

# STUDY ON THE TRADE BALANCE OF EMBODIED ENERGY WITH SPECIAL REGARD TO THE ASIA-PACIFIC REGION

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## Abstract

The objective of this study is to account for the flow of environmental loads embodied in goods and services traded between countries, using energy consumption and the associated carbon dioxide emission as indicators. First, the worldwide trade balance of environmental loads between countries is estimated based on a simplified trade model and the world trade statistics of the IMF and UN. Focusing on the Asia-Pacific region, a more detailed analysis of the balance is then presented, using the input-output tables and the commodity trade statistics available for the respective countries. The flow of embodied environmental loads from Asian countries to Japan and the United States was found to be especially large. It is demonstrated that the rapid economic development in Asian countries has been propelled by exporting energy-intensive products, thereby taking over the environmental responsibilities of developed countries. A similar analysis is presented for trade in timber in the Asia-Pacific region.

**KEYWORDS:** *trade and environment, embodied energy, input-output model, economic development in East Asia, energy and environment, carbon dioxide, global warming*

## 1. Introduction

Through trade in goods and services, economic activities in one country are closely linked to the rest of the world, giving rise to environmental costs in other places. Trade is nothing but the transaction of environmental loads caused by the use of energy and other resources which are put into the production of traded goods and services. By importing energy-intensive products, for example, the importing country can reduce its domestic emission of air pollutants and carbon dioxide from energy use. It can be interpreted in a way that the exporting country is taking over the environmental responsibility of the importing country, and *vice versa*.

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Regarding the global environmental implication of trade, analysis of energy consumption and the associated carbon dioxide emission in East Asia attract our attention. This region including Japan, Korea, China and the ASEAN countries is expected to be the world's second-largest economic power following North and South American economies by the end of the first quarter of the next century (Ichikawa, 1993).

The global environmental impact of the economic activities in this region would further increase in accordance with the expanding production and consumption. Here, the role of international trade in this region is particularly important as its economic development has been and will be propelled by the rapidly increasing export of their industrial products. The flow of carbon dioxide embodied in traded goods and services is expected to be expanded through economic growth and trade liberalization in the region.

Trade policies may either encourage or discourage the emission of carbon dioxide in importing and exporting countries, thereby having significant implications for national policies to stabilize the global warming. However, while developed countries have been implementing a number of techno-economic policies to reduce their domestic carbon dioxide emission, little attention has been paid to the indirect flow of carbon dioxide embodied in traded goods and services between countries.

Imura and Moriguchi (1995), therefore, made an estimate of the export and import balance of energy and carbon dioxide ( $\text{CO}_2$ ) embodied in the goods and services transacted between nations. They dealt with the world economy in a simplified manner: the world was divided into twelve regions and each region was assumed to consist of one economic sector. In the first part of this paper, an improved version of the previous estimate is presented: the world is divided into smaller units, i.e., 91 countries, and newer data from the Directory of Trade Statistics of the IMF and UN are used. In the second part, the trade balance of embodied energy in the region comprising six Asian countries and the United States is estimated by sector in order to focus on the interdependence between Asia-Pacific countries and investigate international environmental implications of selected industrial sectors. The input-output tables and commodity trade statistics available for the respective countries are used for this analysis. Finally, a similar analysis is made on the environmental implication of trade in timber in the same region.

## 2. Analysis of the Worldwide Trade Balance of Embodied Energy

### 2.1 Calculation of the Embodied Energy

The standard methodology of input-output analysis (Miller and Blair, 1985) which has been extensively applied in the calculation of embodied energy and environmental loads (Gay and Proops, 1993; Imura *et al.*, 1994; Tiwaree and Imura, 1994) can be represented by the following equation:

$$\epsilon = E(\hat{X} - X)^{-1} \quad (1)$$

Here,  $\epsilon = (\epsilon_1, \epsilon_2, \dots, \epsilon_n)$  is the embodied energy intensity vector, where  $\epsilon_i$  denotes the total energy required for one unit monetary value demand of the  $i$ -th economic sector;  $E = (E_1, E_2, \dots, E_n)$  is the energy input vector,  $E_i$  being the external input of energy to the  $i$ -th economic sector;  $X = \{X_{ij}\}$  is the input-output table or the transaction matrix between industry sectors; and  $\hat{X}$  is a diagonal matrix, the diagonal element  $\hat{X}_{ii}$  being the total demand of the  $i$ -th economic sector.

