hong Kong (LH)	Export to EU (LO)	Export to R.O.W. (LW)	Statistical Discrepancy (QX)	Total Outputs (XX)
Indonesia	(AI)	A^{II}	A^{IM}	A^{IP}	A^{IS}	A^{IT}	A^{IC}	A^{IN}	A^{IK}	A^{IJ}	A^{IU}	F^{II}	F^{IM}	F^{IP}	F^{IS}	F^{IT}	F^{IC}	F^{IN}	F^{IK}	F^{IJ}	F^{IU}	L^{IH}	L^{IO}	L^{IW}	Q^{I}	X^{I}
Malaysia	(AM)	A^{MI}	A^{MM}	A^{MP}	A^{MS}	A^{MT}	A^{MC}	A^{MN}	A^{MK}	A^{MJ}	A^{MU}	F^{MI}	F^{MM}	F^{MP}	F^{MS}	F^{MT}	F^{MC}	F^{MN}	F^{MK}	F^{MJ}	F^{MU}	L^{MH}	L^{MO}	L^{MW}	Q^{M}	X^{M}
Philippines	(AP)	A^{PI}	A^{PM}	A^{PP}	A^{PS}	A^{PT}	A^{PC}	A^{PN}	A^{PK}	A^{PJ}	A^{PU}	F^{PI}	F^{PM}	F^{PP}	F^{PS}	F^{PT}	F^{PC}	F^{PN}	F^{PK}	F^{PJ}	F^{PU}	L^{PH}	L^{PO}	L^{PW}	Q^{P}	X^{P}
Singapore	(AS)	A^{SI}	A^{SM}	A^{SP}	A^{SS}	A^{ST}	A^{SC}	A^{SN}	A^{SK}	A^{SJ}	A^{SU}	F^{SI}	F^{SM}	F^{SP}	F^{SS}	F^{ST}	F^{SC}	F^{SN}	F^{SK}	F^{SJ}	F^{SU}	L^{SH}	L^{SO}	L^{SW}	Q^{S}	X^{S}
Thailand	(AT)	A^{TI}	A^{TM}	A^{TP}	A^{TS}	A^{TT}	A^{TC}	A^{TN}	A^{TK}	A^{TJ}	A^{TU}	F^{TI}	F^{TM}	F^{TP}	F^{TS}	F^{TT}	F^{TC}	F^{TN}	F^{TK}	F^{TJ}	F^{TU}	L^{TH}	L^{TO}	L^{TW}	Q^{T}	X^{T}
China	(AC)	A^{CI}	A^{CM}	A^{CP}	A^{CS}	A^{CT}	A^{CC}	A^{CN}	A^{CK}	A^{CJ}	A^{CU}	F^{CI}	F^{CM}	F^{CP}	F^{CS}	F^{CT}	F^{CC}	F^{CN}	F^{CK}	F^{CJ}	F^{CU}	L^{CH}	L^{CO}	L^{CW}	Q^{C}	X^{C}
Taiwan	(AN)	A^{NI}	A^{NM}	A^{NP}	A^{NS}	A^{NT}	A^{NC}	A^{NN}	A^{NK}	A^{NJ}	A^{NU}	F^{NI}	F^{NM}	F^{NP}	F^{NS}	F^{NT}	F^{NC}	F^{NN}	F^{NK}	F^{NJ}	F^{NU}	L^{NH}	L^{NO}	L^{NW}	Q^{N}	X^{N}
Korea	(AK)	A^{KI}	A^{KM}	A^{KP}	A^{KS}	A^{KT}	A^{KC}	A^{KN}	A^{KK}	A^{KJ}	A^{KU}	F^{KI}	F^{KM}	F^{KP}	F^{KS}	F^{KT}	F^{KC}	F^{KN}	F^{KK}	F^{KJ}	F^{KU}	L^{KH}	L^{KO}	L^{KW}	Q^{K}	X^{K}
Japan	(AJ)	A^{JI}	A^{JM}	A^{JP}	A^{JS}	A^{JT}	A^{JC}	A^{JN}	A^{JK}	A^{JJ}	A^{JU}	F^{JI}	F^{JM}	F^{JP}	F^{JS}	F^{JT}	F^{JC}	F^{JN}	F^{JK}	F^{JJ}	F^{JU}	L^{JH}	L^{JO}	L^{JW}	Q^{J}	X^{J}
U.S.A.	(AU)	A^{UI}	A^{UM}	A^{UP}	A^{US}	A^{UT}	A^{UC}	A^{UN}	A^{UK}	A^{UJ}	A^{UU}	F^{UI}	F^{UM}	F^{UP}	F^{US}	F^{UT}	F^{UC}	F^{UN}	F^{UK}	F^{UJ}	F^{UU}	L^{UH}	L^{UO}	L^{UW}	Q^{U}	X^{U}
Freight and Insurance	(BF)	BA^{I}	BA^{M}	BA^{P}	BA^{S}	BA^{T}	BA^{C}	BA^{N}	BA^{K}	BA^{J}	BA^{U}	BF^{I}	BF^{M}	BF^{P}	BF^{S}	BF^{T}	BF^{C}	BF^{N}	BF^{K}	BF^{J}	BF^{U}					
Import from Hong Kong	(CH)	A^{HI}	A^{HM}	A^{HP}	A^{HS}	A^{HT}	A^{HC}	A^{HN}	A^{HK}	A^{HJ}	A^{HU}	F^{HI}	F^{HM}	F^{HP}	F^{HS}	F^{HT}	F^{HC}	F^{HN}	F^{HK}	F^{HJ}	F^{HU}					
Import from EU	(CO)	A^{OI}	A^{OM}	A^{OP}	A^{OS}	A^{OT}	A^{OC}	A^{ON}	A^{OK}	A^{OJ}	A^{OU}	F^{OI}	F^{OM}	F^{OP}	F^{OS}	F^{OT}	F^{OC}	F^{ON}	F^{OK}	F^{OJ}	F^{OU}					
Import from the R.O.W.	(CW)	A^{WI}	A^{WM}	A^{WP}	A^{WS}	A^{WT}	A^{WC}	A^{WN}	A^{WK}	A^{WJ}	A^{WU}	F^{WI}	F^{WM}	F^{WP}	F^{WS}	F^{WT}	F^{WC}	F^{WN}	F^{WK}	F^{WJ}	F^{WU}					
Duties and Import Commodity Taxes	(DT)	DA^{I}	DA^{M}	DA^{P}	DA^{S}	DA^{T}	DA^{C}	DA^{N}	DA^{K}	DA^{J}	DA^{U}	DF^{I}	DF^{M}	DF^{P}	DF^{S}	DF^{T}	DF^{C}	DF^{N}	DF^{K}	DF^{J}	DF^{U}					
Value Added	(VV)	V^{I}	V^{M}	V^{P}	V^{S}	V^{T}	V^{C}	V^{N}	V^{K}	V^{J}	V^{U}															
Total Inputs	(XX)	X^{I}	X^{M}	X^{P}	X^{S}	X^{T}	X^{C}	X^{N}	X^{K}	X^{J}	X^{U}															

Valued at producer's price (rows Indonesia to U.S.A.)

