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Interdependence of Economy and Environment in East Asia using EDEN Data Base-Focusing on Korea

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Abstract

There is concern that Asia will be one of the regions with the greatest burden on the global environment as forecasts point to a continuing increase in energy consumption as the region's economic activity expands and its population grows sharply. It is therefore extremely important to look at trends in East Asia when considering environmental issues on a world scale. So I use EDEN Data Base, the only table in the world to estimate Economy and Environment with common format in East Asia to clear the interdependence both of them. In this paper, at first, I introduce of EDEN Data Base and previous researches using this data base and then focusing on Korea, I extend estimation on EDEN Data Base to the 2000 version using the provisional 1995 version and shed light on the actual state and changes in economic and environmental interdependence for three target years.

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1. Introduction

The earth is burdened by many environmental issues including Global warming, Acid rain, Marine pollution and Desertification, and the fact that it is facing a crisis that presents the ultimate adversity, especially from the 1980s, is now irrefutable. This critical situation has become a common perception shared in many countries. As the modern society in which we live enjoys the benefits of economic development, environmental destruction is accelerating on a global scale. Along with implementing environmental measures at the local level, international collaboration is also essential, and we are indeed facing the situation in which conservation of the earth must be considered on an international dimension. There is concern that Asia, home to more than about 60% of the world's population, will be one of the regions with the greatest burden on the global environment as forecasts point to a continuing increase in energy consumption as the region's economic activity expands and its population grows sharply. For example, in 1980 East Asia accounted for about 15% of the world's CO_2 emissions, but by 1995 this had grown to roughly one-quarter, while in emission quantity, the region's emissions have been growing at a much faster pace than the world total with a 1.9-fold increase compared to the world's 1.2-fold increase. It is therefore extremely important to look at trends in East Asia when considering environmental issues on a world scale. Here I will ascertain the state of economic and environmental interdependence in East Asia using EDEN Data Base developed in a common format to clarify the condition of the environmental load in East Asia. Only EDEN Data Base 1990 has been released, so the first aim of this paper is to extend estimation on EDEN Data Base to the 2000 version using the provisional 1995 version especially focusing on Korea. Then, using the 1990, 1995 and 2000 version of EDEN Data Base (hereinafter referred to as the three target years), the second aim is to shed light on the actual state of and changes in economic and environmental interdependence for the three target years.

This paper is composed as follows. In Chapter 2 I touch on the background and an overview of EDEN Data Base, and estimation conditions, and introduce previous research using this Data Base. In Chapter 3, I draw up the 2000 version for Korea, and look into the Economic and Environmental interdependence over the three target years of 1990, 1995 and 2000.

2. Overview of EDEN Data Base and Previous research

2-1 Overview (background and estimation condition)

EDEN (Economic Development and Environmental Navigator) was drawn up by Keio Economic Observatory in collaboration with statistics authorities in various countries to clarify the effect that economic growth and changes in interdependence in East Asia has on the environment and energy supply and demand as a part of the JSPS (Japan Society for the Promotion of Science) Research for the Future Program[1]. With the extensive and long-term expertise of Institute of Developing Economies (IDE), which has prepared the Asian International Input-Output Table, this Data Base enables international comparisons that estimate energy and environmental fields. The target countries are nine countries and regions; Japan, Singapore, Taiwan, Korea, Malaysia, Thailand, Philippines, Indonesia, China, and in East Asia[2], and the target years are the two years of 1990 and 1995. As of March 2006 only the 1990 version with 35-sector tables has been released, and some researchers have made several reports on analysis cases using the 1990 version. The project had set the initial goal of completing and releasing the estimations of the 1990 and 1995 versions, but in view of time restrictions and accuracy, while estimations for the 1995 version have started, they have not reached the stage of public release, and because of the analysis extension over multiple years, public release is some time in the future.[3]

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[1] JSPS for the Promotion of Science, 'Inter-disciplinary Studies for Sustainable Development in Asian countries' (Representative; pf. Yoshioka, Keio Economic Observatory) (1997-2001).

[2] Singapore: National University of Singapore, Taiwan:Taiwan Research Institute, Korea: Korea Energy and Economic Institute, Malaysia :Department of Statistics, Thailand :National Economic and Social Development, Philippines :National Statistical Coordination, Indonesia :Central Board of Statistic, China: State Statistical Bureau, Japan :IDE(the name at that time). The target countries include countries that are usually classified in Southeast Asia, but in this chapter, they are listed under the collective term of East Asia.

[3] As mentioned above, the target years of EDEN Data Base is 1990 and 1995, but the project ended with the completion of estimations and the release of the 1990 version, so the 1995 version exists only as a provisional version. I will therefore extend estimations to the 2000 version considering the release of the 1995 version and also 2000 Input-Output tables in various

EDEN Data Base is composed of five tables as table 1[4] and the estimation process of this Data Base shows figure 1. A table integrates the Input-Output tables of various countries into 76 common EDEN categories[5], and is expressed in those countries' respective currencies.[6] B table is the energy substance input table, and lists energy substance quantity used in each sector and final demand sector for each of the 22 energy types[7]. C table is the energy consumption table, and lists only the energy substances in B table that are consumed as fuel[8]. D table is a calorie table that converts the figures in C table to calories. Therefore B and C tables list units peculiar to each energy type, while D table lists calories, so this allows a direct lateral comparison for each country in absolute quantity and percentage distribution. Lastly, E table is the CO_2

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countries. In addition, the author belonged to the project WGI, which was responsible for EDEN Data Base estimations.

[4] See Kiji(2002) for more detail information about EDEN Data Base.

[5] The number of basic sectors in Input-Output tables varies considerably from country to country, so, taking into account each country's sectors, EDEN set 76 sectors so there would be a common sector classification for the target countries (Appendix 1).

[6] There are two format types for the Input-Output tables: competing import type and non-competing import type according to how imports are handled. In EDEN Data Base, considering the analysis aim, the ISARD non-competing import type, in which domestically produced goods and imported goods are completely differentiated and imports are classified by country and by sector, is preferable, but EDEN Data Base has adopted the competing import type format since in reality it is not possible to obtain accurate data regarding input and output from the target countries.

[7] Refer to Appendix 2 for 22 Energy types.

[8] This excludes B table energy substances that are consumed as raw material (e.g., coal for coke production, crude oil for petroleum refining). The raw material / fuel consumption ratio was not obtained by all target countries, so the values for the countries where it was obtained have been used instead.

/ SO_2 generation table, and it converts carbon and sulfur generation estimated from carbon / sulfur content ratio based on D table into CO_2 and SO_2.[9]

2-2 Previous research using EDEN Data Base

This section will introduce research cases using EDEN Data Base.[10] The analysis is broadly classified into "analysis of the current state of the East Asian Economy and Environment", which is fact finding analysis from EDEN Data Base itself, and "Others", which is applied analysis using EDEN Data Base.

1 Analysis of the current state of the East Asian economy and environment

Analysis of the current state of the East Asian economy and environment using EDEN Data Base consists of single country analysis that analyzes each country, then finally makes a cross-sectional comparison; and international link analysis that links trade statistics to examine the interdependence between countries.

1) Single country analysis — Comparison of economic structure, energy consumption structure, and CO_2 /SO_2 generation structure of each country

Leading examples of single country analysis include Kiji (2002), Kim et al. (2002) and Takenaka (2002).

Kiji (2002) conducts a country-based comparison of energy consumption and CO_2 / SO_2 total generation and percentage distribution in Asian countries, and estimates generations per capita, per value added and per energy consumption unit, and direct and indirect generation for each industry. First, the paper classifies the region into the five countries/regions of Japan, Korea, China, Taiwan, and five Southeast Asian countries,

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[9] EDEN Data Base regards energy generation to which removal activities have been extended as emission, so generation and emission are differentiated. The rate of removal is clear in some countries such as Japan and China, so here it is possible to estimate emission separately.

[10] This also includes analysis cases using EDEN Data Base 1995, which, as mentioned before, has not completed estimations but is still at the provisional stage.

which includes Malaysia, Thailand, Philippines, Indonesia and Singapore and analyzes energy consumption and CO_2 / SO_2 generation for each country / region, then states that considering the energy and environmental issues facing East Asia, China's presence is of paramount importance when looking at total generation. On the other hand, when looking at per capita figures, Japan stands out, and when considering per value added amount[11] figures in the same way, China requires the greatest energy consumption and CO_2 / SO_2 generation to create the same value added unit — respectively, 2.3 times, 3.0 times and 9.1 times as great as that needed by Japan. CO_2 generation per energy consumption unit (it excludes Electric power) is lowest in Indonesia, and high in China and Taiwan. SO_2 generation is low in Japan and Singapore, and particularly high in China. Such disparity is thought to arise mainly from the different types of energy consumed in each country.[12] The energy consumption composition in each country under the five energy classifications(the type of Coal, Oil, Gas and others) shows that in China coal with its high level of CO_2 / SO_2 generation accounts for 75%, and in Singapore petroleum accounts for more than 90%, while in Japan, dependence is spread across many energy types. If look at direct and indirect CO_2 generation per domestic production unit for each sector[13], in Japan there is a significant difference between direct and indirect generation in *machinery and equipment* sector, with indirect generation more than 18 times as great as direct generation. A similar trend can also be seen in Korea, Taiwan and Singapore, confirming the broad base of *machinery and equipment* industry within the country. And similar trends can be seen in *coal products* in Singapore and Taiwan, *petroleum refinery products* and *other services* in the Philippines, and *petroleum refinery products* and *eating and drinking places* in Malaysia.

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[11] The paper uses figures substantiated with purchasing power parity indices calculated from GDP statistics. See Kiji(2002)p.32.