The international trade matrix has a similar structure to that of input-output tables, if we consider that each country or region is represented by one economic sector. Thus, the model as represented by eq.(1) can be directly adapted with minor modifications. Firstly, the suffices  $i$  and  $j$  are replaced by  $\alpha$  and  $\beta$  which denote countries  $\alpha$  and  $\beta$ ;  $X = \{X_{\alpha\beta}\}$  is the international trade matrix which is expressed in monetary values (e.g., US dollars); and  $\hat{X}$  is the diagonal matrix expressing the total final demand of the countries:

$$\hat{X}_{\beta} = Y_{\beta} + \sum_{\alpha} X_{\alpha\beta} \quad (2)$$

where,  $Y_{\beta}$  is the gross domestic product (GDP) of country  $\beta$ , and the net total (direct plus indirect) energy used in country  $\beta$ ,  $E_{\beta}^{(t)}$ , can be expressed in the following way:

$$E_{\beta}^{(t)} = E_{\beta}^{(d)} + E_{\beta}^{(i)} - E_{\beta}^{(e)} \quad (3)$$

Here,

$$E_{\beta}^{(i)} = \sum_{\alpha} \epsilon_{\alpha} X_{\alpha\beta} \quad (4)$$

and

$$E_{\beta}^{(e)} = \sum_{\alpha} \epsilon_{\beta} X_{\beta\alpha} \quad (5)$$

are the total energy embodied in the goods and services imported to and exported from country  $\beta$ , respectively; and  $E_{\beta}^{(d)}$  is the direct (domestic) energy input in country  $\beta$ . Thus, the net import of energy embodied in goods and services of country  $\beta$ ,  $E_{\beta}^{(ni)}$ , can be expressed as

$$E_{\beta}^{(ni)} = E_{\beta}^{(t)} - E_{\beta}^{(d)} = E_{\beta}^{(i)} - E_{\beta}^{(e)} \quad (6)$$

## 2.2 Trade Balance of Embodied Energy in the World

A prime objective of this study is to investigate the environmental implications of the growing trade in Asia. Figure 1 indicates the trade dependency of selected Asian countries, demonstrating the importance of trade for their economic development. As the first step, the above model is applied to a world comprising 91 countries for which a consistent data set of trade statistics, energy consumption, and GDP are available for the year 1990 (United Nations; IEA and IMF, 1990; World Bank, 1994). The remaining countries are simply excluded from the economic system under our study, and the results are aggregated to eleven regions according to the regional classification adopted in the United Nations Trade Statistics.

Table 1 demonstrates the estimated trade balance of the energy flow embodied in traded goods and services between the regions, while Table 2 presents the breakdown of the balance. The result is almost consistent with the previous analysis for the year 1989 in which the same model was applied to the world divided into twelve regions (Imura and Moriguchi, 1995).

As a whole, Western Europe recorded the largest flow both in terms of export and import, reflecting the large size of its economy and the active trade within the region. With respect to the balance of import and export, most of the developed countries such as Western Europe, the United States and Japan are net importers, while developing countries are net exporters.

The largest exporter of embodied energy to Japan is the Asian Region, followed by the United States. They are also the largest importers from Japan. As a net balance, Japan recorded an import surplus of 37.9 million TOE (tons of oil equivalent). Western Europe,

Japan, the United States, and the Asian Region itself are major counterparts for the Asian Region for both import and export.

Trade of embodied energy can be translated into trade of embodied carbon dioxide, using relevant emission coefficients of fossil fuels. Figures 2 and 3 show the relationship between the net import (i.e., import minus export) per capita of embodied carbon dioxide and per capita GDP of some selected countries. As per capita GDP increases, the net import of embodied carbon dioxide increases. Most of the developed countries whose per capita GDP exceeds \$15,000 are net importers, except for Canada and Australia, which are net exporters due to their export of natural resources. On the contrary, the result indicates that developing countries including the rapidly-industrializing economies in Asia are net exporters and their economic development is being achieved through export of embodied energy to more developed countries.