International freight and insurance on the trade between member countries (A**, F**). (row BF)

Valued at C.I.F. (rows CH, CO, CW)

Import duties and import commodity taxes levied on all trade. (row DT)

* Each cell of A** and F** represents a matrix of 76 x 76 and 76 x 4 dimension, respectively.

$$\mathbf{p} = \mathbf{A'}\,\mathbf{p} + \mathbf{M'}\mathbf{p_m} + \mathbf{V'}\,\mathbf{e}$$

$$\mathbf{p} = [\mathbf{I} - \mathbf{A}]^{-1'}\left(\mathbf{M}'\mathbf{p}_{\mathbf{m}} + \mathbf{V}'\mathbf{e}\right) \tag{1}$$

where **p** is the price vector (n by 1), $[\mathbf{I}-\mathbf{A}]^{-1'}$ is the Leontief inverse matrix (transposed), **M’** is the import rate matrix (transposed) (n by s), $\mathbf{p_m}$ is the import price vector (s by 1), **V’** is the valued added rate matrix (n by k), and **e** is a column vector in which all elements are units (k by 1). Also, s=m by o, where m is the number of sectors and o is the number of other countries that Asian nations import from, and k is the number of components of value added, which includes international freight and insurance and duties and import sales tax.

Utilizing this model, we can obtain both the direct and indirect price effects caused by price changes in imported goods in the intermediate sectors. Multiplication of the Leontief inverse matrix and an exogenous import diagonal matrix by the price vector shown as the first term in the parenthesis on the right hand side in Equation (1) illustrates how much the increase in a particular import good's price ultimately pushes up individual good prices in the intermediate sectors.

Making the assumption that crude oil prices outside Asia[4] (primarily ROW and the EU) were to double, we then calculated how much individual goods prices would have risen. The assumption was made that the price of crude oil price doubled from one unit[5] on the based point to two units on the compared point. That assumed the increment of crude oil price was one ($\Delta p_c = 1$) and, here, that unit is US$1,000. Table 2 shows the resulting top thirty price increases in Asia.

Table 2. Price Increase Effects for Crude Oil Beyond Asia: Ranking in Asia + U.S., Top 30/760 sectors.

1	Thailand	Refined petroleum and its products	0.50720
2	Philippines	Refined petroleum and its products	0.46423
3	Korea	Refined petroleum and its products	0.46303
4	Taiwan	Refined petroleum and its products	0.43635
5	Japan	Refined petroleum and its products	0.34958
6	USA	Refined petroleum and its products	0.31126
7	Indonesia	Refined petroleum and its products	0.19268
8	Korea	Electricity and gas	0.17326
9	China	Refined petroleum and its products	0.16041
10	Philippines	Electricity and gas	0.15939
11	Malaysia	Refined petroleum and its products	0.15295
12	Indonesia	Basic industrial chemicals	0.15173
13	Korea	Basic industrial chemicals	0.13773
14	Thailand	Transportation	0.13733
15	Taiwan	Basic industrial chemicals	0.13249
16	Philippines	Transportation	0.09032
17	USA	Electricity and gas	0.08772
18	Thailand	Fishery	0.07723
19	Korea	Synthetic resins and fiber	0.07702
20	USA	Crude petroleum and natural gas	0.06998
21	Philippines	Cement and cement products	0.06973
22	Korea	Transportation	0.06766
23	Taiwan	Iron ore	0.06096
24	Korea	Fishery	0.06061
25	Korea	Other non-metallic mineral products	0.05882
26	Korea	Chemical fertilizers and pesticides	0.05719
27	Japan	Electricity and gas	0.05713
28	USA	Basic industrial chemicals	0.05456
29	Taiwan	Non-metallic ore and quarrying	0.05318
30	Thailand	Electricity and gas	0.05231

As you can see, any crude oil price increase can seriously affect the cost of refined petroleum and its products (hereafter, petroleum) in many countries. In the Philippines, Korea, Taiwan, and Japan, all of which greatly depend on imported oil, crude oil price increases can result in the rise of petroleum by 0.35 – 0.46 unit. Thailand and the U.S. produce their own domestic crude oil, but their imports of crude oil are also large; therefore, those countries' petroleum prices can rise by 0.51 and 0.30, respectively.

Table 3 focuses on Japan and Korea, showing us the results (top 20) from the price effects discussed above. The number in the left column denotes the rank within the 760 total sectors

[4] Outside (or beyond) Asia refers to Hong Kong, the EU, and ROW, which includes the Middle East.
[5] One unit = $1,000

included in this table. It is common that the three large oil-consumption industries, petroleum, electricity and gas (hereafter, electricity), and basic industrial chemicals (hereafter, basic chemicals), in both countries will reflect high price increases. According to Table 3, the price increase in Korean petroleum is approximately 0.46; in Japan, it is 0.35; in Korea, electricity rises 0.17; Japan's electrical increase is 0.06; and basic chemical prices rise in Korea by 0.14 and Japan by 0.04. We note that the price changes in Korea are greater than those in Japan. This indicates that the Korean industrial structure may tend to have greater dependence on crude oil as a basic energy source, and that Japanese industries input other goods relatively more than crude oil. In general, crude oil price changes tend to affect upstream materials industries that consume a large amount of crude oil; however, this influence in Japan is not seen as widely, except within the petroleum industry. Japan's immunity, relative to Korea, to crude oil price changes is calculated in Table 2, which includes only two of Japan's industries among the top 30 sectors.

We can also observe from Table 2 that some manufacturing industries, such as iron and other ores, synthetic resins and fibers, and iron and steel, and select service industries, such as transportation, and fisheries all experience relatively high price increases.

Table 3. The Effects of Price Changes in Japan and Korea for Crude Oil from Outside Asia (Top 20 Commodities).

5	Japan	Refined petroleum and its products	0.34958
27	Japan	Electricity and gas	0.05713
50	Japan	Basic industrial chemicals	0.04231
60	Japan	Non-metallic ore and quarrying	0.03957
111	Japan	Synthetic resins and fiber	0.02552
121	Japan	Other metallic ore	0.02434
125	Japan	Iron ore	0.02412
136	Japan	Fishery	0.02281
164	Japan	Iron and steel	0.02034
191	Japan	Tires and tubes	0.01870
195	Japan	Chemical fertilizers and pesticides	0.01848
212	Japan	Other non-metallic mineral products	0.01767
227	Japan	Transportation	0.01663
238	Japan	Cement and cement products	0.01619
258	Japan	Other construction	0.01534
265	Japan	Weaving and dyeing	0.01498
286	Japan	Glass and glass products	0.01410
291	Japan	Pulp and paper	0.01372
297	Japan	Non-food crops	0.01321
304	Japan	Other chemical products	0.01292

Korea	Refined petroleum and its products	0.46303
Korea	Electricity and gas	0.17326
Korea	Basic industrial chemicals	0.13773
Korea	Synthetic resins and fiber	0.07702
Korea	Transportation	0.06766
Korea	Fishery	0.06061
Korea	Other non-metallic mineral products	0.05882
Korea	Chemical fertilizers and pesticides	0.05719
Korea	Cement and cement products	0.05004
Korea	Iron and steel	0.05004
Korea	Glass and glass products	0.04713
Korea	Unclassified	0.04697
Korea	Plastic products	0.04598
Korea	Other grain	0.04578
Korea	Fish products	0.04371
Korea	Other chemical products	0.04223
Korea	Iron ore	0.04024
Korea	Non-metallic ore and quarrying	0.03989
Korea	Spinning	0.03920
Korea	Other metallic ore	0.03854

Next, we will decompose the effects discussed above in terms of the contribution ratio of each country. This decomposition can determine which country is contributing most to the price increase in the input. The following factor decomposition equation has been modified using Equation (1):

$$\hat{\mathbf{p}}_{\mathbf{D}} = [\mathbf{I} - \mathbf{A}]^{-1'} \hat{\mathbf{M}}_{\mathbf{C}} \quad (2)$$

where $\hat{\mathbf{M}}_{\mathbf{C}}$ is a diagonal matrix divided into each country block (n by q). $\hat{\mathbf{p}}_{\mathbf{D}}$ is a price increase vector divided into each country block (n times q). q is the number of countries in this IO table; here q=10.