[12] Specifically, natural gas and LNG, whose main components are methane and ethane, have low CO2 generation relative to calorific value, whereas coal, whose main component is carbon and which also has high sulfur content, has high CO2 / SO2 generation (See kiji(2002)p.35). So the disparity in generation per energy consumption unit arises depending on the type of energy used domestically.

[13] Twenty independently set industrial classifications are used.

Kim et al. (2002) compares the actual state of energy use and sectors with high energy consumption in nine countries, and, focusing on Light industries and Heavy industries, estimates CO_2 generation per calorie amount by industry, and the direct and indirect induced CO_2 generation for each sector. First, the paper classifies energy into four energy types(the type of Coal, Oil, secondly energy and others), and ascertains the state of energy use by country taking into account the condition of each country's energy resource holdings, especially focusing on Japan and Korea. Energy use composition shows that China has particularly high coal consumption, while the other eight countries are all high in petroleum consumption. One characteristic that can be seen is that the use of non-petroleum energy types is also high in Japan and Korea. The reason for this is that both countries rely heavily on imports for their energy resources, and having learned from their experience of the oil crises, they have been pushing ahead with energy diversification since the 1970s. A comparison of the high energy consumption sectors[14] reveals a common trend in all countries is that *thermal power* and *private-sector consumption* are high energy consuming sectors. Similar to Kiji (2002), the paper analyzed energy consumption and total CO_2 / SO_2 generation for each country to examine generation per capita and household consumption. Looking at per capita CO_2 to household consumption, we can see that generation is high in countries with relatively high income, such as Korea, Japan and Singapore. The paper also analyzed energy consumption and CO_2 / SO_2 generation focusing on the three sectors of *textiles*, which is a typical Light industry, *iron and steel*, which is a Heavy industry, and *thermal power*, which is a high energy consumption industry. For CO_2, the *textile* industry in China and Korea generate almost as much as the *iron and steel industry*, and considering *textile products* are major exports of both countries, there is a strong need for environmental measures not just in the Heavy industries, but in the Light industries as well. CO_2 generation in the *iron and steel* industry is high in China, Japan and Taiwan, but low in Malaysia and other Southeast Asian countries. CO_2 generation in *thermal power* is much higher in China and Japan, but because of an anticipated rise in power demand in Asian countries, the paper highlights the need for a range of countermeasures such as reviews of each country's energy mix. The paper also attempts an index representation linking energy consumption and CO_2 / SO_2 generation with

[14] In addition to the 76 industries, the final consumption sector is also analyzed.

economic activity: specifically, 1) energy consumption and CO_2 / SO_2 generation per output unit, and 2) energy consumption and CO_2 / SO_2 generation per calorie unit of energy consumption, and 3) directly and indirectly induced energy consumption and CO_2 / SO_2 generation per final consumption unit. In China, 1) CO_2 generation per output unit is more than 20 times as high as in Japan[15]. In 2) generation per calorie unit of energy consumption, the difference between countries is greater in SO_2 generation than in CO_2 generation, with China, the highest, four times as high as Japan, the lowest[16]. This is thought to stem from the difference in energy type composition, and where the energy type is the same, from differences in sulfur content rate between countries. The paper points out that in SO_2 generation over the three industries of *textiles*, *iron and steel*, and *thermal power*, the Light industries generate more than the Heavy industries and *thermal power* in China, Korea and Taiwan, and here, too, highlights the need for environmental initiatives in the Light industries. At the end, the paper estimates induced CO_2 generation for each industry. These estimates indicate that even in the same sectors, induced CO_2 generation is substantially different from country to country. The paper gives the following four reasons for this: 1) differences among countries in the goods that can be purchased with the same sum of money, 2) differences in product mix, 3) differences in energy mix, and 4) differences in production technology.

Takenaka (2002) focuses on the energy consumption structure (total consumption, energy structure, highest energy sector) and household sector in the target countries, and clarifies the characteristics of each country's household energy consumption structure. The paper carries out a simple simulation estimating energy consumption resulting from changes in the calorific value per energy unit to examine future trends in energy consumption. Similar to Kiji (2002), the paper compares energy consumption in nine countries, and points out that considering China accounts for 48% and Japan for 32% of total East Asian energy consumption, for a combined total of 80%, both countries have

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[15] Here the paper uses dollar value for output converting each country's currency using a single exchange rate, so care should be given to the result in the aspect that it does not use purchasing power parity.

[16] Japan is low because of the widespread use of desulfurization technology at the fuel stage.

a major influence on environmental issues in East Asia. It also classifies energy consumption into production sector and household consumption sector, and gives the energy consumption ratio for each by country. The household energy consumption ratio differs depending on the country, but those with a high ratio are Malaysia, Indonesia and Korea with 20% followed by JAPAN with 13%, while the lowest are Taiwan and Singapore with 5%. It is therefore understood that household consumption as a percentage of energy consumption is low in Singapore and Taiwan, and high in Korea, Malaysia and Indonesia. Next the paper sheds light on differences in the energy composition in each country through an international comparison of energy type. Among the characteristics to emerge are that Japan has a high electric power ratio, but at the same time it depends on a comparatively diverse range of energy types; Singapore, Taiwan, Korea and Philippines have a high fuel oil ratio; of the ASEAN countries, Malaysia has a high petroleum fuel and natural gas ratio, while Thailand has a strong dependence on diesel oil; and Indonesia depends heavily on plant-based fuel oil, while China is the only country that is heavily dependent on coal. Sectors with the highest level of energy consumption (includes household consumption) are *power, gas and water*, *household consumption*, and *transportation* in Japan and Korea, and *power, gas and water*, and *transportation* in Taiwan, Thailand, and Philippines. In Singapore, the highest are *petroleum refinery and coal products*, and in China, *cement and other nonmetallic mineral manufacture*. Indonesia is the only country where *household consumption* is the highest energy consumer, while *timber and wooden products*, and *wooden furniture* are also high energy consuming sectors. Next the paper focuses on the household consumption sector to determine the total amount and structure of energy consumption. An international comparison of energy type in the household consumption sector shows that in Japan, Singapore and Thailand, the main energy types are gasoline and electric power. In Korea and China coal-based sources are the main energy type, with other coal products in Korea and coal in China. Plant fuel ranks high in Thailand and Indonesia. City gas ranks high only in Japan, Singapore and Korea, three countries with high income levels. Lastly, Takenaka (2002) conducts a simulation on changes in calorific value per energy unit. Calorific value per energy unit is necessary data for estimating the D table, which has been converted into calories from the C table, and varies greatly by country. From its estimate of each country's energy consumption

based on cases where the calorific value per energy unit is 1) at the level of Japan, and 2) at the highest and 3)at the lowest levels in East Asia, the paper points out that, taking into account the “flying-geese” pattern, there are many opportunities for developing countries to learn from developed countries, and each country must obtain information from Japan and other developed countries in East Asia on their past experiences not just in the economy, but also regarding the environment, and make every effort to lower the degree of future uncertainty about environmental issues as much as possible, and take the path of sound economic development processes.

2) International link analysis

EDEN Data Base is prepared under a common format for nine countries, so adding processes linked by trade statistics enables us to ascertain an international interdependence in the Economy and Environment not just for a single country but in relation to multiple countries. Takenaka (2002) is a typical international link analysis. It adopts an East Asia trade matrix for quantifying the international interdependence of East Asian countries in CO_2 generation associated with economic activities in the countries / regions with the aim of drawing up a chart giving an overview of East Asian countries regarding environmental load, such as what goods demand by which country will in turn cause what industries in which country to generate CO_2.

2 Others

Typical applications of analysis using EDEN Data Base include 1) environmental load in the open ocean, 2) trade and the environment, and 3) household energy consumption analysis.

1) Environmental load in the open ocean

Washizu et al. (2002) estimates CO_2 caused by East Asian open ocean transportation, that is, goods transportation between countries, using the 1990 version. Single-country input-output tables only indicate energy consumption by that country’s own national transportation organizations (ships, air transport and so on) over a one-

year period as a total amount, so they cannot reveal the environmental load arising from trade between two given countries. In addition to international link analysis, Washizu et al. (2002) estimated the environmental load accompanying open-ocean transportation. However, the analysis only looked at ships within multiple transportation organizations. Technical information on ocean-going ships used in export / import was not available, so the estimations had a number of constraints, such as assuming the rate of fuel consumption is the same as that of coastal ships, and that the CO_2 basic unit does not change according to the exporting / importing country, and as a result[17], the paper found that for the nine countries as a whole, CO_2 generation associated with goods production amounts to 3.8 billion tons, and generation in the open ocean ranges from a maximum of 37.89 million tons to a minimum of 21 million tons, so it can be said that CO_2 generation in the open ocean accounts for between 0.5% and 1.0% of total CO_2 generation from goods production. By country, CO_2 generation associated with goods production is highest in China with 2.15 billion tons, followed by Japan with 980 million tons, while for CO_2 generation in the open ocean, in exports Indonesia is the highest with 13.09 million tons, and in imports Japan is the highest with a maximum of 15.91 million tons. As for generation induced by domestic final demand, China induces 1.78 billion tons, and Japan 950 million tons. Countries with a high overseas leakage (induction to other countries or the open ocean) are Singapore with 51.4%, followed by Malaysia with 27.3%, and Thailand with 19.5%, while, conversely, countries with low overseas leakage are China with 0.5% and Korea with 7.2%. Looking at Japan, Korea and China by sector, we can see that induction to other countries is high in *electric power, gas and water supply*, and also in Heavy and chemical industry products such as

[17] CO2 generated by ship transportation is worked out by obtaining the consumption of each fuel type from the consumption percentage distribution of each fuel type from the fuel consumption obtained from the fuel consumption rate for the weight of goods to be transported, transportation distance, and type of ship, then multiplying this by the CO2 basic unit.

iron and steel. On the other hand, in ASEAN, emissions are high in *crude oil* and *natural gas*, and *timber and wooden products*.[18]

2) Trade and environment (The influence on economy and environment by FTA)

Trade forms the foundation of the economic system, and has brought development to the world's nations through mutual economic exchanges. Within this, it is absolutely vital to strive for sustainable development that respects the perspectives of both trade and the environment and seeks their coexistence. As the finite nature of resources becomes more obvious, the expansion of trade is becoming increasingly connected with various aspects of the environment and environmental policy, and there is concern that trade expansion and the concomitant economic growth may have an adverse impact on the environment and hinder sustainable development. And as it now stands, trade expansion through the deepening of international interdependence over recent years is affecting the Economy and Environment not just in one's own country, but in other countries as well. Takenaka et al. (2004) envisages trade expansion in two cases of WTO membership and free trade agreements, and analyzes the relationship between the associated economic growth and environmental load[19].