### 3. Balance in the Asia-Pacific Region

#### 3.1 Estimation of the Embodied Energy Flow Between Countries

In the analysis presented above, each country is represented by a single industry sector. If an international input-output table was available, trade balance of embodied energy could be analyzed, enabling us to investigate the detailed industrial structure of countries. However, preparation of such international I-O tables requires great elaboration and resources, and they can be made available only under some limited conditions. At present, the Asian International I-O Table of 1985 prepared by the Institute of Developing Economies is a good data source of this kind (Institute of Developing Economies, 1990), but no newer version has been published. In order to circumvent this difficulty, this paper adopts a conventional method which utilizes national I-O tables and trade statistics of commodities or merchandise available for different countries. Seven countries in Asia-Pacific region are selected for this further study: China, Indonesia, Japan, Korea, Singapore, Thailand, and the United States.

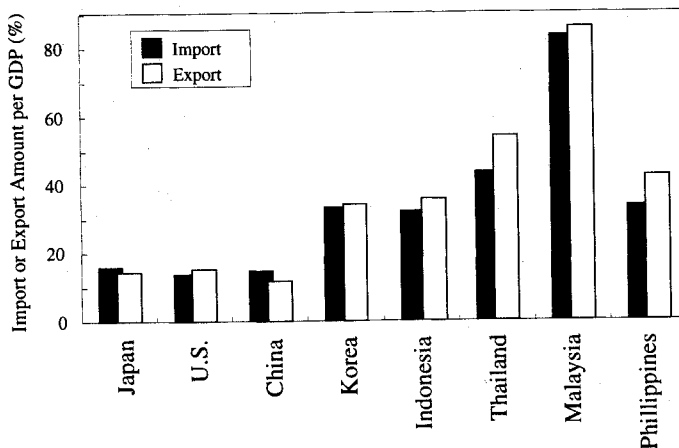


Figure 1. Trade dependency of selected Asia-Pacific countries

Table 1. Trade balance of the embodied energy between regions in 1990 (million TOE)

To \ From	W.Europe	Canada	U.S.	Japan	Australia & N.Z.	Africa	Latin America	Middle East	Asia	E.Europe	Former U.S.S.R.	Total export
W.Europe	249.18	3.15	24.40	7.42	2.70	7.44	4.68	6.49	14.93	11.67	5.57	337.6
Canada	4.30	—	34.50	2.58	0.32	0.29	0.64	0.19	2.09	0.10	0.35	45.4
U.S.	38.01	28.68	—	16.80	3.37	1.75	16.07	2.78	20.88	1.42	1.07	130.8
Japan	10.22	1.10	14.90	—	1.33	0.50	1.38	0.83	14.55	0.39	0.42	45.6
Australia & N.Z.	2.33	0.24	1.67	3.54	1.13	0.09	0.19	0.39	3.65	0.12	0.14	13.5
Africa	12.44	0.30	4.18	1.83	0.15	0.48	0.38	0.26	1.03	0.24	0.05	21.3
Latin America	10.50	0.85	22.97	2.59	0.15	0.28	5.21	0.52	1.78	0.42	0.27	45.5
Middle East	4.69	0.06	1.78	7.59	0.35	0.47	0.52	2.60	4.89	0.56	0.83	24.3
Asia	39.16	3.21	44.48	36.22	3.70	2.60	2.62	3.78	97.44	2.55	5.37	241.1
E.Europe	30.49	0.27	2.20	0.72	0.13	0.87	0.58	1.94	2.63	10.42	13.64	63.9
Former U.S.S.R.	28.90	0.17	1.27	3.65	0.04	0.74	0.19	0.70	4.59	14.42	—	54.7
Total import	430.23	38.04	152.35	82.92	13.37	15.53	32.47	20.48	168.48	42.30	27.70	1023.9

Table 2. Breakdown of the embodied energy requirement (million TOE)

Region	A Domestic Consumption and Investment	B Net Domestic Input	C Export	D Import	E Import - Export	C/A %	D/A %	E/A %
W.Europe	1,366	1,274	338	430	92.6	23.2	29.5	6.3
Canada	211	218	45	38	-7.3	22.3	18.7	-3.6
U.S.	1,920	1,899	131	152	21.5	6.7	7.8	1.1
Japan	428	391	46	83	37.3	9.8	17.8	8.0
Australia & N.Z.	102	103	14	13	-0.1	13.2	13.1	-0.1
Africa	142	147	21	16	-5.8	15.7	11.4	-4.3
Latin America	362	376	46	32	-13.1	13.1	9.3	-3.7
Middle East	168	172	24	20	-3.9	14.8	12.5	-2.4
Asia	1,155	1,288	241	168	-72.6	22.3	15.6	-6.7
E.Europe	381	403	64	42	-21.6	17.8	11.8	-6.0
Former U.S.S.R.	1,343	1,370	55	28	-27.0	4.2	2.1	-2.0
World Total	7,578	7,578	1,024	1,042	0.0	13.5	13.5	0.0

$$[\text{Net Domestic Input}] = [\text{Domestic Consumption and Investment}] + [\text{Export}] - [\text{Import}]$$