Table 4 shows the decomposition results in three sectors, petroleum, electricity, and basic chemicals, and includes the contribution ratio of each country. We have been able to determine that 98% to 99% of all petroleum and electricity price increases in Japan and Korea were directly caused by price changes in imported crude oil.

Table 4. Decomposition with Contribution Ratio by Country for Three Sectors.

Japan

	Refined petroleum and its products	Contribution Ratio	Electricity and gas	Contribution Ratio	Basic industrial chemicals	Contribution Ratio
Indonesia	0.00037	0.11%	0.00059	1.04%	0.00104	2.47%
Malaysia	0.00001	0.00%	0.00005	0.09%	0.00099	2.33%
Philippines	0.00000	0.00%	0.00000	0.01%	0.00067	1.58%
Singapore	0.00000	0.00%	0.00000	0.00%	0.00000	0.00%
Thailand	0.00001	0.00%	0.00001	0.02%	0.00009	0.22%
China	0.00015	0.04%	0.00005	0.08%	0.00054	1.29%
Taiwan	0.00001	0.00%	0.00001	0.02%	0.00015	0.35%
Korea	0.00013	0.04%	0.00018	0.31%	0.01195	28.25%
Japan	0.34855	99.70%	0.05605	98.10%	0.02538	59.99%
USA	0.00034	0.10%	0.00019	0.33%	0.00149	3.52%
Total	0.34958	100.00%	0.05713	100.00%	0.04231	100.00%

Korea

	Refined petroleum and its products	Contribution Rate	Electricity and gas	Contribution Rate	Basic industrial chemicals	Contribution Rate
Indonesia	0.00108	0.23%	0.00066	0.38%	0.00334	2.43%
Malaysia	0.00008	0.02%	0.00011	0.06%	0.00092	0.67%
Philippines	0.00002	0.00%	0.00005	0.03%	0.00043	0.31%
Singapore	0.00000	0.00%	0.00000	0.00%	0.00000	0.00%
Thailand	0.00007	0.02%	0.00013	0.08%	0.00116	0.84%
China	0.00016	0.03%	0.00035	0.20%	0.00161	1.17%
Taiwan	0.00005	0.01%	0.00012	0.07%	0.00118	0.85%
Korea	0.46074	99.51%	0.17021	98.24%	0.11362	82.49%
Japan	0.00025	0.05%	0.00057	0.33%	0.00549	3.98%
USA	0.00059	0.13%	0.00107	0.62%	0.00998	7.25%
Total	0.46303	100.00%	0.17326	100.00%	0.13773	100.00%

Alternatively, approximately 60% of the price increase for basic chemicals in Japan is a direct effect of imported crude oil prices; however, 28% of that amount is an indirect effect of trade through Korea and 3.5% is attributable to the U.S. The price increase of crude oil outside Asia first affects prices in Korea, after which prices on some raw materials that are imported in Japan further raise the price of basic chemicals in Japan. That is, 28% of the 0.04 unit price increase of basic chemicals in Japan is attributable to Korea.

Similarly, 83% of the price increases for basic chemicals in Korea results from the direct effect of imported crude oil prices, while the contribution ratio of the U.S. is 7% and Japan is 4%. This means that approximately 17% of the 0.13 unit price increase of basic chemicals in Korea is attributable to other countries.

In comparing Japan with Korea, we see that Japan's basic chemicals are quite dependent upon raw materials from Korea. However, Korea's access to basic chemicals is influenced more strongly by U.S. imports. In addition, both Japan and Korea receive approximately 2% of their basic chemicals from Indonesia.

As mentioned above, crude oil price increases beyond Asia affects both the Japanese and Korean economies, not just directly but also indirectly through a network of international dependency.

3. The Influence of Crude Oil Price Increases in Asia

In the previous section, we saw how crude oil price increases outside Asia raise the price of goods within Asia, especially in Japan and Korea. However, repercussions from these price changes may not be limited to countries outside Asia, because crude oil is produced in some Asian countries as well as the U.S. For example, the 2000 Asian IO table shows that the U.S. and Asian countries (except Korea and Singapore) do produce crude oil (see Table 5). In Section 2 of this paper, we did not take into consideration the effect of crude oil price increases in Asia and the U.S.

Table 5. Crude Oil Production in Asia and the U.S.

Unit:1,000US$

1	USA	160,131,000
2	China	52,928,385
3	Indonesia	22,116,484
4	Malaysia	10,402,843
5	Thailand	2,700,367
6	Japan	814,288
7	Taiwan	464,035
8	Philippines	7,117
9	Singapore	0
10	Korea	0

Source: 2000 Asian IO

When we think about the effects of price increases within the crude oil sector, we must consider price changes not only outside Asia but also within Asia. Therefore, we would like to examine the effects of crude oil price changes in Asia.

Now, if the price of crude oil exported from America to the Philippines would double, the assumption we made in Section 2 of this paper, let us contemplate how such a change would affect the Japanese and Korean economies.

From a technical viewpoint, the model previously used (Equation 1, which gives the Leontief inverse matrix an exogenous price vector) is not appropriate to the problem at hand because in this case crude oil is an endogenous good. It is necessary to create another exogenous variable from an endogenous vector and give it a new inverse matrix. However, according to Miyazawa (2002), we can instead use a simple method, transforming the equilibrium price model used for the previous calculation. This results in the following equation (3):

$$\begin{pmatrix} \Delta p_1 \\ \vdots \\ \Delta p_{n-1} \end{pmatrix} = \left[\begin{pmatrix} 1-a_{11} & \cdots & -a_{1,n-1} \\ \vdots & \ddots & \\ -a_{n-1,1} & \cdots & 1-a_{n-1,n-1} \end{pmatrix}^{-1} \right]' \begin{pmatrix} a_{n1} \\ \vdots \\ a_{n-1,1} \end{pmatrix} \Delta p_n$$

$$= \begin{pmatrix} b_{n1} / b_{nn} \\ \vdots \\ b_{n,n-1} / b_{nn} \end{pmatrix} \Delta p_n \qquad (3)$$

where $(I-A)^{-1} = (b_{ij})$.

Equation (3) calculates how much a sole price increase of the n^{th} good , Δp_n, raises other goods' prices. Note that this model solely measures the price impact of a particular endogenous good, and we still need to aggregate the result of crude oil price changes in each Asian country, as well as in the U.S.[6]

Table 6 shows the results when we calculate the individual effects of crude oil price increases from the U.S. to the Philippines and then aggregate those results for Japan and Korea. This table lists the top fifteen commodities in descending order.

Table 6. Aggregated Effects in Japan and Korea when Asian Crude Oil Prices Are Doubled (Top 15 Commodities)

6 In the case of simultaneous analysis of the effects of price changes for multiple goods, we cannot directly use the simple method above. For example, we have to transform the equation (n-k) by (n-k), using a transposed matrix where the price increases by k goods.