First, using the 1995 version, Takenaka et al. (2004) verifies the hypothesis that trade liberalization in China may contribute to a lowering of the environmental load as a means of clarifying the economic and environmental effect on China and Japan when China undergoes trade liberalization premised on China, which has enjoyed remarkable

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[18] Future analysis will expand transportation organizations to include air transportation, develop trade data in an identical unit, and, especially regarding ships, obtain technical information on ocean-going and coastal ships.

[19] Refer to Takenaka et al. (2004)p.159-162 for more detail about the relation between trade and environment. Shinozaki et al. (1997) is used as a reference for analysis method. The analysis quantifies the environmental load resulting from an exogenous change with a fixed gross domestic expenditure scale, and does not take into account the effects from income, prices, etc (See Takenaka et al. p.176).

growth in recent years, joining WTO. Specifically, the paper seeks the induced amount of CO_2 and SO_2 generation through the Leontief open model, assuming that China and Japan, which represents all other countries, are the only two countries in the world, and that trade liberalization in China will result in an increase in China's export of relatively cheap goods, i.e. labor-intensive goods, and, conversely, an increase in its import of relatively expensive goods, i.e. labor-saving goods[20]. The result shows an increase in output in both countries, but whereas the induced generation increases in China, it falls in Japan. Combining the two, output increases, and the induced amount of CO_2 and SO_2 generation decreases about 1% each, indicating that China's trade liberalization will have the effect of expanding production in both countries, while contributing toward a reduction in both countries' environmental load. So while it cannot be claimed categorically that trade liberalization in China will contribute toward a reduction in the environmental load, the paper confirmed that there is indeed a strong possibility that it could. By sector, in China there is considerable CO_2 generation increase in *textile products*, whose production expanded due to increased exports, and in *chemical products*, whose production increased through an indirect effect, and a notable decrease in *iron and steel industry*, *non-ferrous metals*, and *power and heat supply services*, whose production dropped with the increase in imports. On the other hand, in Japan there is a considerable CO_2 generation increase in i*ron and steel industry*, whose production increased with the increase in exports, and in *coke and other coal products*, and *power and heat supply services*, whose production increased due to an indirect ripple effect, and a considerable decrease in *air transport*, and *apparel and leather products*, whose production fell with the increase in imports. Combining the two countries, CO_2 generation rose substantially in *textile products* and *chemical products* largely as a result of the effect of increased production in China, and fell substantially in *iron and steel industry*, and *power and heat supply services*, whose production decreased in China.

Second, Takenaka et al. (2002) analyzes the direct and indirect effect of CO_2 generation on the economies and environment of Japan and Korea assuming that an

[20] Purchasing power parity index was used as a judgement standard in sector selection (See Takenaka et al. (2004)p.164).

FTA removing tariffs has been signed between the two countries, specifically, a Japan-Korea FTA that removes Japanese and Korean tariffs. The analytical framework of this paper is a combination of a kind of the integrated simulation model of AIM/CGE (Asia) and Input-Output analysis using with EDEN Data Base. As a result, Japan-Korea FTA would increase the GDP from 0.15% to 0.6% and also increase CO_2/SO_2 generation in each country from 0.17% to 0.25%. A simulation result says that in total effects of both countries the additional environmental load in the degree of increase in CO_2/SO_2 generation would be expected lower than that of estimated degree of their economic expansion of both countries. Then the formation of FTA could be evaluated even as an environmentally sound agreement.

3) Analysis of environmental load accompanying Household consumption

Focusing on Japanese household consumption, Takenaka (2005) analyzes household energy consumption from the perspective of its relationship with 62 household expenditure items for 1990 and 1995.[21] Considering recent international environmental policies, Japan, which was obligated to reduce emissions especially with the Kyoto Protocol coming into force, is at the stage of translating plans for reducing emissions into action, and against this backdrop, we are ourselves obligated to reduce emissions caused by the household sector, which is still trending upward. So empirical analysis is being carried out based on the idea that understanding the current state is the first step toward reducing emissions. Analysis started with an estimation of the household consumption converter by laying out the household consumption vector of A table on a matrix of 62 expenditure items x 76 products, and in addition to changes in

[21] The paper does a similar analysis for Korea as well, and there are plans to expand this to other East Asian countries. Washizu (1996) and Washizu (2001) are examples of analysis with eight major expenditure items for 1990 and 1995 using another database. This chapter deals only with analysis using EDEN Data Base, so it does not touch on Washizu (1996) and others aimed at ultimately drawing up environmental household accounts using other data. The 62 household expenditure items in Takenaka (2005) are expenditure classifications designed to correspond to both the SNA and Household expenditure survey systems. For 1995, however, the provisional version of EDEN is used.

the industrial structure, it clarifies the relationship between the environment and the consumption lifestyle that reflects consumer preferences.

3. Korea-the current state of economy and environment in three target years

Here I will expand EDEN Data Base in the three target years in Korea, and examine changes in the current state of the Economy and Environment.[22] As mentioned in Chapter 2, only the 1990 version of EDEN Data Base has been completed and released, while the 1995 version is still undergoing estimation, and the 2000 version has not even reached the estimation stage. This paper therefore uses the 1995 provisional version assuming the already released 1990 version is correct, and after considering the state of precision, extends this to the 2000 version. Here I judged precision for domestic production from the extent to which it corresponds to the transactions table for the 2000 input-output table estimated independently by each country, and for CO_2, from the extent to which it differs from general statistics on the five-yearly rate of increase. As there is only limited information on total amounts, for both countries the 2000 version was drawn up with specific assumptions on more detailed sector-by-sector generation.

3-1 Preparation and overview of EDEN Data Base 2000

Here I will prepare three-year data for Korea. When confirming the provisional 1995 version of EDEN Data Base, regarding A table, I confirmed from Korea's input-output table that there is a match with the 76, so I judged there were no problems. Regarding CO_2, the rate of increase from 1990 to 1995 was 1.46, and considering the increase rate in general statistics[23] was 1.49, it is judged to be a close match. I will therefore extend the estimation to the 2000 version using information from both years. First, I integrate the transaction table (2000 Input-Output table in Korea, Bank of Korea)

[22] Of all the countries included in EDEN Data Base, Korea most closely resembles Japan in terms of the state of statistics preparation, and because Korea was the first to release the basic transactions table for the 2000 Input-Output table, it has been chosen for analysis.

[23] Refer to Handbook of Energy and Economic Statistics in Japan.

so that it corresponds to EDEN 76. While there are slight variations in the 2000 version such as a sector reorganization in communication and broadcasting and the new establishment of a software-related sector[24](table 3), I prepared A table by integrating the 2000 transaction table into EDEN 76 with the 1995 sector categories as a reference.

Regarding CO_2, in general statistics[25] the rate of increase from 1995 to 2000 is 1.19 times, and, similarly, 1.7 times from 1990 to 2000, so substituting both EDEN year versions, I forecast that Korea's CO_2 generation in 2000 on an EDEN base is 444,661–452,595(1000t-CO_2). At the same time, looking at changes in the CO_2 generation coefficient, the rate of change from 1990 to 1995 is 0.7 times, indicating an average improvement in CO_2 generation efficiency of 30%. Therefore, assuming similar technological advancements took place and efficiency improved by a uniform 30% in each sector from 1995 to 2000, CO_2 generation will be 450,449(1000t-CO_2), which is within the forecast range[26]. However, I assume that 1995 values will be maintained for 15 sectors[27] in which the CO_2 generation coefficient increased from 1990 to 1995. From this, I prepared the 2000 CO_2 generation table (E table) on an EDEN base[28], and developed a three-year database on Korea's Economy and Environment.

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[24] Korea changed to compliance with the 1993 SNA system from the 2000 input-output table. Therefore, care is needed when comparing with other years.

[25] See footnote 24.

[26] It can be conversely ascertained that CO2 generation efficiency improved by an average of about 30% from 1995 to 2000.

[27] The 15 sectors (such as *Dairy farming and livestock raising, Non-edible crops, Coal, Metal ores mining, Spinning and weaving, Printing and publishing, Timber and Wooden products, Coke and other coal products, Other fabricated metal* products, Other power and so on) are those sectors in which the CO2 generation coefficient increased from 1990 to 1995.

[28] Separately, I also estimated 2000 substituting the 1995 value for CO2 generation coefficient with the assumption that there was no change in the technological structure from 1995 to 2000, and it was ascertained that this would result in a CO2 increase of 1.6 times, while technological advancements would keep the increase in CO2 generation for 2000 down to 1.19 times.

3-2 Result

Using EDEN Data Base for the three target years, I will determine interdependence in Korea's Economy and Environment[29].

1)-1 Economic scale

Figure 3 shows changes in economic level over the three target years from a domestic production perspective and changes in per capita economic scale. Korea's domestic production jumped from 418 trillion won in 1990 to 1,392 trillion won in 2000, a 3.32-fold increase in economic scale over the ten-year period. The rate of increase was especially high from 1990 to 1995 at about 2.0 times, so Korea's economic scale expanded more in the first half of the 1990s than it did in the second half. The per capita economic scale rose from 9.76 million Won in 1990 to 18.65 million Won in 1995, an increase of 1.91 times, and to 29.63 million Won in 2000, an increase of 1.58 times[30]. I can therefore say that the increase was higher in the first half of the 1990s, and the per capita increase in domestic production rose about 3.03 times over the ten-year period.