If country  $\alpha$  produces goods and services in industry sector  $k$  and exports them to country  $\beta$ , the pertinent embodied energy flow  $E_{\alpha\beta}^{(k)}$  can be expressed in the following way:

$$E_{\alpha\beta}^{(k)} = \epsilon_{\alpha}^{(k)} T_{\alpha\beta}^{(k)} \quad (7)$$

where  $\epsilon_{\alpha}^{(k)}$  and  $T_{\alpha\beta}^{(k)}$  are the embodied energy intensity per monetary value, and total monetary amount of export from country  $\alpha$  to country  $\beta$  of output of industry sector  $k$ , respectively.  $T_{\alpha\beta}^{(k)}$  is obtained from Commodity Trade Statistics of the United Nations, and Directory of Trade Statistics of IMF, while  $\epsilon_{\alpha}^{(k)}$  is calculated using the I-O tables of the respective countries. When the I-O table is only available for a particular year,  $\epsilon_{\alpha}^{(k)}$  of the year to be analyzed is estimated. For this purpose, a simple method is applied here, which assumes that no change takes place in the industrial structure while the natural resource consumption in each industrial sector changes according to the same rate or proportionately to the total amount of natural resource input per GDP.

There are several methods of I-O analysis to calculate  $\epsilon_{\alpha}^{(k)}$ , but what we are interested in this study is the environmental load incurred through the direct input of energy in country  $\alpha$ . In the calculation of  $\epsilon_{\alpha}^{(k)}$ , therefore, we use equation (1) in which the energy embodied in imported goods and services is simply ignored. With respect to the monetary trade data  $T_{\alpha\beta}^{(k)}$ , we use the F. O. B (free on board) data rather than C. I. F (cost, insurance, and freight) data: this means that environmental loads pertinent to insurance and other international transportation cost are ignored. Moreover, imported goods are sometimes exported again to other countries, and such multiple trade may pose complex questions which can not be fully dealt with by our simplified model.

Industry is classified into 60 to 70 sectors which are equivalent to the 2 to 3 digit codes of the Standard International Trade Classification (SITC) used in the UN Commodity Trade Statistics (United Nations; 1994a). However, the aggregated classification of industrial sectors in the I-O tables generally differs from that of traded commodities. This argument gives rise to a fundamental question about the consistency between I-O tables and trade statistics which are provided from different sources, but there is no commonly established way to avoid this difficulty. Here, we just assume a certain level of good correspondence between the two classification systems.

Number of the aggregated industry sectors in the I-O tables is 27 to 46, depending on the countries and years. Each of them is assigned to one of the nearest sectors of 66 SITCs,

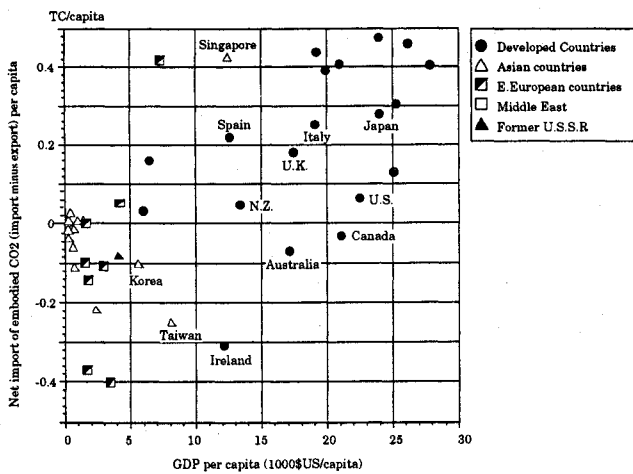


Figure 2. Per capita net import of embodied CO<sub>2</sub> (import - export) and per capita GDP (whole world, 1990)