1	Japan	Crude petroleum and natural gas	1.00339
2	Japan	Electricity and gas	0.04733
3	Japan	Refined petroleum and its products	0.03262
4	Japan	Basic industrial chemicals	0.01968
5	Japan	Chemical fertilizers and pesticides	0.01370
6	Japan	Synthetic resins and fiber	0.01268
7	Japan	Tires and tubes	0.00901
8	Japan	Other metallic ore	0.00834
9	Japan	Iron ore	0.00813
10	Japan	Iron and steel	0.00750
11	Japan	Weaving and dyeing	0.00677
12	Japan	Plastic products	0.00661
13	Japan	Other chemical products	0.00656
14	Japan	Spinning	0.00636
15	Japan	Glass and glass products	0.00632

1	Korea	Refined petroleum and its products	0.07646
2	Korea	Basic industrial chemicals	0.04545
3	Korea	Electricity and gas	0.03099
4	Korea	Synthetic resins and fiber	0.02698
5	Korea	Chemical fertilizers and pesticides	0.02135
6	Korea	Transportation	0.01600
7	Korea	Plastic products	0.01438
8	Korea	Other chemical products	0.01385
9	Korea	Spinning	0.01289
10	Korea	Other non-metallic mineral products	0.01277
11	Korea	Fishery	0.01192
12	Korea	Weaving and dyeing	0.01192
13	Korea	Other rubber products	0.01186
14	Korea	Iron and steel	0.01161
15	Korea	Glass and glass products	0.01150

Here, we used the same crude oil price increment of $\triangle p_C=1$ that we employed in previous equations. Japan's crude oil price is greater than the number one, because Japanese crude oil production is not zero, and the price increase ultimately includes both direct increase effects and the indirect repercussive effects that occur in trading with other sectors.

As you can see, crude oil price increases in Asia have a lesser effect than they do outside Asia, with the exception of Japanese crude oil, and the largest price increase is Korean petroleum, with a 0.08 unit increase. As well, Japanese electricity and Korean basic chemicals each measure an approximately 0.05 unit increase. In this scenario, chemical fertilizer and plastic product prices in both countries were ranked relatively higher than they were in Table 3. We can infer that this results from these particular goods being more dependent upon Asian crude oil.

Further, Table 7 is the result of decomposition by the contribution ratio of each country's Asian crude oil price measuring the three commodities that showed the highest increases in Table 6. We see that Japanese electricity is influenced relatively more by Indonesia and Malaysia, while Japanese petroleum is more affected by Indonesia and China. Korean petroleum has a higher contribution ratio from Indonesia and Malaysia, but Korean basic chemicals are affected more by Indonesia and the U.S. These products in both countries have higher contribution ratios from other Asian countries, such as Indonesia, Malaysia, China, and the U.S. than previously seen in Table 4.

Table 7. Decomposition with Contribution Ratios by Individual Country in Three Sectors (Asian Crude Oil Price Increases).

Japan

	Crude petroleum and natural gas	Contribution Ratio	Electricity and gas	Contribution Ratio	Refined petroleum and its products	Contribution Ratio
Indonesia	0.00201	0.20%	0.02729	57.66%	0.01850	56.71%
Malaysia	0.00101	0.10%	0.01483	31.33%	0.00276	8.47%
Philippines	0.00000	0.00%	0.00000	0.00%	0.00000	0.00%
Thailand	0.00001	0.00%	0.00004	0.08%	0.00014	0.41%
China	0.00019	0.02%	0.00076	1.60%	0.00845	25.89%
Taiwan	0.00000	0.00%	0.00000	0.00%	0.00000	0.00%
Japan	1.00000	99.66%	0.00279	5.90%	0.00097	2.96%
USA	0.00018	0.02%	0.00163	3.43%	0.00181	5.54%
Total	1.00339	100.00%	0.04733	100.00%	0.03262	100.00%

Korea

	Refined petroleum and its products	Contribution Ratio	Basic industrial chemicals	Contribution Ratio	Electricity and gas	Contribution Ratio
Indonesia	0.05025	65.72%	0.01839	40.47%	0.01910	61.62%
Malaysia	0.02043	26.72%	0.00810	17.83%	0.00781	25.21%
Philippines	0.00000	0.00%	0.00000	0.00%	0.00000	0.00%
Thailand	0.00044	0.58%	0.00042	0.92%	0.00019	0.62%
China	0.00230	3.01%	0.00521	11.46%	0.00169	5.45%
Taiwan	0.00000	0.00%	0.00004	0.09%	0.00000	0.01%
Japan	0.00000	0.01%	0.00008	0.17%	0.00001	0.02%
USA	0.00302	3.96%	0.01320	29.05%	0.00219	7.07%
Total	0.07646	100.00%	0.04545	100.00%	0.03099	100.00%

Table 8 integrates the data from Table 3 and Table 6. In Table 8, we determine the total price increase in each sector that results from crude oil price increases worldwide.

Table 8 shows that Japan has the highest crude oil price increase, at 1.01 unit, resulting from the previously mentioned price-increasing assumption. Other price increases illustrated are Korean petroleum at 0.54, Japanese petroleum at 0.38, Korean electricity at 0.20, Korean basic chemicals at 0.18, and Japanese electricity and Korean synthetic resins at 0.10.

The product price increases influenced by crude oil price shocks should include the effects both outside and in Asia. For purposes of this study, we have made the assumption that crude oil prices, regardless of where the oil is produced, have doubled; needless to say, these figures can change depending upon the situation. For example, if the price of crude oil actually rose from $US28 a barrel at the start of 2000 to over $US130 in June 2008, this approximate hike of US$100 could likely pressure price increases of approximately US$54 per unit in Korean petroleum and US$38 per unit in Japanese petroleum.

Further, we note that Japan appears less affected by crude oil price shock than does Korea. As the Japanese Cabinet Office stated in 2008, there may be circumstances where it is difficult to impute rising price costs to small and medium-sized Japanese firms because the country has a more competitive market and its energy efficiency has been greatly improving due to long-time effort.

Table 8. The Comprehensive Effects of Crude Oil Price Increases.

1	Japan	Crude petroleum and natural gas	1.01101
2	Japan	Refined petroleum and its products	0.38220
3	Japan	Electricity and gas	0.10446
4	Japan	Basic industrial chemicals	0.06198
5	Japan	Non-metallic ore and quarrying	0.04525
6	Japan	Synthetic resins and fiber	0.03819
7	Japan	Other metallic ore	0.03268
8	Japan	Iron ore	0.03225
9	Japan	Chemical fertilizers and pesticides	0.03219
10	Japan	Iron and steel	0.02784
11	Japan	Tires and tubes	0.02771
12	Japan	Fishery	0.02626
13	Japan	Other non-metallic mineral products	0.02347
14	Japan	Weaving and dyeing	0.02174
15	Japan	Glass and glass products	0.02042
16	Japan	Cement and cement products	0.02011
17	Japan	Transportation	0.01968
18	Japan	Other chemical products	0.01949
19	Japan	Pulp and paper	0.01923
20	Japan	Plastic products	0.01881

1	Korea	Refined petroleum and its products	0.53949
2	Korea	Electricity and gas	0.20426
3	Korea	Basic industrial chemicals	0.18319
4	Korea	Synthetic resins and fiber	0.10400
5	Korea	Transportation	0.08366
6	Korea	Chemical fertilizers and pesticides	0.07854
7	Korea	Fishery	0.07253
8	Korea	Other non-metallic mineral products	0.07159
9	Korea	Iron and steel	0.06164
10	Korea	Plastic products	0.06036
11	Korea	Cement and cement products	0.05984
12	Korea	Glass and glass products	0.05863
13	Korea	Unclassified	0.05620
14	Korea	Other chemical products	0.05608
15	Korea	Other grain	0.05531
16	Korea	Fish products	0.05350
17	Korea	Spinning	0.05209
18	Korea	Other rubber products	0.04938
19	Korea	Weaving and dyeing	0.04929
20	Korea	Iron ore	0.04760

4. Estimating Demand Functions in Two Sectors

4.1 Model and data

Thus far, we have analyzed the effect of supply side crude oil price increases. These induced effects have not included the effects found on the demand side and were solely made with analysis based on cost-push factors. Therefore, in the following section, we would like to analyze those effects found on the demand side.