1)-2 Industrial structure (Import and Export, Value added)

Here I will look at the industrial structure over the three target years. Figure 4 shows the industrial ratios for the three target years in 7 categories[31]. Broadly, it shows a decrease in the ratio of Primary and Secondary industries, and an increase in the ratio of Tertiary industries. Primary industries accounted for 5.1% in 1990, but this fell to

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[29] This is a nominal analysis in this section; substantive analysis is a future issue. In particular, in the latter half of the 1990s Korea experienced the impact of the Asian crisis, so care is necessary when using the analysis results.

[30] The population of Korea is 42.9 million people in 1990, 45.1 million people in 1995 and 47.0 million people in 2000.

[31] To clarify the overall feature, I integrated EDEN 76 to 7, Primary industry, Secondary (Mining) (Light) (Heavy) (Others) industry, Tertiary (Power & Transportation) (Others) industry. To divide Light and Heavy industry, I refereed to Keio Economic Observatory (1974).

3.8% in 1995, and further to 2.75% in 2000. Secondary industries maintained the highest ratio through the three target years, though it fell from 60.3% in 1990 to 53.7% in 2000. One exception to this downward trend is Heavy industry, and it is the only Secondary industry category that showed an increase, rising from 30.9% in 1990 to 34.8% in 2000. In Tertiary industries, a notable increase was "others", jumping from 34.5% in 1990 to 43.4% in 2000. The industry with the highest ratio among the seven industrial categories was a Secondary industry (Heavy) in 1990 and 1995, but in 2000, a Tertiary industry (Others) rose above the Heavy industry. Looking at changes in Korea's industrial structure over the ten years from 1990 I can see that agriculture, and Mining and Light industry sectors fell, while Heavy industry and the Tertiary industries enjoyed a prominent rise, and that the service industry has overtaken the Heavy industry and now occupies the position of Korea's leading industry.

Next I will examine this by sector. Table 4 lists the top ranking sectors in domestic production. In 1990 the five main sectors in Korea were *buildings*, *commerce*, *motor vehicle*, *other electrical machinery*, and *real estate services*, and while the sectors in the top five did not change in 1995, the percentage share of *other electrical machinery*, *motor vehicle*, and *real estate services* rose, and that of *buildings* and *commerce* fell slightly. In 2000 a change took place in the main sectors, with *other electrical machinery* taking over as the sector with the highest percentage at 8.9%, and *financial and insurance services*, a Tertiary industry (Others), rose to take its place in the top-ranking sectors. Table 5 lists the sectors with a high rate of increase in domestic production. From 1990 to 1995 the increase rate of *repair of motor vehicles*, and *knitting* was particularly high, while *business services*, *gas supply*, and *precision instruments* also enjoyed high rates of increase. From 1995 to 2000 *eating and drinking places* increased 7.2 times, while the increase rate for *postal telecommunication services* was also high, and *gas supply*, *repair of motor vehicles* and *knitting* have continued their high rate of increase from the early 1990s. The ten-year rate of increase from 1990 to 2000 shows that *repair of motor vehicles* is highest at 41.3 times[32], followed by

[32] Regarding *repair of motor vehicles*, the basic classification in the Korean input-output table has undergone significant changes in the name of sectors and details from 1990 to 1995, so care is necessary when using this.

knitting with 28 times, *eating and drinking places* with 19.3 times, and *gas supply* with 11.9 times. Overall, over the ten years output has increased in 71 sectors other than *coke and other coal products, leather and leather products* in the Light industry, and *metal ores mining, coal, and crude oil* and *natural gas* in Mining industry.

As can be seen in the Korean economy over the three target years, economic scale over the ten-year period expanded 3.3 times, and the per capita economic level also rose more than 3.0 times, confirming that Korea developed substantially in the 1990s. In particular, the pace of expansion was much greater in the early 1990s than in the latter half of the decade. As for the industrial sector, the ratios of the Primary industries and Light industry fell, while the ratios of the Heavy industry and service industry rose. Characteristic features of the decade are that in Heavy industry, *other electrical machinery* became the main industry in 2000, and in the service industry, *eating and drinking places* enjoyed a high rate of increase, and *commerce, real estate services*, and *financial and insurance services* became the main industries in 2000.

1)-3 Influence and sensitivity coefficients

Here I look at changes in the degree of interlinkage between industrial sectors through the influence and sensitivity coefficients. The influence coefficient is an indicator for measuring the backward linkage effect, and allows us to determine the degree of direct and indirect influence one industry has on the economic activities of other industries. The sensitivity coefficient is an indicator for measuring the forward linkage effect, and it enables us to determine the extent to which a product of a given industry is demanded by other industries, including those in its own sector, as an intermediate input product. By combining both indicators, I can ascertain the interdependence among industrial sectors within a single country. In general, when analyzing the influence and sensitivity coefficients, I look at placement in four quadrants with coefficient 1 as the standard. Industries falling under the high influence coefficient first or fourth quadrants have a high direct or indirect raw material input rate from various industries, and are broadly based with a relatively high degree of processing requiring many intermediate goods. Industries falling under the high

sensitivity coefficient second or third quadrants have a broad array of demand sectors and a high intermediate demand ratio.[33]

Figure 5 shows the influence and sensitivity coefficients for the seven industries over the three target years. In all three target years, Secondary industry (Light) and Secondary industry (Heavy) are in the first quadrant, only Tertiary industry (Others) is in the second quadrant, and only Secondary industry (Others) is in the fourth quadrant, while Primary industry, Secondary industry (Mining) and Tertiary industry (Power and transport) are in the third quadrant. Light industry and Heavy industry are both in the first quadrant, and are positioned as key industries in Korea, but comparing the two coefficients, I can see that Light industry has a higher influence coefficient, while, Heavy industry has a very high sensitivity coefficient. In both industries, though, the coefficients dropped from 1990 to 2000, although only slightly, so their interdependence with other industries can be said to be on a weakening trend. On the other hand, Tertiary industry (Others) in the second quadrant is characterized by a very high sensitivity coefficient, and while there was no change in the influence coefficient from 1990 to 2000, the sensitivity coefficient rose, positioning it close to the highest ranking Heavy industry. It is therefore an industry with an increasing interlinkage among industries by way of intermediate demand. Although the influence coefficient of the third quadrant Primary industry and Secondary industry (Mining) rose, their sensitivity coefficient is on a downward trend. From the above figures on the status of the seven industries in influence and sensitivity coefficients, I can say that the Light and Heavy industries are still key industries in Korea, but both are falling in both coefficients, and their interlinkage with other industries is trending downward. In contrast, I can see that Tertiary industry (Others) rose significantly in sensitivity coefficient, signifying a strengthening interlinkage by way of intermediate demand. I will now look at the relationship between influence and sensitivity coefficients by each of the 76 industries, focusing on Light industry, Heavy industry, and Tertiary industry

[33] From the above, industries in the first quadrant are high in both coefficients, and are above average in the degree to which they influence and are influenced by production in industry as a whole when final demand occurs. They can be said to be key industries for economic growth, and should be developed with greater priority than other industries (See Ezaki(1985)).

(Others). Table 6 lists the top ranking sectors in both coefficients for the three target years. The influence coefficient is high in Light industry such as *meat and meat products*, and *dairy products*, and Heavy industry such as *iron and steel products*. It is notable that in 2000 *motor vehicle* joined the top ranking group in influence coefficient, while in the sensitivity coefficient, *other chemical products* was the top ranking industry for all three target years, and Tertiary industry (Others) such as *commerce*, and *financial and insurance services*, and *iron and steel* are in the top group of industries.

Table 7 lists sectors whose placement on influence and sensitivity coefficients changed. What should be noted here is that *eating and drinking places*, which falls under Tertiary industry (Others), rose above 1 in both coefficients in 2000, moving from the third quadrant to the first quadrant, positioning itself as a key industry. The influence coefficients of *coal*, and *repair of motor vehicles* rose, moving them to the fourth quadrant in 2000, the sensitivity coefficient of *postal and telecommunication services* rose, while the sensitivity coefficients of *other chemical products*, *buildings*, and *road transport* fell. The influence coefficients of the five sectors of *tea and coffee*, *beverages*, *cement*, *glass and glass products*, and *air transport* rose in 1995, moving them to the fourth quadrant, but in 2000, they fell again, moving them back into the third quadrant. Similarly, *printing and publishing* rose in the sensitivity coefficient in 1995 to move into the first quadrant, but it again fell in 2000, and moved back into the fourth quadrant. The greatest change was seen in *timber and wooden products* — both coefficients rose in 1995 to position it as a key industry, but in 2000 the sensitivity coefficient dropped, and it became a fourth quadrant industry. Overall, the number of first quadrant industries rose from 15 in 1990 to 16 in 1995, but then fell to only 14 in 2000. In particular, in Light industry, *timber and wooden products*, and *printing and publishing* became first quadrant industries in 1995, but moved back in 2000, while in Heavy industry, the sensitivity coefficient of *other chemical products* fell in 2000, pushing it out of the group of key industries. As mentioned earlier, over the seven industries, the above is thought to be one of the factors contributing to a drop in both coefficients from 1990 to 2000 in Light industry and Heavy industry.