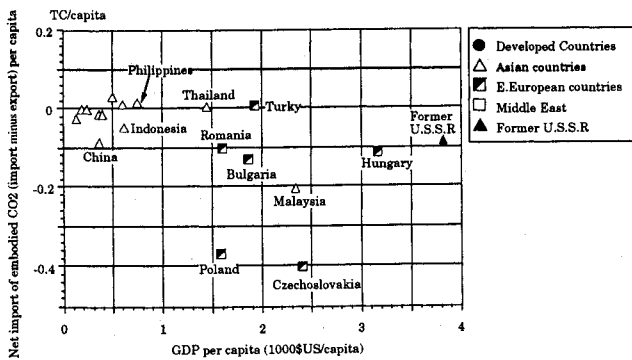


Figure 3. Per capita net import of embodied CO<sub>2</sub> (import - export) and per capita GDP (developing world and economies in transition, 1990)

considering the products of the respective sector. The result of the calculation is shown by 8 SITCs of two digit codes regarding two important sectors, i.e. basic manufactured products, and machines and transport equipment. As for other sectors, the results of the calculation are aggregated into 5 sectors of one digit codes. These results are shown in Table 3. In summary, the model represented by equation (7) is practical and easy to apply, but we should note its limitations.

Table 3. Korea's and China's export of embodied energy to Japan

	Korea(1000TOE)			China(1000TOE)		
	1980	1990	1990/1980	1980	1990	1990/1980
<b>Food, live animals, beverages, and tobacco</b>	142	341	2.40	602	820	1.36
<b>Animal and vegetable oil, and fat</b>	38	39	1.04	764	801	1.05
<b>Chemicals</b>	41	277	6.78	696	985	1.41
<b>Basic manufactured products</b>	201	2,301	11.45	904	2,509	2.78
Leather, dressed fur., etc.	2	3	1.12	11	8	0.68
Rubber manufactures	4	13	3.16	—	4	—
Wood, cork manufactures	7	2	0.24	12	145	12.36
Paper, paperboard and manufactures	2	5	2.14	5	7	1.35
Textile yarn, fabrics, etc.	97	176	1.82	403	509	1.27
Non-metal mineral manufactures	13	147	11.54	238	256	1.08
Iron and steel	63	1,837	29.31	166	1,025	6.17
Non-ferrous metals	6	19	3.09	58	459	7.86
Metal manufactures	7	100	15.10	10	96	9.30
<b>Machines, and transport equipment</b>	80	442	5.52	7	563	81.41
Power generating equipment	4	15	3.48	1	75	114.05
Machines for special industries	2	11	5.96	1	69	136.75
Metalworking machinery	2	7	2.90	0	10	23.36
General industrial machinery	3	20	7.99	—	31	—
Office machines and equipment	3	17	5.72	—	6	—
Telecomm, audio equipment	16	58	3.57	2	41	19.93
Electric machinery etc.	44	275	6.31	2	77	42.54
Road vehicles	2	37	15.10	0	254	706.91
Other transport equipment	4	2	0.41	1	0	0.29
<b>Miscellaneous manufactured goods</b>	149	860	5.75	505	1,313	2.60
<b>Goods not classed by kind</b>	3	16	5.45	44	8	0.18
<b>Total</b>	654	4,275	6.54	3,522	6,999	1.99

### 3.2 Trade Balance of Embodied Energy

Table 4 is an estimate of the trade in embodied energy associated with the transaction of goods and services between the above mentioned seven countries. It shows that Southeast Asia is a net exporter to Japan as well as to the United States. The flow of embodied energy from the

Table 4. Trade balance of the embodied energy between selected countries (million TOE)

From \ To	U.S.	Japan	S.E.Asia*	China	Indonesia	Korea	Singapore	Thailand	Total export	
U.S.	—	17.70	12.46	2.19	0.85	5.75	2.60	1.08	30.16	
Japan	13.87	—	11.43	1.86	1.20	4.17	1.90	2.29	25.30	
S.E.Asia*	12.73	13.83	—	8.75	0.56	1.01	2.06	2.98	2.13	35.31
China	5.75	7.00	5.30	—	0.46	1.75	1.60	1.49	18.05	
Indonesia	0.48	0.93	0.89	0.16	—	0.15	0.49	0.10	2.30	
Korea	4.53	4.27	1.56	0.30	0.38	—	0.46	0.41	10.36	
Singapore	0.46	0.18	0.35	0.05	0.10	0.07	—	0.14	1.00	
Thailand	1.51	1.44	0.65	0.05	0.06	0.10	0.44	—	3.60	
<b>Total import</b>	26.60	31.53	32.64	4.61	3.06	11.98	7.48	5.50	90.77	