Here, we will estimate demand functions with respect to energy demand and determine those parameters in order to learn the effects of price changes. In addition, we will analyze how these effects transform the results of supply side effects.

However, instead of estimating multivariable demand function, as applicable to Sector 76 and as demonstrated in the previous section, we will estimate only two energy-related functions in Japan and Korea, petroleum and electricity, due to limited data.

We used real SNA data based on year 2000 reporting by the Japanese Cabinet Office, the SNA index number, and industrial production and price indices as reported by the Bank of Korea. All information is time series data from 1980 to 2006.

Similar studies have previously been conducted related to the price elasticity of energy demands. Nrayan, Smyth, and Prasad (2007) estimated the price elasticity of demand in each G7 country; Hang and M. Tu (2007) estimated the price elasticity of energy demands in China, and Kaul (1995) estimated it in some African countries. These studies concluded that energy demand price elasticity was not so high. The exception to this finding was in Nrayan, Smyth, and Prasad (2007), who determined a long price elasticity in Japanese electricity demand.

4.2 The Unit Root and Cointegration Tests

First, before making any estimation of function, we must run the unit root test for those variables used in our demand analysis; this is because our variables are all time series data. The results of the unit root test are reflected in Table 9.

Table 9. The Unit Root Test for Selected Variables (Petroleum, Electricity and Their Prices).

Japan

varibale	I(n)	Type	t-statistic
lnO	I(1)	Const	-5.56518 **
lnE	I(1)	Const	-4.76126 **
lnY	I(1)	Const	-3.67328 *
ln(O/Y)	I(1)	Const	-5.51715 **
ln(E/Y)	I(1)	Const	-4.61903 **
ln(po/py)	I(1)	Const	-5.63925 **
ln(pe/py)	I(0)	Const+Linear Trend	-4.39245 *

**: 1%significant level,*: 5%significant level

Korea

varibale	I(n)	Type	t-statistic
lnO	I(1)	Const	-3.6161 *
lnE	I(1)	Const	-3.55656 *
lnY	I(1)	Const	-4.62155 **
ln(O/Y)	I(0)	None	-3.04444 **
ln(E/Y)	I(1)	Const	-3.76346 **
ln(po/py)	I(1)	Const+Linear Trend	-3.8337 *
ln(pe/py)	I(0)	Const	-2.92514 $

**: 1%significant level,*: 5%significant level
$: 10% significant level

Here, O is petroleum products, p_o is a price index of petroleum based on year 2000 data, p_y is the GDP price index, p_E is a price index of electricity, y is the real GDP, E is electrical products, and $\ln()$ is the logarithm.

According to Table 9, all variables are *I(1)*, which has a unit root, except for a relative price of electricity in Japan and the ratio of petroleum to GDP and a relative price of electricity in Korea, which are *I(0)* variables.

Next, because the linear combination of these variables could be I(0) variable , we tested these I(1) variables for cointegration relations using the Johansen cointegration method. There were four variables in Japan, $\ln(O)$, $\ln(\frac{p_o}{p_y})$, $\ln(E)$, and $\ln(Y)$, and there were three variables in Korea, $\ln(O)$, $\ln(\frac{p_o}{p_y})$, and $\ln(\frac{E}{Y})$. We found that there were at most three cointegration equations with trace testing and at most one cointegration equation with a maximum eigenvalue test in Japan, operating under the assumption that there was no deterministic trend but a constant intercept. Alternatively, there were at most two conintegration equations at both trace and maximum eigenvalue testing in Korea, operating under the assumption that there were both a deterministic trend and intercept.

These results indicate that a long-run linear relationship among variables can exist. Thus, an estimation using only stationary difference data could drop important information, even if we were to estimate equations without accounting for any conintegration relationship. Therefore, we had to estimate a specific VAR model that did include cointegration, VECM (Vector Error Correction Model). The period estimated was twenty-six years, from 1980 to 2006.

$$\mathbf{\Delta Y_t} = \boldsymbol{\alpha}_\mathbf{i}(\mathbf{Y_{it-1}} - \sum_{\mathbf{i \neq j}}^{\mathbf{k}} \boldsymbol{\beta}'_\mathbf{j}\mathbf{Y_{jt-1}}) + \sum_{\mathbf{m-1}}^{\mathbf{p}} \mathbf{\Gamma \Delta y_{it-m}} + \boldsymbol{\varepsilon}_{it} \qquad (4)$$

The first term inside the parentheses on the right hand side of Equation (4) is the error correction term (ECT) that represents cointegration. The vector $\boldsymbol{\alpha}_\mathbf{i}$ is the adjustment coefficient vector. Table 10 and Table 11 show the results obtained estimating the equation[7] with lag 2, but here only two dependent variables were used due to limited space.

According to Table 10, the individual coefficient in the ECT in the Japanese VECM is significant although the ECT itself is not likely to be significant.[8] One of the two ECT coefficients in each dependent variable in the Korean VECM is insignificant. Again, the estimated result of the VECM was not necessarily desirable, despite the fact that we were able to find cointegration relations among variables in our test. One reason for this is certainly due to our small test size, limited to only twenty-four variables, and it is generally difficult to obtain compelling results with such a small sample. Another reason is that the power of the unit root and cointegration tests is limited is due to methodology. These problems remain to be addressed in future research.

Two of our objectives in this paper are to analyze the demand change when each energy-related good’s price changes and to estimate each demand’s price elasticity. However, the relative prices of electricity of both Japan and Korea were excluded from the cointegration test because those figures were initially admitted as stationary data, I(0).

Therefore, let us proceed by estimating demand functions in both Japan and Korea, including electrical price. One approach to this task is, of course, to use an estimation of VAR models, but we found that there could be a long-run linear relationship of the cointegration relations among

[7] The sample size numbered twenty-four due to the lag.
[8] Regarding the sign condition of variables, all signs are theoretically correct, except one between Japan’s petroleum and GDP. In Korea, the sign between the relative price of petroleum and electricity is negative to reflect that both petroleum and electricity appear to be complementary goods.

variables. Taking that into consideration, we instead estimated using typical OLS models and second stage least squares (2SLS) models, employing level data, not difference data.

Table 10. Japanese VECM Estimates for Petroleum and Electricity.

Dependent Variables ⊿Y	explanatory variables	
D(JAPANLNO)	ECT	−0.48734
		[−0.64906]
	D(JAPANLNO(−1))	0.05304
		[0.07455]
	D(JAPANLNO(−2))	−0.49198
		[−0.96451]
	D(JAPANLNPOPY(−1))	−0.10690
		[−0.26298]
	D(JAPANLNPOPY(−2))	−0.75754
		[−1.74670]
	D(JAPANLNE(−1))	0.51446
		[0.64526]
	D(JAPANLNE(−2))	−0.01069
		[−0.01631]
	D(JAPANLNY(−1))	−2.24898
		[−1.33850]
	D(JAPANLNY(−2))	0.71654
		[0.50941]
	t−statistics in [ ]	
	Adj. R−squared	−0.20832
	Sum sq. resids	0.14316
D(JAPANLNE)	ECT	−0.85832
		[−1.74052]
	D(JAPANLNO(−1))	0.49699
		[1.06365]
	D(JAPANLNO(−2))	0.15832
		[0.47259]
	D(JAPANLNPOPY(−1))	−0.17679
		[−0.66220]
	D(JAPANLNPOPY(−2))	−0.35773
		[−1.25588]
	D(JAPANLNE(−1))	−0.00542
		[−0.01034]
	D(JAPANLNE(−2))	−0.69204
		[−1.60750]
	D(JAPANLNY(−1))	−1.97448
		[−1.78923]
	D(JAPANLNY(−2))	1.63217
		[1.76675]
	t−statistics in [ ]	
	Adj. R−squared	−0.00704
	Sum sq. resids	0.06175

ECT	
JAPANLNO(−1)	1.00000
JAPANLNPOPY(−1)	0.40033
	[3.46503]
JAPANLNE(−1)	−1.01649
	[−11.9114]
JAPANLNY(−1)	1.05110
	[11.3289]
C	−12.70928
	[−13.0259]
t−statistics in [ ]	

Table 11. Korean VECM Estimates for Petroleum and Electricity.