2)-1 CO_2 Generation

Next I will look at CO_2 generation over the three target years from E table. Figure 6 shows CO_2 generation by Korea, and CO_2 generation per capita and per domestic production unit. First, in total amount (right axis), CO_2generation totaled about 250 million tons in 1990, but increased 1.46 times to about 373 million tons in 1995, and further increased 1.20 times to about 450 million tons in 2000. Therefore, the rate of change from 1990 to 2000 is 1.77 times, and is higher in the first half of the 1990s than in the second half. Generation per capita shows that it increased 1.39 times from 1990 to 1995, and 1.15 times from 1995 to 2000, for a total increase of 1.61 times over the ten-year period. In contrast, CO_2 generation per domestic production unit dropped to 0.73 times from 1990 to 1995, and to 0.72 times from 1995 to 2000, for a total drop to 0.53 times over the ten years. From the above, on a total amount base the rate of increase of CO_2 generation fell in the second half of the 1990s, but increased 1.7 times over the ten years, and while per capita generation increased 1.6 times, per domestic production unit generation was roughly halved over that period. It can therefore be said that in terms of absolute amount, the environmental load increased, but from the perspective of production efficiency, the environmental load is tending to improve.

Figure 7 shows CO_2 generation by each of the seven industries. Overall, the Tertiary industry, and especially Power and transport, has generated the highest amount in all three target years, followed by Secondary industry, and Primary industry, and over the ten-year period, the generation ratio of the Tertiary industry increased from 58.6% to 69.2%, while the generation ratios of the Primary and Secondary industries fell. In particular, Heavy industry dropped significantly from 26.7% to 20.7%, while the share of Tertiary industry (Power and transport) rose above 50%. Tertiary industry (Others) also rose from 14.6% to 18.2%.

Next I will look at CO_2 generation by each of the 76 industries. Table 8 lists the sectors that generate large amounts of CO_2. In all three target years *thermal power* has generated the most CO_2, accounting for 29% of total generation in 1995 and 2000. In 1990 the top ranking sectors were the transport sector, namely *road transport* and *water transport*, *cement*, and *commerce*, and in 1995 the ratio for *iron and steel*, a Heavy industry, increased, so the top five in 1995 were *thermal power*, *road transport*, *water*

transport, *cement*, and *iron and steel*, accounting for more than 52% of total CO_2 generation. In 2000 the ratio of *eating and drinking places*, and *other power* increased, and with the other three of *thermal power*, *water transport*, and *road transport*, the top five in 2000 account for more than 53% of total generation. Table 9 lists the sectors with high rates of increase in CO_2 generation. From 1990 to 1995 the increase rate for *repair of motor vehicles* is highest at 8.4 times, and as mentioned earlier, this is considered to be due to an increase in production volume. Also characteristic is the increase in generation by *other fabricated metal products* and *eating and drinking places*. From 1995 to 2000, the five sectors with the highest increase in CO_2 generation were *eating and drinking places*, *gas supply*, *repair of motor vehicles*, *knitting*, and *postal and telecommunication services*, all of which recorded high rates of increase in output. Looking at changes from 1990 to 2000, *repair of motor vehicles* shows the highest increase in generation, followed by *eating and drinking places*, *knitting*, and *gas supply*. Therefore, looking at trends in Korea's CO_2 generation from EDEN Data Base over the three target years, I can see that CO_2 generation increased 1.7 times through the 1990s, and that the rate of increase was higher in the first half of the 1990s than in the second half. Per capita generation increased 1.6 times, but generation per domestic production unit fell by about 50%, so while on a total amount base, generation increased, from the perspective of production efficiency, these figures show a comparatively strong improvement. By sector, there is a marked increase in generation by Tertiary industry, and especially in 2000, in addition to *thermal power*, *road transport*, and *water transport*, CO_2 generation by *eating and drinking places*, which is classified a Tertiary industry and enjoyed a substantial increase in production itself, stands out. Moreover, in 1995 and 2000, the top five sectors alone generated more than 50% of the total amount, so the sectors that generate CO_2 are relatively limited.

2)-2 Induced CO_2 generation by final demand item

Next I will look at CO_2 generation by final demand item[34]. Figure 8 shows the ratio of CO_2 generation for each final demand item (Private consumption expenditures,

[34] This is level of dependence for each final demand item, and it enables us to determine which final demand items are depended on in the direct and indirect generation of CO2.

Government consumption expenditures, Gross domestic fixed capital formation, Increase in Stocks, and Export) for each year. Overall, CO_2 generation derived from consumption (Private and Government) is the highest amount in each year, accounting for about 47% of total generation, and there has been little change seen in this ratio over the ten year period. On the other hand, the ratio derived from investment, especially domestic fixed capital formation, is decreasing, while CO_2 generation from exports increased from 30% in 1990 to 39% in 2000. Consequently, I can see a structural change in that about half of the CO_2 generation in Korea in the 1990s was from consumption, while generation accompanying production aimed at export has been increasing.

The above is on a total amount base, but similarly, Figure 9 shows induced CO_2 generation by final demand item for each of the seven industries. By final demand item, in all years the four industries of Primary industry, Secondary industry (Light), Tertiary industry (Power and transport) and Tertiary industry (Others) have a high induced CO_2 generation through consumption, Secondary industry (Others) is the only industry with high induced CO_2 generation through investment, and the two industries of Secondary industry (Mining) and Secondary industry (Heavy) have high induced CO_2 generation through exports. By industry, Primary industry in particular has high generation from consumption, and through the 1990s its ratio percentage was in the high 60s. Secondary industry (Mining) has a relatively strong tendency to be dispersed among the final demand items, but among them, the export ratio is high, rising from 38% in 1990 to 53% in 2000. Secondary industry (Light) has a high generation through consumption, with the ratio increasing in 1995 while the export ratio decreased, and in 2000, consumption is again the main factor, though the export ratio strengthened. Like Secondary industry (Mining), Secondary industry (Heavy) has a strong tendency to be dispersed, but the import ratio increased, and in 2000 more than half of generation is from production for export. As mentioned earlier, Secondary industry (Others) is the only industry in which generation resulting from investment accounts for more than 90%. Until 1995 in Tertiary industry (Power and transport) generation through consumption accounted for more than half of induced CO_2 generation, but in 2000 the export ratio increased almost to the level of consumption. In Tertiary industry (Others) generation through consumption in 2000 accounts for more than 70%, so generation

resulting from consumption is increasing. From the above, I can see that overall as mentioned before, the ratio through exports is increasing, but I can say this is attributed to the rise in induced generation derived from exports within Secondary industry, especially in Mining and Heavy industry. By the 76 industries, those whose main final demand item newly shifted from consumption to export during the 1990s include *petroleum refinery products*, *coke and other coal products*, *iron and steel*, *iron and steel products*, *motor vehicles*, and *other transport equipment*, while those whose generation from export increased substantially are the six industries of *coke and other coal products*, *ship building and repairing*, *other transport equipment*, *machinery and equipment* n.e.c., *railway transport*, and *other transport* and transport-related services, and I can say that because of the increase in induced CO_2 generation from export in these sectors, the export ratio of the Heavy industry sector as a whole rose.

2)-3 Induced CO_2 generation associated with an increase in final demand

Focusing on the three industries of Secondary industry (Light), Secondary industry (Heavy) and Tertiary industry (Others) from among the seven industrial classifications, Figure 10 shows changes by year in directly and indirectly induced CO_2 generation when final demand in each of the industries expands by about one trillion Won[35]. Even assuming final demand in each of the industries expanded by the same scale, there are differences in the induced CO_2 generation, however, a common characteristic among all three industries is that 1995 is less than 1990, and 2000 is less than 1995. In particular, generation by Light industry and Tertiary industry (Others) in 2000 is half of that in 1990, and, similarly, generation by Heavy industry in 2000 is 38% of that in 1990, so even with the same scale of demand increase, I can say that 2000 is in a more environmentally friendly condition. This is considered to be due to improvements in technological efficiency. Comparing a breakdown of CO_2 generation among the three industries, in Light industry, the generation ratio for Light industry itself is the lowest, and CO_2 generation also arises in Tertiary industry (Power and transport) and Heavy industry, and Primary industry. However, this own-industry

[35] One trillion Won correspond to 0.55% of final demand in 1990, 0.26% in 1995 and 0.17% in 2000.

generation ratio is rising each year, and in 2000, 48% was generated by Light industry itself. On the other hand, Heavy industry has the highest own-industry generation ratio, and more than 60% is generated by the Heavy industry itself, and the remaining 25% is generated by Secondary industry (Power and transport), and Tertiary industry (Others). Heavy industry's own-sector generation ratio, however, has been falling each year, whereas the generation ratio for Tertiary industry (Power and transport) and Tertiary industry (Others) is increasing. Tertiary industry (Others) generates 50% in its own industry, and the remainder is generated by Tertiary industry (Power and transport), and Heavy industry, and this own-industry ratio is, like the Light industry, trending upward year by year. This result reflects the degree of interdependence among the seven industries, and as was made clear by placement in the influence and sensitivity coefficients, it is thought that the main factors for reductions in CO_2 generation in each industry include a weakening interdependent relationship with the Heavy industry, which is especially technologically inefficient regarding the environment, i.e., it has a high generation coefficient, and conversely, a rising interdependent relationship with the low generation coefficient Tertiary industry (Others).

4. Conclusion

In this paper I prepared a database for environmental analysis over the three target years for East Asia, one of the regions that are the main factors in the environmental load, and especially Japan and Korea, and ascertained the characteristics of the interdependence in the economy and the environment.

In Chapter 2 I discussed the background to the preparation of EDEN Data Base and an overview, and looked at previous research. The main aspects of this were fact-finding analysis using EDEN itself, and empirical analysis applying EDEN. Regarding the former, only the 1990 version has been released, so the analysis covered the situation in a single fiscal year. As for the latter, EDEN Data Base was used also in analysis for clarifying the issue of environmental load in the open ocean, which is quite substantial but has yet to be studied extensively because of a lack of data, the issue of trade and environment under a growing need to determine the environmental load, which is no longer a single country base but takes into account multiple countries,

associated with a deepening international interdependence against the current globalization backdrop, and the issue of consumption lifestyle and the environment to ascertain the current state of environmental load in the household sector, which, domestically, is on an increasing trend.