\*S.E.Asia Represent the sum of China, Indonesia, Korea, Singapore, and Thailand

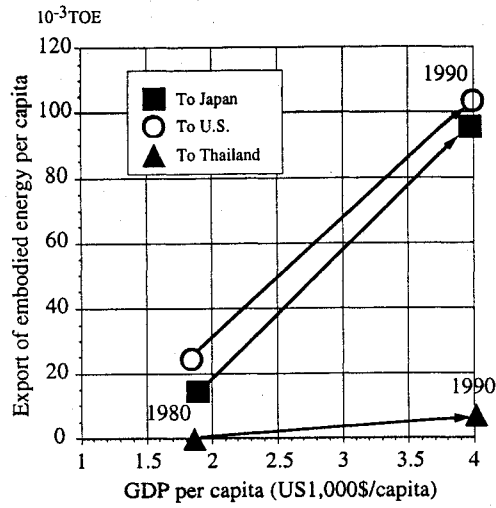


Figure 4. Trade balance of embodied energy between selected countries (million TOE)

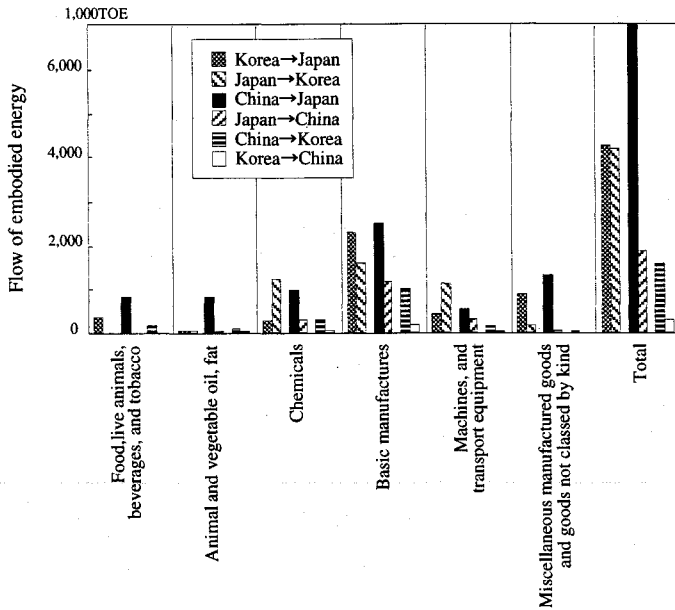


Figure 5. Flow of embodied energy for selected sectors between China, Japan, and Korea(1990)

United States to Japan exceeds the opposite flow unlike monetary trade imbalance between the two countries. Japan's import of chemicals and non-ferrous metals (mainly aluminum) causes this intensive flow of embodied energy from the United States to Japan.

What attracts our attention to East Asian countries is the international environmental implication of their rapid industrialization propelled by export. Here, Korea is taken up as a representative of newly industrializing economies in Asia. Figure 4 represents Korea's per capita export of embodied energy to Japan, Thailand and the United States. It shows that Korea's export of embodied energy to the United States and Japan significantly increased according to its economic development.

China also attracts our attention due to its rapid growth achieved since the 1980s and its growth potential in the future. China's and Korea's export of embodied energy to Japan for selected industry sectors are compared in Table 3. From 1980 to 1990, Japan's import of embodied energy from Korea and China increased 5.8 and 1.7 times, respectively. Increase in the embodied energy flow associated with the export of iron and steel products from Korea to Japan is quite remarkable. It has increased 26 times in the ten years, accounting for 43% of the total export of the embodied energy to Japan in 1990. Regarding the export from China to Japan, increase in machine and transport equipment is quite remarkable while basic manufactures keep the largest share.

The breakdown of the inter-country flows of embodied energy among China, Korea, and Japan in 1990 is shown in Figure 5. Between Japan and Korea, trade of chemicals, industrial products, and machines make up a large share in the flow of embodied energy. Total flows between them are fairly balanced. On the other hand, the flow from China to Japan is notably larger than the opposite flow. China's export of basic manufactures such as textiles and fabrics, iron and steel, and other miscellaneous manufactured goods causes the large flow of embodied energy to Japan. The relationship between China and Korea has a structure similar to that between China and Japan. Energy-intensive industries such as basic manufacturing and machines are growing in China and supplying products to Japan and other countries. This indicates that Japan and Korea are responsible for the environmental loads in China through trade. Thus it might be concluded that China's rapid industrial development is being achieved by taking over the environmental loads of more developed countries such as Japan.