Dependent Variables⊿Y	explanatory variables	
D(KOREALNO)	ECT1	−0.93992
		[−4.92131]
	ECT2	0.77969
		[1.71146]
	D(KOREALNO(−1))	0.08176
		[0.64743]
	D(KOREALNO(−2))	−0.23158
		[−1.14257]
	D(KOREALNPOPY(−1))	0.71010
		[3.66156]
		0.30896
	D(KOREALNPOPY(−2))	[2.39217]
		−0.92653
	D(KOREALNEY(−1))	[−2.29770]
		−0.57399
	D(KOREALNEY(−2))	[−1.37171]
		0.10671
	C	−0.19393
		[5.41770]
	t−statistics in [ ]	
	Adj. R−squared	0.78378
	Sum sq. resids	0.02754
D(KOREALNPOPY)	ECT1	−0.33358
		[−1.27871]
	ECT2	1.88778
		[3.03371]
	D(KOREALNO(−1))	0.95820
		[5.55537]
	D(KOREALNO(−2))	0.22971
		[0.82973]
	D(KOREALNPOPY(−1))	−0.25337
		[−0.95649]
		−0.14131
	D(KOREALNPOPY(−2))	[−0.80104]
		−1.16581
	D(KOREALNEY(−1))	[−2.11661]
		−0.12011
	D(KOREALNEY(−2))	[−0.21014]
		−0.08967
	C	−0.26489
		[−3.33295]
	t−statistics in [ ]	
	Adj. R−squared	0.81450
	Sum sq. resids	0.05138

	ECT1	ECT2
KOREALNO(−1)	1.00000	0.00000
KOREALNPOPY(−1)	0.63683	0.10021
	[10.8494]	[2.74057]
KOREALNEY(−1)	0.00000	1.00000
TREND(80)	−0.04856	0.00301
	[−14.6347]	[1.45839]
C	−6.07038	−0.42769

4.3 Estimate Models and Methodology

It should be noted that estimated petroleum demand functions differ between Japan and Korea. Japan's petroleum demand function is accepted in the form of the following, Equation (5):

$$\ln(O_t)_J = \alpha + \beta_1 \ln\left(\frac{p_{ot}}{p_{yt}}\right)_J + \beta_2 \ln\left(\frac{E_t}{y_t}\right)_J + \varepsilon_t \qquad (5)$$

$$t = 1980, \cdots, 2006$$

where O_t is the real production of petroleum, p_{ot} is the price index of petroleum, p_{yt} is the price index of the GDP, y_t is the real GDP, E_t is the real production of electricity, and *ln*( ) expresses a logarithm. The second term on the right hand side is the relative price of petroleum and the third term is electrical demand per GDP.

In contrast, for Korea's petroleum demand function we employed Equation (6), below, which uses a production index based on year 2000 data expressed as variables O_t and E_t:

$$\ln(O_t)_K = \pi + \delta_1 \ln\left(\frac{p_{ot}}{p_{yt}}\right)_K + \delta_2 \ln(y_t)_K + \delta_3 \ln\left(\frac{E_t}{y_t}\right)_K + \nu_t \qquad (6)$$
$$t = 1980, \cdots, 2006$$

Next, for the Japanese electricity demand function we used Equation (7), below, one that is in a form symmetric to Equation (5):

$$\ln(E_t)_J = \gamma + \lambda_1 \ln\left(\frac{p_{Et}}{p_{yt}}\right)_J + \lambda_2 \ln\left(\frac{O_t}{y_t}\right)_J + \mu_t \qquad (7)$$
$$t = 1980, \cdots, 2006$$

where p_{Et} is price index of electricity.

Korea's electricity demand function is written as Equation (8), in a form asymmetric to Equation (5) because the third term on the right hand side is slightly different from the term as expressed in Equation (5):

$$\ln(E_t)_K = \kappa + \phi_1 \ln\left(\frac{p_{Et}}{p_{yt}}\right)_K + \phi_2 \ln(y_t)_K + \phi_3 \ln\left(\frac{p_{ot}}{p_{yt}}\right)_K + \vartheta_t \qquad (8)$$
$$t = 1980, \cdots, 2006$$

Since petroleum and electricity both are used in equations (5) and (7) for Japan as endogenous variables, individual OLS estimators might not be unbiased or consistent. In that case, 2SLS (the two-stage least squares method) for a simultaneous equation system is ostensibly more acceptable. Further, because Equation (6) for Korea includes endogenous variable electricity as an explanatory variable, a similar problem may occur with that equation.

Therefore, before making our estimation, we conducted the Wu-Hausman test for exogenous variables with equations (5) to (7). As a result, we reached the null hypothesis of H0: the coefficient of the test variable of 0 was not rejected in each of the petroleum demand equations, (5) and (6), in both Japan and Korea. That is, electricity variables in both equations can be treated as statistically exogenous variables. It is well known that the OLS estimator is the best one in the sense of BLUE if all variables were exogenous ones. Thus, we estimated three equations, (5), (6), and (8), with OLS.[9]

---

9 For these estimations, we also checked cointegration with the Engle-Granger test in

However, we estimated Japanese electricity demand function using Equation (7), employing 2SLS as simultaneous equations with (5), because the null hypothesis for exogenous variables was rejected in the Wu-Hausman test. In these equations, there are three exogenous variables in the system, although there are two endogenous variables in (7) and two exogenous variables; thus, this system is just identified and cleared the order condition.

Table 12 illustrates our estimation results and allows us to point out the following conclusions. First, the price elasticity of Japan's electrical demand is greater, at -1.24, while the elasticity of petroleum in both countries, as well as Korea's electrical demand, does not show elasticity. Those factors are at -0.39, -0.16, and -0.98, respectively. This conclusion about Japan's electrical price elasticity is consistent with the results obtained by Nrayan, Smyth, and Prasad (2007). Second, the electrical price elasticity is a greater absolute value than that of Korean petroleum. Third, the substitution ratio of electrical demand decrease to petroleum demand increase in Japan is approximately -0.64 from our estimated results, whereas the ratio of electrical price increase to petroleum price increase in Korea is approximately 0.313. Fourth, if we assume that there is no change in price, petroleum and electricity are not substitute goods but complementary goods in both countries pursuant to those coefficients. (The coefficient of electricity per GDP, which is an explanatory variable of petroleum demand function, is 1.15 in Japan and 1.99 in Korea.)

Interpreting the relationship between electricity and petroleum was a challenge for us; however, we report our general finding that, in both Japan and Korea, petroleum demand tends to increase with electrical demand. That is the side as complement good. Alternatively, electrical consumption tends to decrease where petroleum demand and prices rise, and this nature is a side as substitute good.

Table 12. Demand Functions in Japan and Korea (Petroleum and Electricity).