In Chapter 3 I first developed data in a common format over the three target years, focusing on Korea. As the 1995 provisional version is quite accurate, I extended the estimations to the 2000 version based on the 1990 and 1995 versions. At this stage, however, sector-based generation figures are not available, so judging from the total amount, I drew up these figures assuming a 70% improvement in environmental technology for each sector from 1995 to 2000. Through this, I was able to determine the characteristics of the structure of and changes in the economic and environmental interdependence over the three target years, and not just for the single year of 1990. As a result, economic scale in Korea expand 3.3 times as domestic production and more than 3.0 times as domestic production in per capita from 1990 to 2000. In particularly, the rate of increase was higher in the first half of the 1990s than last half. As for the industrial structure over the three target years, the ratio of Primary and Secondary industry decrease and Tertiary industry increase. But one exception to this down ward trend is Heavy industry, and it is the only Secondary industry category that showed an increase, especially *Other electrical machinery and apparatus* became main industry in Korea as domestic production. In Tertiary industry, a notable increase was “Others”, jumping from 34.5% in 1990 to 43.4% in 2000, the rate of *Eating and drinking place*, *Commerce*, *Real estate services*, *Financial and insurance services* especially were increased and then Tertiary industry (Others) rose above Heavy industry. Next I look at changes in the degree of interlinkage between industrial sectors through Influence and Sensitivity coefficients, Light and Heavy industries are still key industries from 1990 to 2000, but both coefficients slightly dropped, so their interlinkage can be said to be on a weakening trend in three target years. Sensitivity coefficient of Tertiary industry rose, so it could be increased interlinkade among industry by way of intermediate demand. We will now look at the relationship between influence and sensitivity coefficients by each of the 76 industries. In Light industry, *Timber and Wooden products*, *Printing and publishing* became key industry in 1995, but drooped out again in 2000. In Heavy industry, *Other chemical products* drooped out from key industry in 2000. On the other

hand, *Eating and drinking place* in Tertiary industry became key industry in 2000. Next we look at CO_2 generation, the total amount of CO_2 generation in Korea increased 1.7 times through 10 years and increased 1.6 times as per capita, too. On the other hand, CO_2 generation per domestic production unit decreased half in 2000 from 1990, so it can be said that Environmental load in Korea increased as a total amount but decreased as a production efficient. As for each industries, Tertiary industry only increased. As for CO_2 generation by final demand item, CO_2 generation derived from consumption is the highest through ten years, on the other hand, the ratio derived from exports increased, especially for Heavy and Mining industry. As for EDEN 76 sector, *Petroleum refinery products*, *Coke and other coal products*, *Iron and steel products*, *Other transport equipment*, *Other electrical machinery and apparatus*, include Heavy industry are increased derived from export. Finally, I will see the directly and indirectly induced CO_2 generation by the expansion of each final demand as a same scale, focusing on the three industries of Light industry, Heavy industry and Tertiary industry (Others). The induced CO_2 generation in three industries decreased in 2000 from 1990, and it can be said that 2000 is in a more environmentally friendly condition because of the generation ratio of Heavy industry decreased but the ratio of Tertiary industry increased in three industries. So the change of interdependency among industry and improvement of technological efficiency regarding the environment brings the environmentally friendly situation in Korea.

I started analysis with the preparation of EDEN Data Base for Korea for the three target years, and examined structural changes in the economic and environmental structure over the three target years. At this stage information on sector-based generation for 2000 is not available, so judging from the total amount in general statistics, I carried out the analysis assuming, for convenience, a 30% improvement in environmental technology for each sector. As a future issue, I need to review the coefficient for each sector by collecting detailed data on environmental and production technology to draw up a more accurate 2000 version. EDEN Data Base is the only table in the world to estimate the economy and environment in nine countries in East Asia using a common format. Under the current state of EDEN Data Base release, I can only carry out a cross-sectional comparison of the nine countries for 1990, but I am seeking to establish the estimation methods in this paper as the basis of extended estimations,

and where possible, undertake extended estimations of the 2000 version in a similar manner for countries other than Korea so I can carry out time series and cross-sectional analysis over the three target years for the nine East Asian countries.

Environmental load is incidental to economic activities, and considering the backdrop of an international interdependence among countries and industries, resolving this issue requires policy intervention based on international collaboration. EDEN Data Base used in this paper is an analysis tool for quantitative analysis of the interdependence between economic activities in the business sector in various countries, and the environmental issues that arise incidental to these activities, and by clarifying the state of the global environment, which is taking on a rapidly growing presence in world awareness with the expanding economic activities, it is an invaluable database when considering global preservation. Unfortunately, though, only the 1990 version of EDEN Data Base has been released, so it has as yet not reached the multipurpose use stage. I am hoping to develop EDEN Data Base versions for each year in each country as soon as possible, and from this, consider methods of dealing with global environmental issues whose resolution is a matter of great urgency.

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Table 1: Structure of EDEN Data Base

		Unit	Intermediate Demand	Final Demand
A	Transaction table	Respective currencies	76×76	76×5
B	Energy substance input table	Specific physical unit	22×76	22×5
C	Energy Consumption table	Specific physical unit	22×76	22×5
D	Calorie Table	Calories	22×76	22×5
E	CO_2・SO_2 generation table	ton	2×76	2×5

Source: This table is an excerpt from Kiji(2002)p.25.

Figure 1: Outline of EDEN Data Base

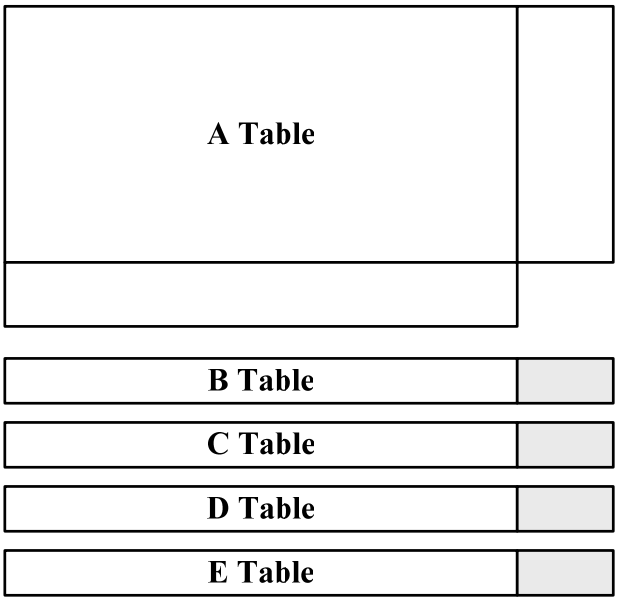


Figure 2: Estimation process of EDEN Data Base

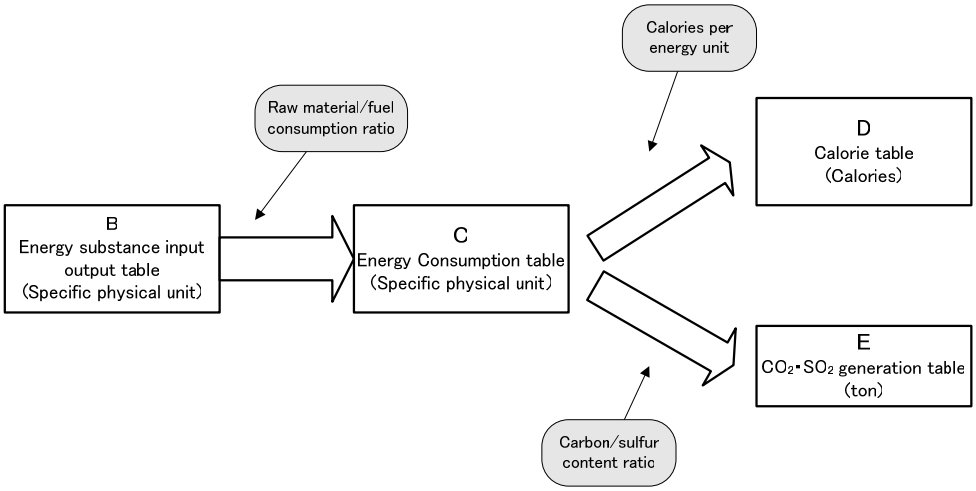


Table 2 : Outline of previous analysis-single country

	Kiji(2002)	Kim et al.(2002)	Takenaka(2002)
Sector	20	76	48
Energy	5	4	5
Features	The paper uses figures substantiated with purchasing power parity indices calculated from GDP statistic	Mainly focusing on Japan and Korea, and Light and Heavy industry.	Mainly focusing on Household sector carries out a simple simulation estimating energy consumption resulting from changes in the calorific value per energy unit to examine future trends in energy consumption.