### 3.3 Trade-Balance of Forest Resources

The concept of embodied energy can be applied to consider the environmental load caused by the consumption of depleting resources.

Japan imports a large amount of timber from other countries, and it is thereby responsible for the depletion of forest resources in exporting countries. If  $\epsilon_{\alpha}^{(k)}$  in eq.(7) is replaced by the amount of logged timber required per dollar's worth of final demand of the  $k$ -th industry in country  $\alpha$ , the trade balance of timber and its products is obtained. Table 5 demonstrates the trade balance and production of timber (or the amount of logged timber) of six selected countries in 1990. Among the countries, Japan, Korea, and China are net importers (in terms of timber and its products), while the United States, Thailand, and Indonesia are net exporters. Export from the United States to Japan is the largest followed by that from Indonesia to Japan. Japan is the largest importer in the region, accounting for 20% of the responsibility for environmental impacts caused by timber logging in the United States and Indonesia.

Table 5. Trade balance and production of timber in selected countries in 1990 (million sqm)

From	To	U.S.	Japan	Korea	China	Thailand	Indonesia	Total export	Production of Timber
U.S.	—	—	102.00	13.34	6.93	0.44	0.51	123.21	501.0
Japan	0.31	—	—	0.07	0.02	0.03	0.02	0.45	29.8
Korea	0.30	0.28	—	—	0.01	0.01	0.01	0.62	6.6
China	6.32	7.85	0.69	—	—	0.37	0.16	15.39	277.0
Thailand	1.40	2.16	0.09	0.09	—	—	0.02	3.76	37.7
Indonesia	14.50	34.76	7.72	7.72	0.25	—	—	67.87	171.5
Total import	22.91	147.05	21.92	21.92	1.09	0.71	211.31	1023.6	

### 3.4 Concluding Remarks

In this study, the trade of energy and carbon dioxide embodied in goods and services among different countries and/or regions is analyzed, applying input-output models and using international trade statistics and energy data. The trade balance between selected Asia-Pacific countries are estimated, and their relationships with national industrial structures discussed. It is demonstrated that the rapid industrialization of Asian countries such as China is attained by exporting embodied energy to developed countries such as Japan.

Regarding the adverse effects of trade, local environmental problems such as industrial pollution and over-exploitation of natural resources have been mainly studied (OECD, 1994; World Bank, 1992; Charnovitz, 1994 and 1995). Unlike local problems, impact of trade on the global environment has not drawn much attention because its effect is invisible or difficult to detect (Røpke, 1994; Steiner, 1994). Little is known about the effect of trade on the global climate. However, trade of carbon dioxide embodied in goods and services will be expanded through trade liberalization, and it could have significant contribution to the accumulation of carbon dioxide in the global atmosphere.

The Framework Convention on Climate Change requests developed countries to limit anthropogenic emissions of greenhouse gases. Here, "emissions" simply means the release of greenhouse gases and/or their precursors into the atmosphere (United Nations, 1994b) and little attention is paid to the import of embodied CO<sub>2</sub>. It is not regarded as the emission under the Convention. Some part of the reduction or stabilization of the domestic CO<sub>2</sub> emission could be achieved by increasing the import of embodied CO<sub>2</sub> from other countries. This trend would tend to be further increase as the economy is globalized.

Japan is an example of countries whose import of embodied energy is increasing. Embodied energy flow into Japan through the trade of iron and steel from Korea and China amounted to 1.84 and 1.03 million TOE, respectively, in 1990 (Table 3). As Korea and China are rapidly increasing their production of steel and other heavy industries, the flow of the embodied energy into Japan is increasing, accompanied with the increase of the import of energy intensive products. As a whole, Japan's estimated net import of the embodied energy was 37.3 million TOE in 1990. This amount corresponds to 8.0% of its total domestic energy consumption (Table 2).

As far as direct domestic emission is concerned, importers are not responsible for CO<sub>2</sub> emitted in the exporting countries. However, the importers are often developed countries which have better technologies and financial resources for the reduction of the emission. On the other hands, exporters are often developing countries which are in lack of both technologies and money. This consideration would be important when we study the feasibility of "activities jointly implemented" (United Nations, 1995) which require cooperation between developed and developing countries.

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