Petroleum demand function(Japan)

	coefficient	S.E	t	P-value
α **	12.63225	0.38730	32.61585	0.00000
ln(Pot/Pyt)**	-0.39312	0.04237	-9.27749	0.00000
ln(Et/yt)**	1.14625	0.10869	10.54635	0.00000

**: 1%significant level

Adj R2: 0.828103 DW: 1.460502

Petroleum demand function(Korea)

	coefficient	S.E	t	P-value
π **	2.19023	0.25063	8.73894	0.00000
ln(po/py)**	-0.16245	0.03855	-4.21381	0.00033
ln(y)**	0.64991	0.03387	19.18692	0.00000
ln(E/y)**	1.98522	0.18163	10.93029	0.00000

**: 1%significant level

Adj R2: 0.98616 DW: 1.22324

order to compare the results of the Johansen cointegration test. We determined that each variable of Japanese petroleum demand function was significant at a 5% level in the Engle-Granger test, although it was not found to be significant in the Johansen test. On the contrary, any variables of Korean petroleum and electrical demand functions were insignificant, while there were at most three cointegration equations in the Johansen test. These results seem to be attributable to the weak power of the test with a small sample, although the mixture of variables such as I(1) and I(0) might also affect the results. This problem remains to be addressed.

Electricity demand function(Japan)

	coefficient	S.E	t	P-value
λ **	6.64886	1.00378	6.62381	0.00000
ln(Pet/Pyt)*	−1.23522	0.53737	−2.29862	0.03054
ln(O^t/yt)**	−0.64160	0.21936	−2.92479	0.00741

**: 1%significant level,*: 5%significant level

Adj R2: 0.604168 DW: 0.32482

Electricity demand function(Korea)

	coefficient	S.E	t	P-value
κ **	4.83424	0.60055	8.04966	0.00000
ln(pe/py)**	−0.97965	0.10587	−9.25325	0.00000
ln(y)**	0.61506	0.05725	10.74281	0.00000
ln(po/py)**	0.31301	0.03892	8.04239	0.00000

**: 1%significant level

Adj R2: 0.99711 DW: 0.69298

5. The Repercussive Effects of Rising Energy Prices

5. 1 The marginal coefficients of demand as prices change

Using the estimation results in Table 12, we can also analyze how price increases in Table 8 show decreased demand for petroleum and electricity in both Japan and Korea. Those results are reported in Table 13.

First, Table 13 illustrates that a 0.38 unit of price increase of Japanese petroleum results in a 30% demand decrease. Approximately 15% of this demand decrease directly results from the price increase of petroleum, and the additional 15% decrease is induced by the effect of decreasing electrical demand caused by the price increase. The latter indirect effect occurs because the petroleum function includes electrical demand as a complementary good. Then the price increase assumes 0.10 units per Table 8.

Alternatively, a Korean petroleum price increase of 0.54 units results in an approximately 15% demand decrease . This is composed of an 8.8% direct decrease in demand for petroleum and the additional 6% decrease is induced by the decrease in electrical demand. The latter effect also occurs because the petroleum function includes electrical demand as a complementary good, but this demand for electricity has changed in two ways from the Korean demand function. One change results from the electrical demand decreasing as the price rises, and the other change is the demand increase as a substitute effect because of the rising price of petroleum. Since the total effect of these two changes results in the overall decrease of electrical demand, petroleum demand also decreases.

Table 13. Changes in Petroleum and Electrical Demands Resulting from Price Increases.

Petroleum Demand effect in Japan		
Marginal demand by petroleum price increase	⊿O/⊿po	−0.15025
Marginal demand by electricity demand change	⊿O/⊿E・⊿E/⊿pE	−0.1479
Total effect		−0.29814
Electricity Demand effect in Japan		
Marginal demand by electricity price increase	⊿E/⊿pE	−0.12903
Marginal demand by petroleum demand change	⊿E/⊿O・⊿O/⊿po	0.096397
Total effect		−0.03263

Petroleum Demand effect in Korea		
Marginal demand by petroleum price increase	⊿O/⊿po	−0.08764
Marginal demand by electricity demand change	⊿O/⊿E	−0.06195
Total effect		−0.14959
Electricity Demand effect in Korea		
Marginal demand by electricity price increase	⊿E/⊿pE	−0.20007
Marginal demand by petroleum demand change	⊿E/⊿po	0.16886
Total effect		−0.03121

Second, a 0.10 unit price increase in the cost of Japanese electricity induces an approximately 3.3% decrease in demand. Approximately 13% of this decrease results from rising electrical prices, and the remaining 9.6% demand increase is induced as substitution good by decreased petroleum demand due to a 0.38 unit price increase. The petroleum good is treated as a substitute good in Japan's electrical demand function as mentioned above.

Third, a 0.20 unit price increase of Korean electricity induces an approximately 3% decrease in demand. Twenty percent of the demand decrease results from rising prices, while approximately 17% is a demand increase as a substitute good of the 0.54 unit price increase of Korean petroleum.

As mentioned above, we can determine that price increases of both petroleum and electricity will decrease those demands in Japan and Korea within a range from 3% to 30%. This inference is made from a demand side analysis. According to estimates for demand functions in both countries, electrical demand has the effect of a substitute petroleum good and, because of that, the damage seen with demand decreases is less than is observed with petroleum.

In contrast, there is a significant difference between Japan and Korea. While Korea experiences greater effects in petroleum and electrical prices resulting from crude oil price increases, Japan experiences a more serious demand decrease in both sectors. This difference seems to emerge because Japan has more elastic parameters in both the petroleum and electricity markets than does Korea.

As a result, a price increase in crude oil in turn raises prices of other energy goods, such as petroleum and electricity, from 0.1 to 0.5 units, while decreasing those demands from 3% to 30%. Although petroleum demand has relatively less price elasticity, electrical demand has greater price elasticity, and price increases for crude oil appear to have greater influence upon petroleum prices. That is, petroleum is affected more seriously by crude oil price increases and has less price elasticity. Alternatively, electricity is affected less by crude oil prices and has greater price elasticity. As a composite result of these factors, diminishing electrical demand is not as serious, but diminishing petroleum demand could prove more serious in both Japan and Korea.

5.2 The Repercussive Effects of Decreased Energy Demands

If the demand decreases previously discussed were to occur, how would total final demands decrease in response?

First, using the year 2000 Asian IO table that we employed in Section 2, we can calculate a direct decrease in final demands for petroleum and electricity with those demands increasing in price in both sectors as shown in Table 13. As demonstrated in Table 14, the total final demand decrease in both the petroleum and electrical sectors in Japan is approximately $12.6 billion, while in Korea it is approximately $1.9 billion, one-seventh of Japan's decrease. In the year 2000 Asian IO table, because the ratio of Japan's total output as compared to Korea's is approximately 7.23 times greater, Japan's demand decrease is smaller when compared with those overall demand decrease figures.

Next, by using Table 14, we can calculate the repercussive effects that these demand decreases in both countries have upon the entire Asian economy by using the equilibrium output model. Table 15 shows the total repercussive effects in Japan and Korea as abstracted from the total Asian results.

Table 14. Estimated Petroleum and Electrical Demand Decreases in Japan and Korea.

Final Demand in 2 sectors, Japan	Unit:1,000US$
Refined petroleum and its produc	−10,756,537
Electricity and gas	−1,818,510
total	−12,575,046

Final Demand in 2 sector	Unit:1,000US$
Refined petroleum and its	−1,625,483
Electricity and gas	−231,192
total	−1,856,675

Table 15. Induced Output Decreases of Petroleum and Electricity in Japan and Korea.