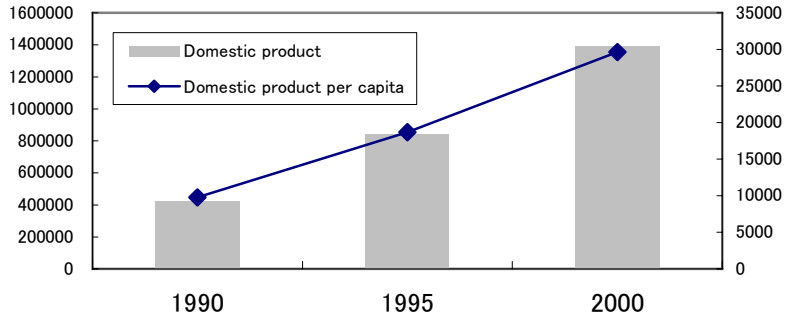
Source:Author makes this figure referring to Kiji(2002), Kim et al.(2002), and Takenaka(2002)

Table 3 : The list of change sector in 2000 from 1995

1995	2000
Unrefined liquors and rice wine.3173	Section deletion.
Mineral and spring water.*3177*,*Manufactured ice*.3178	Integrate to *Spring water and manufactured ice*.0084.
Engines and turbines.4001	Change name, *International combustion engines turbines*.0226.
—	Separate and new establishment *Machinery for manufacturing semi conduct*.0244 from *Misc.machinery and equipment of special purpose*.
Other electronic signal equipment.4112	Change name, *Flat digital displa*y.0255.
Telegraph and telephone.6402	Separate *Telephone*.0347 and *High-speed network services*.0348 a
Broadcasting(private non-profit).6404 , *Broadcasting(commercial)*.6405	Separate *Terrestrial broadcastin*g.0350 and *Cable broadcasting*.0351.
Depositoryinstitutions.6501, *Non-depository credit institutions*.6502	Separate *Central bank and banking institutions*.0352, *Non-bank depository institution*,0353 and *Other financial brokerage institutions*.0354.
—	Separate *Computer soft wares development*.0364 from *Computer programming, data processing,* and *other computer related services.*
Research and news syndicated services.6617	Change name, *Information provision services*.0368.

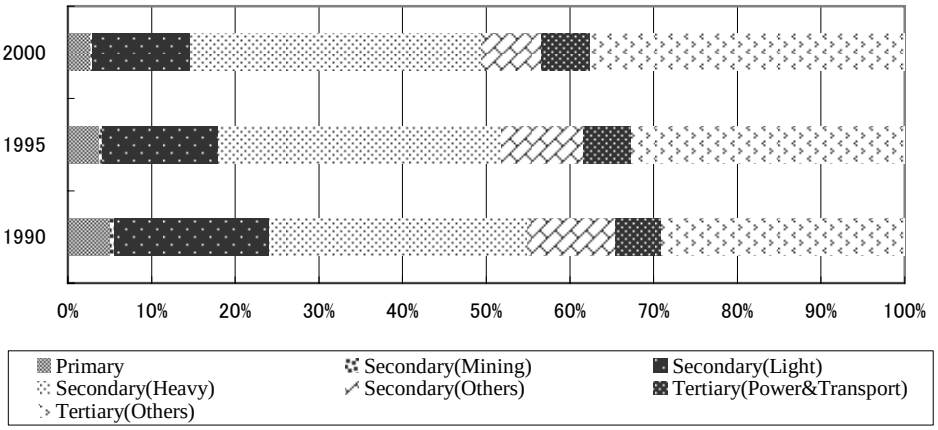
Source: Author makes this table referring to The Bank of Korea(2003).

Figure 3: Korea-Economic scale in three target years



Unit: Domestic product-One billion won, Population-One million people.

Figure 4: Korea-Industry structure in three target years



Source: Author makes this figure from EDEN Data Base(A Table).

Table 4 : Korea-Top ranking sectors of Domestic Products(%)

	1990		1995		2000	
1	Buildings	7.38	Buildings	6.61	Other electrical machinery	8.98
2	Commerce	6.62	Other electrical machinery	6.05	Real estate services	5.88
3	Motor vehicle	4.38	Commerce	5.89	Commerce	5.01
4	Other electrical machinery	4.30	Motor Vehicle	4.71	Financial and insurance services	4.55
5	Real estate services	3.97	Real estate services	4.61	Motor vehicle	4.25

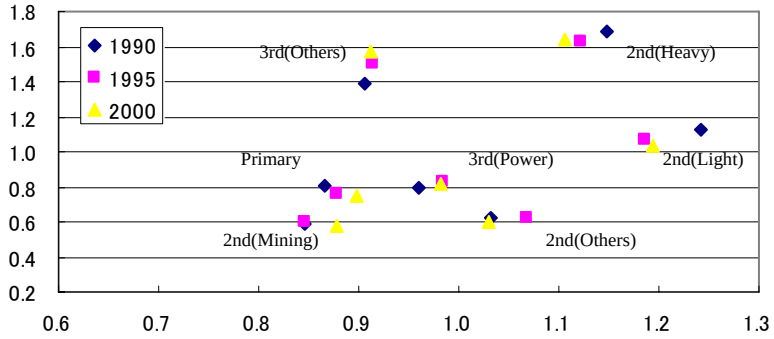
Source: Author makes this table from EDEN Data Base(A Table).

Table 5 : Korea- Top sectors with a high rate of increase in domestic production

	1995 / 1990		2000 / 1995		2000 / 1990	
1	Repair of motor vehicles	12.62	Eating and drinking place	7.25	Repair of motor vehicles	41.31
2	Knitting	9.00	Gas supply	3.61	Knitting	28.00
3	Business services	3.59	Repair of motor vehicles	3.27	Eating and drinking place	19.34
4	Gas supply	3.29	Knitting	3.11	Gas supply	11.92
5	Precision instruments	2.84	Postal telecommunication services	3.09	Petroleum refinery products	7.54

Source: Author makes this table from EDEN Data Base(A Table).

Figure 5 : Korea-Influence and Sensitivity coefficient for 7 industry



Source: Author makes this figure from EDEN Data Base(A Table),

Note: Horizontal axis-Influence coefficient, Vertical axis-sensitivity coefficient.

Table 6 : Korea-Top ranking sectors of Influence and Sensitivity coefficient

		Influence Coefficient		Sensitivity coefficient	
1990	1	Meat and meat products	1.67	Other Chemical products	3.29
	2	Dairy products	1.52	Commerce	2.59
	3	Not elsewhere classified	1.44	Financial and insurance services	2.34
	4	Iron and steel products	1.38	Not elsewhere classified	2.04
	5	Iron and steel	1.37	Iron and steel	1.98
1995	1	Meat and meat products	1.59	Other Chemical products	2.98
	2	Not elsewhere classified	1.41	Business services	2.90
	3	Dairy products	1.39	Financial and insurance services	2.47
	4	Dairy farming and Livestock	1.37	Not elsewhere classified	2.06
	5	Iron and steel products	1.33	Petroleum refinery products	1.88
2000	1	Meat and meat products	1.61	Other Chemical products	3.20
	2	Not elsewhere classified	1.39	Financial and insurance services	2.61
	3	Dairy products	1.37	Business services	2.60
	4	Motor vehicle	1.34	Petroleum refinery products	2.54

	5	Iron and steel products	1.30	Commerce	2.06

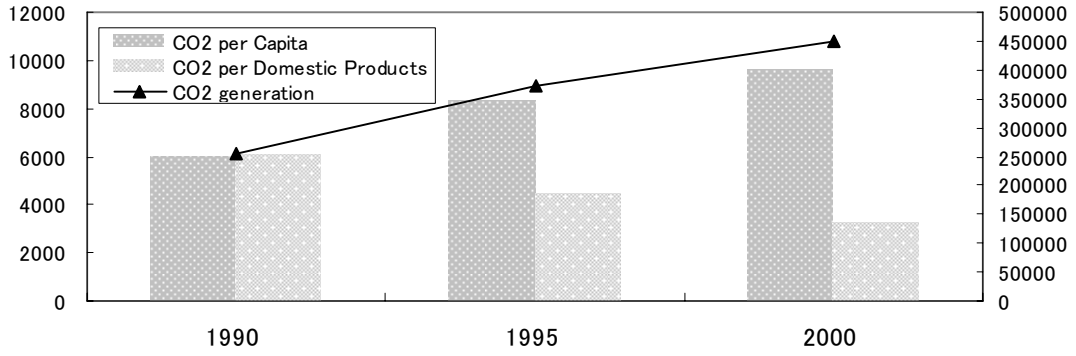
Source: Author makes this tabke from EDEN Data Base(A table).

Table 7 : Korea –Lists of sectors whose placement on Influence and Sensitivity coefficients changed

	1990	1995	2000
Coal	Ⅲ	Ⅳ	Ⅳ
Tea and Coffee, Beverages, Cement, Glass and glass products, Air transport	Ⅲ	Ⅳ	Ⅲ
Timber and Wooden products	Ⅲ	Ⅰ	Ⅳ
Printing and publishing	Ⅳ	Ⅰ	Ⅳ
Other chemical products	Ⅰ	Ⅰ	Ⅳ
Buildings	Ⅰ	Ⅳ	Ⅳ
Road transport	Ⅱ	Ⅱ	Ⅲ
Air transport	Ⅲ	Ⅳ	Ⅲ
Eating and drinking place	Ⅲ	Ⅲ	Ⅰ
Postal and telecommunication services	Ⅲ	Ⅲ	Ⅱ
Repair of motor vehicles	Ⅲ	Ⅲ	Ⅳ

Source: Author makes this table from EDEN Data Base(A Table).

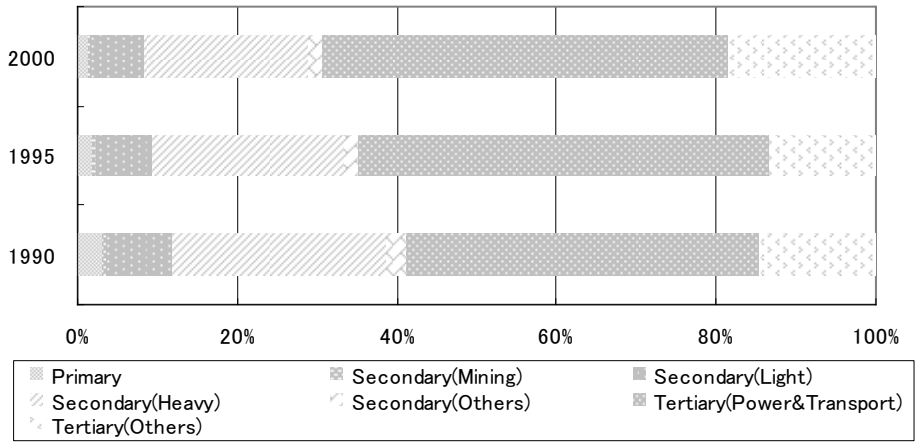
Figure 6 : Korea-CO_2 generation (total, per capita and per domestic product)



Source: Author makes this figure from EDEN Data Base(E Table),

Unit: CO_2-1000t-CO_2, Population-One million people, Domestic Products-10 trillion Won.

Figure 7 : Korea- CO_2 generation in seven industries.



Source: Author makes this figure from EDEN Data Base(E Table).

Table 8 : Korea- List of the sectors that generate large amounts of CO_2

	1990		1995		2000	
1	Thermal power	22.0%	Thermal power	29.4%	Thermal power	28.8%
2	Road transport	11.1%	Road transport	8.6%	Eating and drinking place	6.8%
3	Water transport	5.6%	Water transport	6.2%	Water transport	6.8%
4	Cement	5.4%	Cement	4.2%	Road transport	6.7%
5	Commerce	5.4%	Iron and steel	4.2%	Other power	3.9%

Source: Author makes this table from EDEN Data Base(E Table).

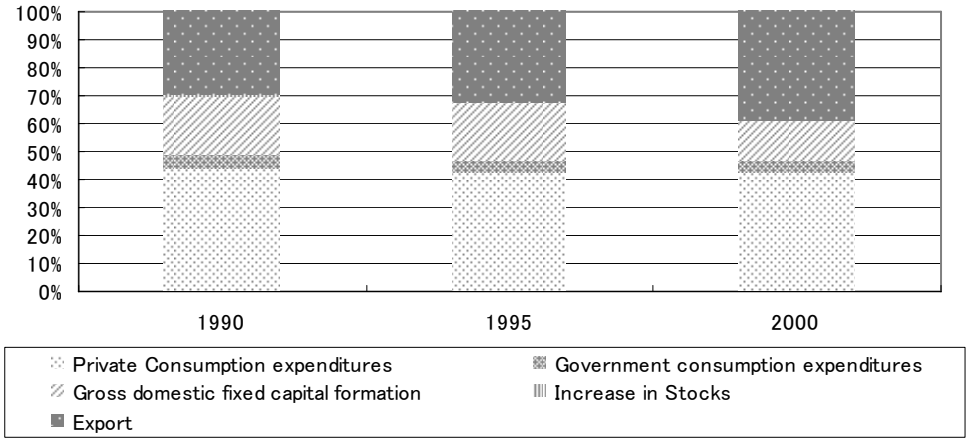
Table 9 : Korea-List of the sectors with high rates of increase in CO_2 generation

	1995/1990		2000/1995		2000/1990	
1	Repair of motor vehicles	8.41	Eating and drinking place	5.08	Repair of motor vehicles	19.26
2	Knitting	4.57	Gas supply	2.53	Eating and drinking place	13.39
3	Other fabricated metal products	3.09	Repair of motor vehicles	2.29	Knitting	9.96

4	Gas supply	2.94	Knitting	2.18	Gas supply	7.44
5	Eating and drinking place	2.64	Postal and telecommunication services	2.17	Other power	4.71

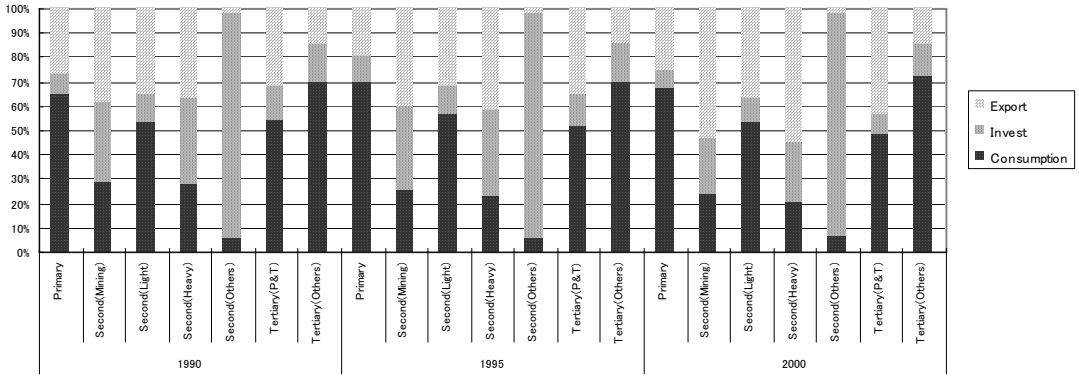
Source: Author makes this table from EDEN Data Base(E Table).

Figure 8 : Korea-The ratio of CO_2 generation for each Final demand item



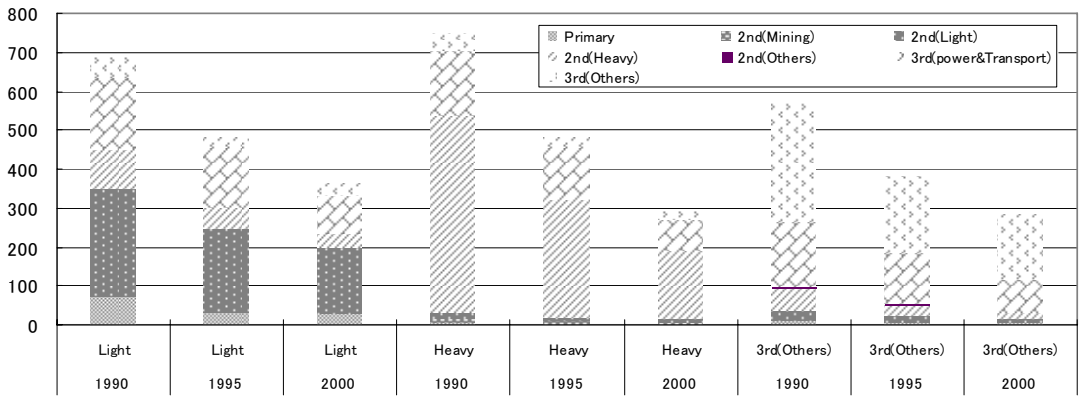
Source: Author makes this figure from EDEN Data Base(A and E table).

Figure 9 : Korea- Induced CO_2 generation by Final demand item in seven industries



Source: Author makes this figure from EDEN Data Base(A and E table).

Figure 10 : Korea- Changes by year in directly and indirectly induced CO_2 generation when Final demand in each of the industries expands by about one trillion Won



Source: Author makes this figure from EDEN Data Base(A and E Table).

Unit: 1000t-CO_2.

Appendix 1 : EDEN 76 classification

1	Paddy	39	Iron and steel
2	Fruits	40	Iron and steel products
3	Dairy farming and Livestock raising	41	Non-ferrous metal products
4	Other edible crops	42	Metallic furniture and accessories
5	Non-edible crops	43	Other fabricated metal products
6	Agricultural services	44	Household electrical appliances
7	Forestry(Inc. Hunting)	45	Other electrical machinery and apparatus
8	Fishing	46	Motor vehicle
9	Coal	47	Ship building and repairing
10	Crude oil and Natural gas	48	Other transport equipment
11	Metal ores miming	49	Precision instruments
12	Non-metallic ores mining	50	Machinery and equipment n.e.c
13	Dairy products	51	Other manufactured products
14	Meat and meat products	52	Thermal power
15	Other foods	53	Other power
16	Animal feeds	54	Gas supply
17	Tea and coffee	55	Water, Steam & hot water supply, Sewage, Sanitary services
18	Beverages	56	Buildings
19	Tobacco	57	Civil engineering
20	Spinning and weaving	58	Commerce
21	Knitting	59	Railway transport
22	Wearing apparel and other fabricated textile products	60	Road transport
23	Leather and leather products	61	Water transport
24	Timber and Wooden products	62	Air transport
25	Wooden furniture	63	Other transport and transport relating services

26	Pulp, paper and paper products	64	Eating and drinking place
27	Printing and publishing	65	Hotels & other lodging place
28	Fertilizer	66	Postal and telecommunication services
29	Drugs and medicine	67	Financial and insurance services
30	Soap, detergent and toiletries	68	Real estate services
31	Other chemical products	69	Business services
32	Petroleum refinery products	70	Public administration
33	Coke and other coal products	71	Education
34	Rubber products	72	Medical and health services
35	Plastic products	73	Repair of motor vehicles
36	Cement	74	Other repairs, n.e.c
37	Glass and glass products	75	Other services
38	Other non-metallic mineral products	76	Not-elsewhere classified

Source: This table excerpt from EDEN Data Base.

Appendix 2 : 22 Energy classification

1	Coal	12	LPG
2	Coke	13	Other Petroleum fuels
3	Other Coal products	14	Naphtha’s
4	Crude Oil(Inc. Liquid oil)	15	Other Petroleum Products
5	Natural Gas	16	Total Electricity
6	Liquefied Natural Gas	17	Town Gas
7	Gasoline	18	Vegetable fuels
8	Jet Fuel	19	Industrial waste gas
9	Kerosene	20	Industrial or General Waste
10	Diesel Oil	21	Steam and Hot water supply
11	Fuel Oil	22	Natural energy

Source: This table excerpt from EDEN Data Base.

Appendix 3 : 76sectors for 7 Industry

7 Industry		EDEN 76
1	Primary industry	1,3,4,5,6,7,8
2	Secondary (Mining)	9,10,11,12
3	Secondary(Light)	13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,34,35,37
4	Secondary(Heavy)	28,29,30,31,32,33,36,38,39,40,41,42,43,44,45,46,47,48,49,50,51
5	Secondary(Others)	56,57
6	Tertiary(Power & transport)	52,53,54,55,59,60,61,62,63
7	Tertiary(Others)	6,59,64,65,66,67,68,69,70,71,72,73,74,75,76

Source: The author makes this table.