Induced effect, Japan Unit:1,000US$
Induced output decrease by final demand in 2 sectors
−16,103,384
The ratio to total final demand
−0.363%

Induced effect, Korea Unit:1,000US$
Induced output decrease by final demand in 2 sectors
−2,228,118
The ratio to total final demand
−0.464%

The cost repercussions induced when final demand decreases are approximately $16.1 billion in Japan and $2.2 billion in Korea. Japan's magnitude of repercussions is more than seven times greater than that of Korea, but the ratio of repercussion over final demand figures are the same, approximately 0.36% in Japan and 0.46% in Korea.

As mentioned above, we can conclude that if the price of crude oil were to double outside Asia and in Asia finally were to induce similar decreases of approximately 0.4% of final demands in Japan and Korea, under these assumptions, such price shock would affect only petroleum and electrical demands in both countries.

These demand decreases are not so great when compared with final demand or total output in both countries. However, these decreases do make up approximately 17% to 18% of the aggregation of petroleum and electricity in Japan and 12% to 13% of that aggregate in Korea. Therefore, the effects of demand decreases at these magnitudes might be significant beyond the petroleum and electrical industries.

6. Concluding Remarks

This paper, in three steps, has analyzed how crude oil price increases affect energy-importing countries, using Japan and Korea as examples and the Asian IO table and macro economic data.

First, we calculated how a crude oil price shock outside Asia could induce repercussive effects within Japan and Korea. Second, we calculated how crude oil price increases in Asia and the U.S. affect Japan and Korea. Third, we estimated the demand functions of petroleum and electricity in both countries to gauge the influences of price change on the demand side, and then we analyzed the repercussive effects of demand decreases when prices rise.

As a result, we established the following scenarios:

(1) If prices were to double from one unit ($1,000) to two units of crude oil outside Asia, this would cause prices to increase in Asia in many sectors, up to more than 0.5 unit. These effects were found to be significant in the petroleum sector in Thailand, the Philippines, Korea, Taiwan, and Japan (in descendent order). Eight sectors in Korea were included among the top thirty sectors that are most influenced by crude oil price increases beyond Asia from a total of 760 sectors. However, only Japanese petroleum and electricity were included in the top thirty sectors and even then the influence upon Japan when crude oil increased in price was relatively weak as compared to the overall price shock effect industry-wide.

(2) The induced price increase of petroleum in Japan was 0.35 units and 0.46 units in Korea. Otherwise, electricity and basic chemicals in Korea were predicted to report price increases from 0.14 units to 0.17 units.

(3) The contribution rate price increases in petroleum, electricity, and basic chemicals in Japan and Korea showed that more than 98% of the rising prices of petroleum and electricity in individual countries were induced by the direct influence of increasing crude oil prices from outside Asia. Alternatively, 40% of price increases in Japan’s basic chemicals were induced by the influence of other countries’ price changes. In Korea, 18% was induced as a result of foreign price

increases.

(4) Next, we determined that a doubled price of crude oil within Asia did not affect Japan or Korea much more than crude oil price increases beyond Asia. These effects were noted as 0.03 units of petroleum in Japan and 0.07 units of petroleum in Korea. This result demonstrates that both Japan and Korea have a stronger crude oil interdependency outside Asia than they do in Asia. The total effects of price changes in each sector because of crude oil price increases was found to be 0.38 units for Japan’s petroleum and 0.54 units for Korea’s petroleum; these effects were measured at 0.10 units for Japanese electricity, and 0.20 units for Korean petroleum.

(5) Moreover, we analyzed demand in terms of price change by using the selected parameters of petroleum and electrical demand functions in Japan and Korea. Taking previously determined price elasticity and complement and substitution effect factors into consideration, we estimated that the effects upon demand in each sector as caused by price increases made up approximately 30% of the decrease in Japan’s petroleum demand, 15% of the decreased demand for petroleum in Korea, 3.3% of the decrease demand for electricity in Japan, and 3.1% of the decreased demand in Korea for electricity. We can interpret these results by observing that crude oil price increases do not affect Japan’s petroleum and electricity prices relatively. However, once these prices increase dramatically, demands in these sectors will correspond sensitively and tend to decrease further. Alternatively, crude oil price increases in turn elevate the prices of many goods in Korea, although the demand decrease effects of those price changes is not significant.

(6) Finally, we estimated the overall repercussive effects in the economy, which effects were induced by the direct demand decreases we estimated for each sector in both Japan and Korea. As a result, we determined that approximately 0.36% of Japan’s final demand and 0.46% of Korea’s would decline individually.

According to these study results, simultaneous crude oil price increases worldwide generate different effects on Japanese and Korean prices, although the ultimate repercussive effect ends up being similar in magnitude to the final demand in each country because of price elasticity considerations, as well as complement and substitution effects from demand functions.

The demand side effects discussed in this paper have been estimated using a simplifying assumption that has included only two sectors, whereas actual economic effects will be more complicated. If we could estimate further demand functions for the other sectors, for example for the other seventy-four sectors that are suitable for our supply side IO model, we could be able to more accurately analyze the effects caused by crude oil price increases.

That research question remains to be answered. We are also interested in the economic effects occurring in other Asian countries and the U.S. However, these questions are as yet unexplored and would benefit from further analysis and research.

References

1) Hang , L. and Tu, M., The impacts of energy prices on energy intensity: Evidence of China, *Energy Policy 35*, pp.2978-2988, 2007.

2) Kim, H., Kaneko, S. and Ichihashi, M., Driving Forces behind the World's Fastest Increase in CO2 Emission of Korea in 1990s - Growth, Trade and Industrial Transformation, *Journal of Environmental Information Science*, Vol.36, No.5, Mar. 2008.

3) Hirose, M., Quantitative analysis on the repercussion effects of price changes of import goods (in Japanese), *Shokei Ronsyu*, Vol.24, No.1, pp. 255-265, 1996.

4) Institute of Developing Economices Japan External Trade Organization Japan, *Asian International Input-Output Table 2000*, Institute of Developing Economices Japan External Trade Organization Japan, March 2006.

5) Iwaoka, S., On the influence to our country of the soaring crude oil price (in Japanese), *Review of Tokyo-Mtitsubishi*, No.2004-17, pp.1-5, 2004. S. (?? Is something missing here? ??)

6) Kaul, S., Price Elasticity of Petroleum Productions in Selected African Countries, *Energy Convers. Mgmt* Vol.36, No.4, pp.219-224, 1995.

7) Minami, T. , Soaring crude oil price and Japan economy (in Japanese), *Monetary Market* (Nourin Chukin Sogo kenkyujo), Apr., 2004.

8) Miyazawa, K., *Introduction to Input-Output Analysis* (in Japanese), Nihon Keizai Shinbunsya, 2002.

9) Japan Cabinet Office, *Japanese economy 2004* (in Japanese), http://www5.cao.go.jp/keizai3/whitepaper.html., 2004.

10) -, *Japanese economy 2007-2008* (in Japanese), Keizai Sangyo chosakai, 2008.

11) Nrayan, P.K., Smyth, R.and Prasad, A., Elasticity consumption in G7 countries, *Engergy Policy 35,* pp.4485-4494, 2007.

12) Ono, M., On the influence to Japanese economy by the price increase of crude oil (in Japanese), *International Trade and Investment,* Spring No.71, pp.77-88, 2008.

13) -, On the influence to Japanese economy by the price increase of crude oil (vol.3) (in Japanese), *International*

Trade and Investment, Winter 2005/No.62, pp.132-141, 2005.

14) Yamada, S., Soaring petroleum price and the influence to Japan and USA (in Japanese), *Mitsubishi Soken Club*, Vol.3 No.7, pp.28-29, 2006.